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Comorbidity of PTSD, Major Depression, and Substance Use Disorder among Adolescent Victims of the Spring 2011 Tornadoes in Alabama and Joplin, Missouri

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Abstract

Objective—The purpose of this study was two-fold: (1) to estimate the prevalence of comorbid posttraumatic stress disorder (PTSD), major depressive episode (MDE), and substance use disorder (SUD), and (2) to identify risk factors for patterns of comorbidity among adolescents affected by disasters.

Method—A population-based sample of 2,000 adolescents (51% female; 71% Caucasian, 26% African-American) aged 12–17 years (M=14.5, SD=1.7) and their parents was recruited from communities affected by the Spring 2011 tornadoes in Alabama and Joplin, Missouri. Participants completed structured telephone interviews assessing demographic characteristics, impact of disaster, prior trauma history, DSM-IV symptoms of PTSD and MDE, and SUD symptoms. Prevalence estimates were calculated for PTSD+MDE, PTSD+SUD, MDE+SUD, and PTSD +MDE+SUD. Hierarchical logistic regression was used to identify risk factors for each comorbidity profile.

Results—Overall prevalence since the tornado was 3.7% for PTSD+MDE, 1.1% for PTSD +SUD, 1.0% for MDE+SUD, and 0.7% for PTSD+MDE+SUD. Girls were significantly more likely than boys to meet criteria for PTSD+MDE and MDE+SUD (*p*s < .05). Female gender, exposure to prior traumatic events, and persistent loss of services were significant risk factors for patterns of comorbidity. Parental injury was associated with elevated risk for PTSD+MDE.

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Adolescents should be evaluated for comorbid problems, including SUD, following disasters so that appropriate referrals to evidence-based treatments can be made.

Conclusions—Results suggest that screening procedures to identify adolescents at risk for comorbid disorders should assess demographic characteristics (gender), impact of the disaster on the family, and adolescents' prior history of stressful events.

Prevalence and Predictors of Post-Disaster Psychiatric Problems

Many individuals struggle with psychiatric problems such as posttraumatic stress disorder (PTSD), depression, and substance use disorders (SUD) following disasters (Norris et al., 2002). Few studies have addressed prevalence and predictors of co-occurring problems in adolescents, however. Norris et al. (2002) examined consequences of disaster exposure among over 60,000 participants drawn from over 160 samples, and found nearly 40% showed severe or very severe impairment, defined as clinically significant distress or meeting diagnostic criteria for one or more psychiatric disorders. Few studies addressed adolescent post-disaster mental health, but initial evidence for developmental differences emerged. Youth had higher risk than adults for developing disaster-related psychiatric problems, including PTSD, underscoring the need for more research on adolescent post-disaster mental health.

Contributors to post-disaster functioning include multiple influences across multiple levels of a person's ecology (Norris et al., 2002; Weems & Overstreet, 2008). *Individual-level* factors include female gender; ethnic minority status; poverty; sustaining personal injury or severe threat to life; living in a highly disrupted community; high levels of secondary stress; pre-disaster psychiatric problems; interpersonal conflict; poor coping; and poor social resources. *Event-level* factors consist of extreme, widespread damage; serious, ongoing financial hardship for the community; and high injury and fatality rates. Furr et al. (2010) conducted a meta-analytic review of the association between disaster exposure and PTSD symptoms in youth and found that female gender, higher death toll, closer disaster proximity, greater personal loss, higher perceived threat of harm, and higher distress all related to greater PTSD symptoms. Additional research supports female gender, fear for one's own safety or the safety of loved ones, and prior trauma exposure as important predictors of psychiatric problems following a range of disasters (Fan et al., 2011; La Greca et al., 2013). The influence of age on post-disaster psychiatric outcomes is also commonly evaluated, but findings are mixed, partly due to insufficient sample sizes to examine age effects (Norris et al., 2002). Whereas Furr et al. (2010) found no age effect on PTSD symptoms, recent studies in adolescent samples report higher levels of PTSD (Fan et al., 2010) and depression (Adams et al., 2014; Fan et al., 2010) among older versus younger adolescents. Considered together, prior research supports evaluation of multiple sources of influence in predicting adolescent, post-disaster psychopathology.

