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## How Should We Screen for Depression Following a Natural Disaster? An ROC Approach to Post-Disaster Screening in Adolescents and Adults

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### Abstract

**Background**—The present study's aim was to provide the foundation for an efficient, empirically based protocol for depression screening following a natural disaster. Utilizing a Receiver Operating Characteristic (ROC) analytic approach, the study tested a) what specific disaster-related stressors (i.e., property damage, loss of basic services) and individual-related constructs (i.e., PTSD symptoms, trauma history, social support) conveyed the greatest risk for post-natural disaster depression, b) specific cutoff scores across these measures, and c) whether the significance or cutoff scores for each construct varied between adolescents and adults.

**Methods**—Structured phone-based clinical interviews were conducted with 2,000 adolescents who lived through a tornado and 1,543 adults who survived a hurricane.

**Results**—Findings suggested that in both adolescents and adults, individual-related constructs forecasted greater risk for depressive symptoms following a natural disaster compared to disaster-related stressors. Furthermore, trauma history and PTSD symptoms were particularly strong indicators for adolescent depressive symptoms compared to adult depressive symptoms.

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The authors have no conflicts of interest to report.

#### Contributions

Drs. Ron Acierno, Ken Ruggiero, and Carla Danielson designed the original studies which the present data was built upon. Dr. Zachary Adams, Dr. Brian Brunnell, and Ms. Suvarna Menon read drafts of the manuscript and provided instrumental feedback at different stages of the process. Dr. Eric Youngstrom consulted Dr. Joseph Cohen on the ROC statistical approach. Dr. Joseph Cohen wrote the manuscript and conducted statistical analyses.

Adolescents and adults who reported vulnerable scores for social support, trauma history, and lifetime PTSD symptoms were approximately twice as likely to present as depressed following the natural disaster.

**Limitations**—Findings from the present study were limited to post-disaster assessments and based on self-reported functioning 6–12 months following the natural disaster.

**Conclusions**—The present study synthesizes the extensive body of research on post-disaster functioning by providing a clear framework for which questions may be most important to ask when screening for depression following a natural disaster.

### Keywords

Depression; Natural Disasters; Adolescents; Empirically-Based Assessment

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In 2016, the United States Preventative Services Task Force (USPSTF, 2016) published formal recommendations for universal depression screening with adolescents (ages 12–18) and adults. Overall, both adolescent and adult reports received a grade of “B”, noting that there is “high certainty” that there is a “net benefit” for universal depression screening, but also acknowledging that more research was warranted. For adults, the report emphasizes depression screening in vulnerable populations such as older adults, and pregnant/postpartum women. For adolescents, the report recommends screening even if appropriate treatment is not readily available. The acknowledgement that monitoring alone is a health benefit represents an important departure from the USPSTF’s last report in 2009. Systems of care may not always be capable of implementing a comprehensive intervention in the wake of a positive screen. Undoubtedly, this is most true in resource-intensive environments that may serve those most vulnerable to depression. For instance, in communities recently impacted by a natural disaster there are several barriers for individuals seeking appropriate mental health treatment (Bonanno et al., 2010; North & Pfefferbaum, 2013). Therefore, empirically-based, efficient screening procedures are needed to a) prioritize those most at-risk and b) allow for continuing monitoring as the healthcare infrastructure adapts and recovers in the aftermath of a natural disaster.

The goal of the present study was to examine which questions may be most vital to ask adolescents and adults when screening for depression following a natural disaster. Specifically, we utilized an evidence-based approach (EBA) to identify important screening items and establish specific recommendations for when further monitoring, assessment, or intervention may be needed. Different than traditional depression screeners for this context (see Pfefferbaum & North, 2016), we utilized multiple indicators for depression in our screening approach. As non-traditional providers may be tasked with conducting post-disaster depression screening (Bonanno et al., 2010), these individuals may lack the training to comfortably screen for depressive symptoms or be operating in environments that are not conducive to the disclosure of sensitive information. Therefore, we utilized a wide array of questions that may be less sensitive in nature, but still confer depression-risk. Furthermore, utilizing this multidimensional approach to screening is consistent with current recommendations to incorporate additional information beyond the sum of DSM symptoms when screening for depression (Fried & Nesse, 2015; Hill, Yaroslavsky, & Pettit, 2015;

Shetter & Tanner, 2012). For instance, Hill and colleagues (2015) demonstrated that including items assessing social disconnection and negative feedback-seeking improved their ability to detect patterns of depression symptoms in a sample of University students. By conducting this research we sought to bridge the gap between research and practice and offer recommendations that could lead to the first EBA disaster depression screener.

## Post-Disaster Depression

Natural disasters levy widespread negative consequences, including significant symptoms of emotional distress (Lai, La Greca, Auslander, & Short, 2013). Two common, and the most well-studied, forms of post-trauma mental health outcomes are posttraumatic stress disorder (PTSD) and depression (Bonde et al., 2016; Norris et al., 2002). After some support that PTSD and depression may be contributing to a shared traumatic response (Au et al., 2013; O'Donnell et al., 2004), extant research suggests these trauma responses to be distinct (Cao et al., 2015; Grant et al., 2008; Gros et al., 2010). In a recent community sample, Cao and colleagues (2015) identified four response patterns in the aftermath of a natural disaster: (1) minimal symptoms, (2) predominately depression, (3) predominately PTSD, and (4) comorbid PTSD and depression. Of note, individuals with a predominately depressed presentation represented approximately one-fifth of the community sample (and 40% of those presenting with symptoms), and reported more somatic complaints and elevated levels of interpersonal problems compared to those characterized by PTSD symptoms.