Patterns of Psychiatric Comorbidity after Disasters

Trauma-exposed youth often demonstrate multiple psychiatric problems beyond PTSD (Danielson et al., 2010). Findings from a national sample of adolescents indicate 26% of youth with PTSD and 38% of those with depression also met criteria for SUD; patterns of

comorbidity were strongly associated with greater trauma exposure (Kilpatrick et al., 2003). Despite evidence that comorbidities are associated with more severe, impairing, and persistent symptoms than single diagnoses in community samples of adolescents (Roberts, Roberts, & Xing, 2007) and disaster-exposed children (Lai et al., 2012), few studies describe comorbidity patterns among disaster-affected adolescents. Disaster mental health comorbidity research is largely limited to PTSD and depression; with prevalence estimates around 10% in youth samples across disaster types (e.g., hurricanes, earthquakes, cyclones; Fan et al., 2011; Kar & Bastia, 2006; Lai et al., 2012). Parallel to adult disaster samples (Başoglu et al., 2004), initial evidence among adolescents suggests that comorbidity differs by gender, with higher estimated comorbidity in girls (10.5%) than boys (6.5%; Fan et al., 2011). Notable methodological limitations of prior research include: focus on PTSD to the exclusion of comorbidities; use of purposive or convenience sampling; exclusion of caregiver reports; and insufficient power to examine predictors of psychiatric outcomes (Furr et al, 2010).

Understanding Comorbidity

As comorbidity confers more negative health consequences than a single mental disorder (Kar & Bastia, 2006; Roberts et al., 2007), it is important to identify factors that increase the likelihood of comorbid internalizing distress and SUD. The preponderance of evidence suggests internalizing problems typically predate and increase risk for SUD (Couwenbergh et al., 2006; O'Neil et al., 2011). Individual-level factors—(e.g., gender, ethnic disparities; Couwenbergh et al., 2006; Kilpatrick et al., 2003; O'Neil et al., 2011)—may also serve as transdiagnostic risk factors and underlie both substance use and emotional distress. Environmental, or contextual-level, factors, such as major life stressors and past trauma experiences, also confer risk for comorbid SUD and internalizing disorders (e.g., Cloitre et al., 2009; de Graaf et al., 2002; Kilpatrick et al., 2003). Thus, youths' prior history of exposure to disasters or other traumatic events may predict post-disaster comorbidities. Specifically, level of disaster impact appears to moderate risk for comorbid PTSD +depression, with more severe impact associated with higher likelihood of comorbidity (Goenjian et al., 2001; Lai et al., 2012).

The Present Study

Most prior research on prevalence and predictors of post-disaster psychiatric problems focuses on single psychiatric disorders and does not examine demographic and event characteristics as contributors to risk. The focus of this study was to estimate prevalence of *comorbid* PTSD, depression, and substance abuse in a large, population-based sample of adolescents exposed to a major natural disaster, namely tornadoes that struck Alabama and Joplin, MO during Spring 2011. We used a novel address-based sampling procedure to maximize the sample's generalizability to the population of families exposed to the tornadoes. Few studies have investigated tornado survivors despite the common frequency, high degree of destruction, and unpredictability of that disaster type compared to others (Adams et al., 2014). Prevalence and examination of risk factors for single-diagnosis PTSD and MDE in this sample have been published elsewhere (Adams et al., 2014).

To our knowledge, this is the first study to examine comorbid PTSD, depression, and substance abuse in a population-based, tornado-exposed adolescent sample. We had several hypotheses based on theory and prior research. First, we predicted that comorbid PTSD +depression would be as common as PTSD or depression alone and more common than the comorbidity of either PTSD+SUD or depression+SUD. Second, given the variety of influences on youth functioning post-disaster, we investigated risk and resilience factors across individual, family, and event levels of analysis (La Greca et al., 1996; Weems & Overstreet, 2008). Consistent with prior research among disaster-affected adults and research on trauma-exposed adolescents (Danielson et al., 2010), we predicted that female gender and greater disaster impact would be associated with higher likelihood of comorbidity relative to single diagnoses. We predicted that older age would be associated with higher likelihood of comorbidity given patterns observed in general community samples (e.g., Kilpatrick et al., 2003) and disaster-exposed samples of youth (Adams et al., 2014).