A recent meta-analysis indicated that estimates of depression among natural disaster survivors ranged from 5% to 50% across studies (Tang, Liu, Liu, Xue, & Zhang, 2014). Emerging findings suggest that variability in outcomes may reflect different rates of susceptibility to depression in different community populations. For instance, past research suggests that adolescents may have particularly high risk for depression following a natural disaster compared to other age groups (Bonanno et al., 2010; Thienkrua et al., 2006). These findings may reflect the need to have developmentally-sensitive screening procedures for depression following a natural disaster. Given the deleterious impact of depression and risk of suicide following a natural disaster (Cao et al., 2015; Kolves, Kolves, & De Leo, 2013), improved methods for detecting depressive symptoms across the lifespan following such an event is of critical importance.

Extensive research demonstrates that different constructs may forecast increased risk for specific patterns of post-disaster psychological distress. For instance, experiences during the natural disaster (e.g., being trapped) may be more indicative of PTSD following a natural disaster compared to depression (Tracy et al., 2011). Meanwhile, a collection of studies show that additional processes, specifically disaster-related stressors and individual-level factors, may lead to post-disaster depression (Brewin, Andrews, & Valentine, 2000; La Greca et al., 2010; Tracy et al., 2011). Disaster-related stressors can include objective characteristics of the event's impact on one's life. Property damage and loss of basic resources (e.g., electricity, water) are indicators of disaster impact commonly assessed following a natural disaster (Bonanno et al., 2010; Sattler et al., 2006). Individual-level factors, on the other hand, may refer to specific personal attributes or life experiences that influence how one copes with the aftermath of a disaster. The present study examined three

individual-level processes, prior trauma exposure, past PTSD, and social support, which are commonly studied when examining the mental health impact of natural disasters (La Greca & Silverman, 2009; Tang et al., 2014) and may be particularly relevant in developing a post-disaster depression trauma screening protocol.

Prior trauma exposure is an important indicator of mental health functioning following a natural disaster (Brewin, Andrews, & Valentine, 2000). Specific to depression, meta-analytic findings demonstrate that it is one of the most robust indicators of depression symptomatology compared to other disaster-related stressors and individual-level predictors (Tang et al., 2014). Relatedly, past symptoms of PTSD may also serve as a relatively strong indicator of post-disaster depression. After reviewing the literature, Stander, Thomsen, and Highfill-McCoy (2014) suggested a causal relation between PTSD and depression, in which pre-military trauma PTSD forecasted depressive symptoms following exposure to war. Demonstrating a strong relation between lifetime PTSD and post-disaster depression can have important implications in disaster-preparedness protocols within mental health services. Finally, self-perceived social support represents a malleable process targeted by evidence-informed intervention and prevention programs (La Greca & Silverman, 2009). Therefore, an empirically-based screening procedure including this construct may indicate youth who can most benefit from the current approaches utilized within the disaster-treatment field. Overall, by testing these individual-level indicators, along with disaster-related stressors, it can be better understood which factors are most vital as part of a comprehensive, post-disaster screening process.

## The Importance of an Empirically-Based Assessment Approach

Since September 11, 2001, intervention-based research for post-disaster psychological distress has grown exponentially (Pfefferbaum & North, 2016). These investigations have included approaches for addressing mental health consequences at the population-level (e.g., Pynoos, Steinberg, & Brymer, 2007), and specific protocols that can treat post-disaster depression in adolescents and adults (see La Greca & Silverman, 2009; North & Pfefferbaum, 2013). Universal to all of these clinical approaches, is the recommendation for strong screening procedures to identify the most vulnerable individuals within compromised community and healthcare settings. Yet, a paucity of research has examined what screening procedures may be best to screen for depression following a natural disaster. Leaders in the field (e.g., Pfefferbaum & North, 2016) often cite typical screening inventories utilized for depression (e.g., the Children's Depression Inventory for adolescents; Kovacs, 1985), noting the economic feasibility and efficiency in which these measures may be implemented within a system. However, as noted earlier, this a) limits the screening to strictly symptoms, b) does not address the specific context of depression-risk following a natural disaster, and c) assumes the setting is conducive to asking for and disclosing sensitive information.

Receiver Operating Characteristic (ROC) analyses offer an opportunity to identify which post-disaster indicators may best forecast depression outcomes following a natural disaster, and to establish specific cutoff points for when these vulnerabilities become most problematic (Youngstrom, 2014). ROC-based cutoffs can inform when an individual should be referred for clinical services and which types of services (e.g., no intervention,

comprehensive assessment, brief psychotherapy, pharmacotherapy) may be most appropriate. This approach may be especially well suited to the post-disaster milieu where first responders, public health workers, primary care clinicians, school personnel, and others are tasked with prioritizing the needs of citizens in affected communities and allocating limited resources accordingly.

To date, no published studies have applied ROC analyses to depression risk in a post-disaster context. However, past investigations utilizing ROC analyses have provided empirical guidelines for assessing depression in adolescent (Dierker et al., 2001) and adult (e.g., Lasa, Aysuo-Mateos, Vazquez-Barquero, Diez-Manrique, & Dowrick, 2000) populations in both clinical (Dolle et al., 2012) and community (Tran, Tran, & Fisher, 2014) settings. Furthermore, O'Donnell and colleagues (2008) used ROC principles to develop cutoffs on an emergency department (ED) screener for patients who suffered a traumatic brain injury. Based on their findings, the authors established the validity of a 10-item brief self-report screener that assesses individual vulnerabilities (e.g., past mental health, social support) and successfully identified patients at risk for developing emotional distress in the 6 months following the traumatic event.

## The Present Study

The present study involved ROC analyses on data from two different disaster-affected samples. The first sample included adolescents recruited from communities impacted by the 2011 tornadoes in Joplin, Missouri and the southeastern United States. The 2011 tornadoes represented one of the most devastating stretches for natural disasters in U.S. history (Ruggiero et al., 2015). The second sample included adults recruited from communities impacted by the 2004 Florida hurricanes (Charley, Frances, Ivan, and Jeanne), which brought unprecedented financial and personal costs to the region (Acierno et al., 2007). The exploratory, primary aims for the present study were to (a) identify which post-disaster individual and disaster-related variables conferred the greatest risk for depression, (b) examine whether any of these factors vary between adolescent and adult populations, and (c) establish cutoff points across depression indicators that frontline community and health providers can use.

## Method

### Participants

**Adolescent Sample**—Adolescent participants were recruited as part of a longitudinal study design testing the effectiveness of a web-based intervention for post-disaster mental health problems (see Ruggiero et al., 2015). The present study was based on baseline data which assessed depression, and other psychosocial processes, prior to families' engagement with the intervention. Selection criteria prioritized identification of families directly impacted by a tornado. NOAA tornado track latitude/longitude coordinates were used to obtain surrounding radii of affected addresses based on where the tornadoes touched down (National Oceanic & Atmospheric Administration, 2011). The sample consisted of 2,000 adolescents between the ages of 12 and 17 ( $M = 14.5$ ,  $SD = 1.7$ ) and their caregivers. The

sample was balanced with regard to sex (50.9% female), and was 70.5% White/Caucasian (25.6% Black/African-American, 3.9% other; see Ruggiero et al., 2015 for further details).

**Adult Sample**—Adult participants were recruited as part of a study designed to examine the psychological impact of the 2004 Florida hurricanes. Random digit dial techniques were utilized with 38 Florida counties that were exposed to hurricane-force winds in 2004. The total sample consisted of 1,543 adults between the ages of 18 and 95 ( $M = 63.37$ ;  $SD = 15.22$ ). The sample was mostly female (64.5%) and predominantly Caucasian (92.0%; see Acierno et al., 2006 for further details).

## Procedure

**Adolescent Study**—Potentially eligible households were contacted via phone to confirm eligibility. After informed consent was obtained, interested adolescents and parent dyads independently completed a structured telephone interview approximately 8 months ( $M = 8.8$  months,  $SD = 2.6$ ; range = 4–13 months) following the tornado. Adolescents who completed the baseline interview were mailed a \$15 incentive.

**Adult Study**—Interviews were conducted within 12 months of hurricane exposures. Once adults provided consent to participate in the study, they participated in the structured phone interview to assess demographics, risk factors, protective factors, hurricane impact, and psychological distress. Participants were mailed \$20 upon completion of the interview.

## Measures

### Adolescents

**Disaster-Related Stressors:** Caregivers were asked several questions about the family's experiences during and after the tornado. Specifically, property damage (i.e., damage to one's house, vehicle, furniture, personal item and pet) and loss of services for over a week (i.e., water, electricity, clean clothing, food, shelter, transportation, and spending money) were assessed. Responses to all of these questions were dichotomized (0=no, 1=yes), and the variable was a counting variable, with higher scores indicating elevated levels of impact from the tornado. For property damage scores ranged between 0–5 ( $M = 1.45$ ;  $SD = 1.63$ ) and for basic loss scores ranged between 0–7 ( $M = 0.66$ ;  $SD = 1.10$ ).

**Trauma History:** Adolescents were asked whether they had ever experienced one of five different types of potentially traumatic events including physical assault, physical abuse, witnessed domestic violence, witnessed community violence, and serious accidents. Behaviorally specific prompts were used for each trauma type, consistent with questions used in the National Survey of Adolescents (NSA; Kilpatrick et al., 2000). In this study, a count of the total number of prior potentially traumatic event types endorsed by each adolescent was used as an index of trauma history severity (Range = 0–5;  $M = 1.03$ ;  $SD = 1.13$ ).