Method

Context

Spring 2011 was the fourth deadliest and costliest tornado outbreak in US history. Overall, 1,706 confirmed tornadoes touched down, resulting in 552 confirmed fatalities and approximately $14 billion in damages (NOAA, 2011, 2013). The deadliest storms were the 109 confirmed tornadoes between April 25–28 (339 fatalities) across the Southern U.S. (NOAA, 2011). On May 22, a 1-mile wide EF-5 tornado struck Joplin, Missouri, resulting in 161 casualties and $2.2 billion in insurance payouts (NOAA, 2011, 2013).

Procedure

Two thousand families were recruited from affected areas. A highly targeted address-based sampling strategy was used to facilitate recruitment of cell-phone-only households and to minimize the number of unaffected households recruited (Henderson et al., 2012). NOAA (2011) tornado track latitude/longitude coordinates were used to define surrounding radii of potential addresses to ensure households in the identified sampling area were affected by the tornadoes. We then identified household addresses within our targeted geographic zone with a matching landline telephone (matched sample). Household addresses without identifiable matched landline numbers (unmatched sample; mostly cell-phone-only) were mailed a letter that explained the study, provided a screening questionnaire, and a telephone number was requested. Respondents who returned questionnaires received $5 regardless of eligibility. Households in the resulting recruitment pools were contacted to assess study eligibility.

Eligible caregivers resided at their address when the tornado occurred, were legal guardian of an adolescent aged 12 to 17 years, and had reliable home Internet access. The last criterion did not have a major effect on recruitment, consistent with data that 95% of adolescents use the Internet and 93% have household computer access (Madden et al., 2013). Highly trained professional interviewers at Abt SRBI (New York, NY)—a survey research firm with extensive experience conducting large-scale epidemiologic surveys on sensitive topics such as mental health, substance use, and victimization—conducted the

structured interviews. Computer-assisted telephone interview (CATI) technology was used to promote standardized administration, minimize respondent fatigue, and increase respondent adherence. CATI methods also increase detection of sensitive incidents (Cantor & Lynch, 2000). Interviewers obtained informed consent from participants. In homes with multiple eligible caregivers or adolescents, the most recent birthday method was used to select participants. Adolescent-caregiver dyads completed interviews between September 2011 and June 2012, on average 8.8 months after tornado exposure [*SD*=2.6; range=4.0–13.5]. This delay between tornadoes and assessments ensured ample time for restoration of electricity, telephone, and Internet services. Adolescents were asked whether they were in a safe place to talk before interviewers proceeded with questions. Questions were worded to require closed-ended responses (i.e., yes/no) to encourage honest responses from adolescents and promote privacy in case someone else in the home could overhear their responses. Interviews lasted approximately 25 minutes. Households that completed interviews were mailed a $15 incentive. The overall cooperation rate, calculated according to the American Association for Public Opinion Research standards (i.e., [number screened] divided by [number screened + screen-outs + unknown eligibility]), was 61%. The study was conducted in compliance with the authors' Institutional Review Board.

Participants

Sample demographic characteristics are summarized in Table 1. Nearly 25% of families reported annual household incomes below the poverty threshold for a family of four based on 2012 U.S. Census data. Data were weighted to ensure sample demographic distributions were consistent with regional Census estimates.

Measures

Disaster exposure and impact variables—Caregivers were viewed as more reliable reporters than adolescents of the storms' impact on the household. Caregivers were asked whether they: (1) were present when the tornado hit; (2) sustained any physical injuries; (3) were concerned about the safety or whereabouts of loved ones; and (4) were displaced from their home (and for how long). Caregivers were asked about damage caused by the tornado to their homes, vehicles, furniture, personal items, and pets. A count of the different types of *property damage* incurred was used as a predictor in the analysis (Cronbach's alpha=.75). Caregivers were asked whether they were without basic services (water, electricity, clean clothing, food, shelter, transportation, and spending money) for a period of greater than one week. A count of the number of *lost services* was used as a predictor in the analysis (Cronbach's alpha=.67). *Time since tornado* was defined as time (in months) between the date of the tornado and the date of assessment. Impact characteristics were entered individually as predictors in analyses.

Prior exposure to natural disasters—Adolescents were asked whether they had ever experienced another natural disaster prior to the most recent tornado (1=yes, 0=no).