**Social Support:** A modified version of the Social Support for Adolescents Scale (SSAS; Seidman et al., 1995) assessed the extent to which adolescents could turn to their mothers, fathers, siblings, close friends, and peers for 1) emotional social support (“talking about a



personal problem”); 2) instrumental social support (“money and other things”); and 3) recreational social support (“have fun with”). Responses were made on a 3-point Likert scale ranging from “Not at all” to “A great deal.” Higher scores indicated higher levels of social support. Scores were summed across relationships and averaged across types of social support to form a global social support scale. Total scores ranged between 1.67 and 10 in the present study ( $M=7.09$ ;  $SD=1.64$ ). Reliability estimates for the 15-item measure were acceptable ( $\alpha=.80$ ) and consistent with past research (Birman, Trickett, & Vinokurov, 2002).

**Posttraumatic Stress Disorder (PTSD):** The National Survey of Adolescents-Replication PTSD module (Resnick, Kilpatrick, Dansky, Saunders, & Best, 1993) was used to assess the 17 *DSM-IV* symptom criteria for PTSD. Symptom criteria were scored dichotomously as present or absent during the adolescent’s lifetime. PTSD scores were represented dimensionally in the present study (Range 0–17;  $M = 3.38$ ;  $SD = 3.87$ ). Consistent with previous research (Kilpatrick et al., 1998), the present study demonstrated acceptable internal reliability ( $\alpha = 0.88$ ).

**Major Depressive Disorder (MDE):** The NSA-R depression module (Resnick et al., 1993) was used to assess the 9 *DSM-IV* symptom criteria for MDE. Symptom criteria were scored dichotomously as present or absent and assessed since the time of the tornado ( $M = 8$  months). Total scores were dichotomous with adolescents either having depression or not.

Past research has provided support for the reliability and concurrent validity of this measure as a diagnostic tool for MDE (Kilpatrick, Ruggiero, Acierno, Saunders, Resnick, & Best, 2003).

### Adults

**Disaster-Related Stressors:** Individuals were asked several questions about their experiences during and after the hurricane. We assessed property damage (i.e., damage to furniture, sentimental possessions, vehicles, pet, or crops) and loss of services (i.e., water, electricity, clean clothing, food, and telephone service). Responses to all questions were dichotomized (0=no, 1=yes), and the variable was a counting variable, with higher scores indicating elevated levels of impact from the tornado. For property damage scores ranged between 0–5 ( $M= 0.80$ ;  $SD=0.84$ ) and for basic loss scores ranged between 0–5 ( $M=0.61$ ;  $SD=0.95$ ).

**Trauma History:** A slightly modified version of the National Women’s Study Event History-PTSD module (Kilpatrick, Resnick, Saunders, & Best, 1989) was used to identify exposure to potentially traumatic events. Participants were asked if they were ever exposed to and feared death or serious injury during these events: 1) prior natural disasters, 2) serious accidents at work or in a car, 3) being physically attacked with a gun, knife, or other weapon, 4) being attacked without a weapon but with the intent to kill or seriously injure, 5) being in military combat. The number of different events was summed to form a count of different events experienced by the individuals ( $M = 0.6$ ,  $SD = 0.9$ ). Past research demonstrates that this is a reliable and valid measure of prior trauma (Resnick et al., 1993).

**Social Support:** Social support was assessed through a modified version of the Medical Outcomes Study (MOS) module (Sherbourne & Stewart, 1991). Five measures mapped on to three aspects of social support: *emotional* (e.g., “someone available to love you and make you feel wanted”), *instrumental* (e.g., “someone available to help you if you were confined to bed”), and *appraisal* (e.g., “someone available to give good advice in a crisis”). Answers for each of the five questions ranged on a 4-point scale from “none of the time” to “all of the time” (sample range: 0–20;  $M = 15.9$ ,  $SD = 4.8$ ). Consistent with past research (Sherbourne & Stewart, 1991), the present study found acceptable internal consistency for this measure ( $\alpha = .80$ ).

**Posttraumatic Stress Disorder (PTSD):** The 17 PTSD symptoms were assessed across the lifetime using the National Women’s Study PTSD module (Kilpatrick et al., 1989). Each symptom represented a dichotomous answer in which individuals answered “yes” or “no.” PTSD scores were represented dimensionally in the present study (Range 0–17;  $M = 1.6$ ;  $SD = 2.8$ ). Consistent with previous research (Resnick et al., 1993), the present study demonstrated acceptable internal reliability ( $\alpha = .79$ ).

**Major Depressive Disorder (MDE):** 10 symptoms of depression occurring since the hurricane through structured interview questions modified from the SCID-IV. These questions targeted depression criteria using yes/no response formats for each *DSM-IV* symptom. Total scores were dichotomized between having depression or not. Utilizing the SCID-IV is a common way of assessing depression diagnostic criteria (First, Spitzer, Gibbon, & Williams, 2012).

## Data Analysis

Receiver Operating Characteristic (ROC) analyses followed recommendations by Youngstrom (2014). Areas under the curve (AUC) analyses quantified how well each predictor classified depression diagnoses (i.e., sensitivity) and identified cases that did not have depression (i.e., specificity). Per Swet’s (1988) recommendations, AUC values above .70 were deemed adequate predictors of depression status. Hanley and McNeil’s (1983) test of dependent AUCs tested which indicator had the best predictive accuracy for depression diagnoses. For the most discriminating indicators, we created multilevel diagnostic likelihood ratios based on tertiles (Straus et al., 2011). DLRs less than 1 indicate that corresponding predictor scores are *less* likely to lead to a diagnosis of depression. For DLR scores between 0.10 and 0.25, one can be “moderately certain” that the person does not have a depression diagnosis in most settings (Straus et al., 2011). Scores above 1 indicate an increased risk for depression diagnosis.

## Results

Correlations between relevant demographic variables and indicator variables are presented in Table 1. With regard to depression diagnoses, 7.9% ( $N = 157$ ) of the adolescent sample and 4.9% ( $N = 75$ ) of the adult sample met criteria for a depression diagnosis, exceeding the minimum number of 20 cases recommended by Kraemer (1992) when estimating diagnostic efficiency parameters. Additional correlation analyses showed the adolescent girls ( $r = .09$ ,  $p$



< .01) and older adolescents ( $r = .05, p = .04$ ) were more likely to present with depression, as were younger adults ( $r = .07, p < .01$ ). AUC statistics are presented in Table 2, along with corresponding *Cohen's d* scores. For adolescents, social support and trauma history exerted a “medium” effect on depression diagnosis, while lifetime PTSD symptoms exerted a “very large effect” (Cohen, 1988). For adults, social support exerted a “large effect” and lifetime PTSD symptoms exerted a “very large effect.” Of note, for adolescents, two predictors—basic loss and property damage—included the null hypothesis (0.50) within the confidence interval; for adults, only basic loss contained the null hypothesis in its estimate. Findings that include the null hypothesis suggest that these variables fared no better than chance in predicting depression outcomes in adolescents and adults, respectively, and were eliminated from subsequent analyses.

Next, we tested whether specific indicators were superior to each other in predicting depression outcomes both within and between adolescents and adults (Hanley & McNeil, 1983). Within adolescents, pairwise comparisons were made between social support, trauma history, and lifetime history of PTSD symptoms. Given the number of independent analyses, our  $p$  value was set to .01 prior to analyses. Results demonstrated that having lifetime PTSD served as a better indicator for depression than both social support ( $z = 11.93, p < .001$ ) and trauma history ( $z = 13.72, p < .001$ ). Meanwhile, social support and trauma history were equivalent predictors ( $z = -.21, p = .83$ ). Within adults, lifetime history of PTSD was also a better indicator of depression status compared to trauma history ( $z = 8.07, p < .001$ ), social support ( $z = 5.01, p < .001$ ), and property damage ( $z = 8.11, p < .001$ ). Social support was a stronger predictor than both property damage ( $z = 3.06, p = .002$ ) and trauma history ( $z = 2.91, p = .003$ ), and trauma history and property damage were equivalent predictors of depression ( $z = .18, p = .88$ ). Our final set of pairwise comparisons concentrated on whether the three significant predictors of depression (social support, trauma history, and PTSD) shared by both samples differed in strength between adolescents and adults. Findings suggested that lifetime PTSD ( $z = 2.78, p < .01$ ) and trauma history ( $z = 3.14, p < .001$ ) were stronger indicators for depression in adolescents, while social support ( $z = .50, p = .61$ ) was equivalent between the two samples.

We next calculated diagnostic likelihood ratios (DLR) to understand the clinical impact at different levels of the each predictor variable. DLRs across all significant indicators can be found in Table 3. Findings suggested that the upper third of scores on each indicator variable conveyed significantly increased likelihood of depression (lower scores for social support indicate greater vulnerability). Meanwhile, the middle third of scores either conveyed no additional risk compared to the rest of the population (e.g., with DLRs ranging between 0.75–1.00) or near certainty that the individual will not develop a depression diagnosis following a natural disaster (e.g., possessing 1–2 lifetime PTSD symptoms). As for the lowest third, across all indicators these scores suggested “moderate certainty” (Strauss et al., 2011) that these individuals do not have depression. Finally, DLR scores were converted into posterior probability values using Youngstrom’s (2014) online calculator. Given that sex and age for adolescents, and age for adults were significantly related to depression diagnoses, these respective variables were dichotomized (via median split for age) and probabilities for these constructs were calculated independently. As shown in Table 4, adolescents and adults

were approximately twice as likely to develop depression possessing an “at-risk” score across relevant constructs.

## Discussion

Routine depression screening is now recognized as an important public health goal, especially in vulnerable populations, and even when interventions may not be readily available (USPTF, 2016). Extensive research demonstrates that both adolescents and adults are vulnerable to depression following a natural disaster (Bonanno et al., 2010) and that post-disaster, depressed-presentations may be more severe and functionally impairing compared to a PTSD response (Cao et al., 2015). In sum, we found that individual characteristics, as opposed to disaster-related stressors, better forecasted depression outcomes in both adolescents and adults. More specifically, impaired post-disaster social support and previous PTSD symptoms were strong indicators of post-disaster depression in both adolescents and adults, and adolescents were more sensitive to pre-existing PTSD and prior traumas compared to adults. These results provide the foundation for a coherent set of recommendations for how to screen for depression in both adolescents and adults following a natural disaster.

Findings from the present study help to synthesize the post-disaster depression literature. In a recent meta-analysis, Tang and colleagues (2014) identified 16 individual and disaster-related constructs related to post-disaster depression outcomes. The present study builds on this review by illustrating which of these constructs may be most important to screen for following a natural disaster. Specifically, lifetime PTSD symptoms conveyed the greatest risk for depression in both adolescents and adults. This is consistent with other trauma-related findings that demonstrated pre-combat PTSD uniquely forecasted depression in military veterans (Stander et al., 2014). Social support and trauma history (especially in adolescents) also emerged as significant indicators of depression status since the natural disaster. Meanwhile, property damage, the only disaster-related stressor that predicted depression status, was only significant in adults and represented an inferior proxy compared to other indicators.

Our finding that individual-level factors conveyed greater depression risk in both adolescents and adults adds to the growing literature which demonstrates unique risk profiles for depression and PTSD following a disaster (Galea et al., 2008; Miguel-Tobal et al., 2006; Tracy et al., 2011). In contextualizing their findings, Tracy and colleagues (2011) concluded that PTSD is more likely to be connected to facets of the actual disaster (e.g., “felt trapped during the storm”), whereas depression may be more closely linked to post-disaster stressors, such as relocation. However, even post-disaster stressors such as property damage or basic loss did not confer risk for depression in adolescents, and property damage served as a relatively weak indicator in adults. Therefore, post-disaster stressors, such as relocation (e.g., Kilic et al., 2006), may only forecast depression if it significantly impacts one’s social support, or activates another individual-level indicator.

Trauma history and lifetime mental health were stronger indicators of depression-risk in adolescents compared to adults. Recent research suggests that adolescents may have even

greater risk for emotional distress following a natural disaster compared to adults (Bonanno et al., 2010) and younger children (Thienkrua et al., 2006). One possible reason is that adolescence represents a critical period with regard to depression due to several constructs, including the emergence of cognitive vulnerabilities (Abela & Hankin, 2008). Recent research suggests that certain cognitive processes, such as rumination, may be especially deleterious in adolescence (Sutterlin, Paap, Babic, Kubler, & Vogege, 2012). Thus, trauma history and lifetime mental health may be especially strong indicators of post-disaster depression symptomatology in adolescents because stressors associated with natural disasters may trigger negative cognitions about the past. Depression screening following a natural disaster should not only prioritize adolescents, but ask specific questions concerning lifetime mental health and trauma history to best understand current functioning and subsequent risk.

Due to the post-disaster context, having an efficient and accurate way to assess depression is of critical importance. Current recommendations state that initial steps should include questions about the disaster's events and related-stressors in order to best understand that individual's risk for emotional distress (North & Pfefferbaum, 2013). However, our results suggest this information may be less relevant compared to individual-related processes when assessing for depression. Most current post-disaster symptom screeners focus on symptoms (e.g., Boscarino, Kirchner, Hoffman, Sartorius, Adams, & Figley, 2012), but it is recommended that screeners including psychosocial factors such as social support may be more effective in screening for emotional distress in vulnerable populations (O'Donnell et al., 2008; Schetter & Tanner, 2012). The present study recommends that social support, trauma history (especially in adolescents), or lifetime PTSD may serve as beneficial screening items for both adult and adolescent depression following a natural disaster.

Findings concerning trauma history and lifetime PTSD symptoms provide perhaps the clearest guidelines to health and community health workers. For both adolescents and adults, having experienced 2 or more traumatic events prior to the natural disaster was associated with an approximate two-fold increase in depression-risk. Similarly, if adolescents experienced at least two symptoms of PTSD in the past, and adults experienced 3 or more PTSD symptoms, then they were twice as likely to be diagnosed with depression. Within Youngstrom's model (2014) for EBA, individuals with these vulnerable scores should be referred for mental health services. Although the nature of perceived social support prevents equally clear and translatable cutoff points from emerging, its significance in forecasting depression is noteworthy. In the months, and even years, following a natural disaster the healthcare system may be overwhelmed with the needs of an impacted community. Therefore, non-traditional providers may be responsible for assessing and monitoring mental health following a natural disaster (Bonanno et al., 2010). Thus, social support may serve as a useful, less-sensitive proxy for depression that can allow non-traditional health providers to facilitate the screening and triaging process. Current efforts to standardize social health questionnaires across health settings (Hahn et al., 2014) may help future studies to establish EBA-based cutoffs that can be equally easy to interpret and translate across disaster settings.

Our study should be considered within the context of noteworthy limitations. First, the present study focused on multiple natural disasters that occurred in different geographic

regions. Although past research has not identified consistent differences in mental health outcomes across different forms of natural disasters (e.g., tornados versus hurricanes; Briere & Elliot, 2000) other geographic or temporal factors unrelated to development may have influenced our results. Future studies should aim to replicate our findings within a sample that includes both youth and adults. Second, our study also focused solely on self-report measures of distress, leaving open the possibility of bias. More objective measures of functioning and/or disaster-related stressors may accurately detect new indicators of depression following a natural disaster. Third, analyses for our study were based on previously collected epidemiological datasets. While these studies allowed us to test our hypotheses in a large overall sample ( $N = 3,543$ ), it did limit our ability to include additional relevant disaster-related stressors and individual-level processes. For instance, despite the important influence socioeconomic status (SES) may have on the emergence of post-disaster emotional distress (Tracy et al., 2011), the methods used between the two studies were not adequate enough to thoroughly test the influence of SES on depression.

Finally, our findings were based on studies that assessed depression status approximately 6–12 months following the natural disaster. Although we assessed for symptoms since the natural disasters, it is possible that the delay in assessment resulted in different reports of functioning and impact than in the immediate aftermath of the disasters. Relatedly, only having post-disaster assessments limited our ability to make inferences concerning pre-disaster functioning. This is in part the reason we did not include lifetime depression symptoms as an indicator in our models, as we could not ensure that it would not overlap with our criterion variable of post-disaster depression. Therefore, social support, trauma history, and lifetime PTSD symptoms should be contextualized as indicators of post-disaster depression risk based on the present study's methods and not vulnerability factors for disaster outcomes.

The present study represents an important step towards generating practical, precision-medicine guidelines for workers tasked with triaging natural disaster survivors in an efficient, cost-effective manner. Pending replication of our results with assessments closer in proximity to a natural disaster, our findings can be translated into a structured public health response following a natural disaster. Recent research has identified both adaptive and maladaptive long-term patterns of post-disaster mental health and these response styles differ for youth and adults (Bonanno et al., 2010; Cao et al., 2015 La Greca, Lai, et al., 2013). To the authors' knowledge, no screening procedures for these different trajectory styles currently exist. However, with the development of ROC procedures for prospective data (Pepe et al., 2008), this represents a logical extension of the present study, and can further bridge the gap between basic vulnerability research and applied, post-disaster mental health intervention/prevention programming.

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### Highlights

- Individual-level processes (e.g., social support) are indicators for depression.
- Disaster-level processes were inferior indicators for post-disaster depression.
- Adolescents were more sensitive to individual-level processes compared to adults.
- Evidence-based assessment cutoff scores are provided for each significant indicator.

**Table 1**

Correlations between adolescent and adult variables.

| Variables          | 1      | 2      | 3      | 4      | 5      | 6     | 7 |
|--------------------|--------|--------|--------|--------|--------|-------|---|
| <i>Adolescents</i> |        |        |        |        |        |       |   |
| 1) Lifetime PTSD   |        |        |        |        |        |       |   |
| 2) Trauma History  | .50**  |        |        |        |        |       |   |
| 3) Social Support  | -.33** | -.21** |        |        |        |       |   |
| 4) Property        | .02    | .04*   | -.04   |        |        |       |   |
| 5) Basic Loss      | .02    | .03    | -.01   | .53**  |        |       |   |
| 6) Sex             | -.10** | .13**  | -.02   | -.02   | -.01   |       |   |
| 7) Age             | .08**  | .11**  | .00    | .01    | .01    | -.05* |   |
| <i>Adults</i>      |        |        |        |        |        |       |   |
| 1) Lifetime PTSD   |        |        |        |        |        |       |   |
| 2) Trauma History  | .31**  |        |        |        |        |       |   |
| 3) Social Support  | -.29** | -.04   |        |        |        |       |   |
| 4) Property        | .20**  | .10**  | -.04   |        |        |       |   |
| 5) Basic Loss      | .15**  | .01    | -.07** | .40**  |        |       |   |
| 6) Sex             | -.07** | .28**  | .00    | -.08** | .01    |       |   |
| 7) Age             | -.15** | -.13** | -.05   | -.09** | -.16** | .05   |   |

*Note: Adolescents:* Lifetime PTSD = National Survey of Adolescents-Replication (NSA-R), Lifetime PTSD module; Trauma History = NSA-R, Trauma Module; Social Support = Social Support for Adolescents Scale (SSAS); Property = Property damage counting variable. Basic Loss = Basic Loss counting variable. Sex: (Female = 0; Male = 1). **Adults:** PTSD History = National Women's Survey (NWS)-PTSD Module; Trauma History = National Women's Survey Event History (NWS-EH)-Trauma module; Social Support = Medical Outcomes Study (MOS)-Social Support Module; Property = Property damage counting variable. Basic Loss = Basic Loss counting variable. Sex: (Female = 0; Male = 1).

\* < .05,

\*\* < .01.

**Table 2**

Adolescent and adult area under the curve (AUC) summary statistics

| Measures       | Adolescent Sample |          | Adult Sample         |          |
|----------------|-------------------|----------|----------------------|----------|
|                | AUC               | CI       | AUC                  | CI       |
| Basic Loss     | .52               | .48, .58 | .57                  | .49, .64 |
| Property       | .51               | .47, .56 | .59*                 | .52, .65 |
| Social Support | .71**             | .66, .75 | .73**                | .67, .79 |
| Trauma History | .71**             | .69, .75 | .78 <sup>###</sup>   | .53, .66 |
| Lifetime PTSD  | .94**             | .93, .95 | 2.20 <sup>####</sup> | .86, .92 |

Note: AUC = Area under the Curve; CI = Confidence Interval; Cohen's *d* = effect size; Basic Loss = Basic loss counting variable. Property = Property damage counting variable. Social Support = SSAS (Adolescents), MOS-Social Support Module (Adults); Trauma History = NSA-R, Trauma Module (Adolescents), NSWEH-Trauma Module (Adults); Lifetime PTSD = NSA-R, Lifetime PTSD Module (Adolescents); NWS-PTSD Module (Adults).

\*\*  $p < .01$ ;

<sup>#</sup> = small effect,

<sup>##</sup> = medium effect,

<sup>###</sup> = large effect,

<sup>####</sup> = very large effect.

Table 3

Diagnostic Likelihood Ratios (DLR) for adolescents and adults.

|                    |                | Low Risk         | Medium Risk  | High Risk   |
|--------------------|----------------|------------------|--------------|-------------|
| <b>Adolescents</b> | Lifetime PTSD  | Score 0 Symptoms | 1–2 Symptoms | 3+ Symptoms |
|                    |                | DLR 0.00         | 0.00         | 2.01        |
|                    | Trauma History | Score 0 PTEs     | 1 PTEs       | 2+ PTEs     |
|                    |                | DLR 0.36         | 0.83         | 2.31        |
|                    | Social Support | Score 8.01+      | 6.34–8.00    | 0–6.33      |
|                    |                | DLR 0.39         | 0.79         | 2.23        |
|                    | Lifetime PTSD  | Score 0 Symptoms | 1–2 Symptoms | 3+ Symptoms |
|                    |                | DLR 0.00         | 0.13         | 2.41        |
|                    | Trauma History | Score 0 PTEs     | 1 PTEs       | 2+ PTEs     |
|                    | DLR 0.65       | 0.97             | 1.40         |             |
| Social Support     | Score 20+      | 16–19            | 0–14         |             |
|                    | DLR 0.22       | 0.75             | 1.99         |             |
| Property Damage    | Score 0        | 1                | 2+           |             |
|                    | DLR 0.72       | 1.02             | 1.73         |             |

Note: **Adolescents:** Lifetime PTSD = NSA-R, Lifetime PTSD module; Trauma History = NSA-R, Trauma Module; Social Support = SSAS; **Adult:** Lifetime PTSD = NWS-PTSD Module; Trauma History = NWSEH-Trauma module; Social Support = MOS-Social Support Module; Property Damage = Property damage counting variable.



Table 4

Probabilities based on Diagnostic Likelihood Ratios

|                        | Prior Probability | DLR  | Posterior Probability | Level |
|------------------------|-------------------|------|-----------------------|-------|
| <b>PTSD History</b>    | 7.5%              | 2.01 | 14%                   | .54   |
| Girls                  | 10.3%             |      | 19%                   |       |
| Boys                   | 5.6%              |      | 11%                   |       |
| Young Adolescents      | 6.8%              |      | 13%                   |       |
| Old Adolescents        | 8.9%              |      | 17%                   |       |
| <b>Trauma History</b>  | 7.5%              | 2.31 | 16%                   | .33   |
| Girls                  | 10.3%             |      | 20%                   |       |
| Boys                   | 5.6%              |      | 13%                   |       |
| Young Adolescents      | 6.8%              |      | 14%                   |       |
| Older Adolescents      | 8.9%              |      | 18%                   |       |
| <b>Social Support</b>  | 7.5%              | 2.23 | 15%                   | .53   |
| Girls                  | 10.3%             |      | 20%                   |       |
| Boys                   | 5.6%              |      | 12%                   |       |
| Young Adolescents      | 6.8%              |      | 14%                   |       |
| Older Adolescents      | 8.9%              |      | 18%                   |       |
| <b>PTSD History</b>    | 4.9%              | 2.41 | 11%                   | .53   |
| Young Adults           | 7.5%              |      | 16%                   |       |
| Old Adults             | 3.9%              |      | 9%                    |       |
| <b>Trauma History</b>  | 4.9%              | 1.40 | 7%                    | .35   |
| Younger Adults         | 7.5%              |      | 10%                   |       |
| Older Adults           | 3.9%              |      | 5%                    |       |
| <b>Social Support</b>  | 4.9%              | 1.99 | 9%                    | .46   |
| Younger Adults         | 7.5%              |      | 14%                   |       |
| Older Adults           | 3.9%              |      | 8%                    |       |
| <b>Property Damage</b> | 4.9%              | 1.73 | 8%                    | .17   |
| Younger Adults         | 7.5%              |      | 12%                   |       |
| Older Adults           | 3.9%              |      | 7%                    |       |

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Note: Prior Probability = Chance of having depression without knowledge of indicator; Posterior Probability = Chance of having depression given vulnerable score on that indicator. Level = Percentage of cases scoring at or above a given diagnostic threshold. **Adolescents:** PTSD History = NSA-R, Lifetime PTSD module; Young = Ages 12–14; Old = Ages 15–17; Trauma History = NSA-R, Trauma Module; Social Support = SSAS; **Adult:** PTSD History = NWS-PTSD Module; Young = Ages 18–16; Old = > 65 years old; Trauma = NWS-PTSD module; Social Support = MOS-Social Support Module; Property Damage = Property damage counting variable.