Other potentially traumatic experiences—Adolescents were asked whether they had ever experienced each 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 (Kilpatrick et al., 2003). A count of prior event types endorsed was used as an index of prior trauma history severity.

PTSD—Adolescent PTSD was assessed using the NSA-PTSD module (Kilpatrick et al., 2003). This fully-structured interview assessed DSM-IV (American Psychiatric Association, 2000) symptom criteria for PTSD. Participants were asked whether they had experienced each symptom for a period of two weeks or longer. Participants were asked the last time they experienced endorsed symptoms (ever in their lifetimes, since the tornado, in the past 4 weeks). Participants were coded as positive for PTSD if they endorsed enough symptoms to meet criteria for PTSD during the time period since the tornado (Cronbach's alpha=.87). Research on this measure has provided support for reliability and concurrent validity (Kilpatrick et al., 2003; Resnick et al., 1993).

Major Depressive Episode (MDE)—Adolescent MDE was assessed using the NSA-Depression module. This structured diagnostic interview assessed for the presence of each DSM-IV MDE symptom criterion for a period of two weeks or longer. Participants were asked when they last experienced endorsed symptoms (ever in their lifetimes, since the tornado, in the past 4 weeks). Participants were coded as positive if they endorsed enough symptoms to meet criteria for MDE during the time period since the tornado (Cronbach's alpha=.79). Psychometric data support the scale's internal consistency and convergent validity (Boscarino et al., 2006; Kilpatrick et al., 2003).

SUD—Adolescent SUD was assessed using the CRAFFT (Knight et al., 2003), a well-validated 6-item self-report measure of drug and alcohol use disorder symptoms designed for adolescents. The CRAFFT assessed potential substance abuse in the adolescent's lifetime, since the tornado, and in the past four weeks. The scale has adequate internal consistency (Cronbach's alpha=.68) and good validity (Knight et al., 2003). Sensitivity and specificity of the CRAFFT were 0.92 and 0.64, respectively, for a cutoff score of 2 endorsed items (Knight et al., 2003). Participants were classified as meeting criteria for a *probable SUD* if they endorsed two or more CRAFFT items since the tornado.

Comorbid diagnoses—Adolescents were coded as positive for comorbidity (e.g., PTSD +MDE) if they met diagnostic criteria for both disorders during the time period since the tornado. This timeframe was selected given the study's focus on post-disaster psychiatric problems. Comorbidity was restricted to co-occurrence of clinical problems that met or exceeded established diagnostic thresholds. For initial prevalence estimates, an inclusive approach to operationalizing comorbidity was used, whereby participants who met diagnostic criteria for two disorders—regardless of whether they met criteria for any other diagnoses—were counted as cases. For hierarchical logistic regression analyses, an exclusive approach to operationalizing comorbidity was used, because an inclusive approach may have masked predictors of specific combinations. For example, individuals coded as positive for PTSD+MDE met criteria for only those disorders.

Data Analysis

Analyses were performed using SPSS v.22. Prevalence and descriptive statistics are presented for comorbidity profiles using the timeframe since the tornado. We examined whether estimates differed for boys and girls and for adolescents of different ages (12–13, 14–15, 16–17 years). Following the analytic approach used in prior studies on predictors of comorbidity (e.g., Kilpatrick et al., 2003; de Graaf et al., 2002), hierarchical logistic regression was used for analyses investigating risk factors for comorbid disorders. Predictors were entered in three steps: (1) demographics (gender [female=0]; age; race [Caucasian=0]; past-year household income [> $20,000=0]), (2) prior trauma history (prior exposure to a natural disaster, total number of prior potentially traumatic event types), and (3) tornado exposure characteristics (time since tornado, caregiver present for tornado, caregiver injured during tornado, caregiver concerned about safety of others during or after tornado, count of types of property damage from the tornado, count of loss of services and resources from tornado). We first examined which factors were associated with particular combinations of comorbid disorders, where the reference group was defined as youth without that pattern of comorbidity. We then examined which factors were associated with comorbid vs. single or "pure" constituent disorders that composed each comorbidity combination (i.e., PTSD +MDE vs. PTSD; PTSD+MDE vs. MDE). This approach limits comparability of parameter estimates across models due to differences in the reference group, but allows examination of specific predictors of each comorbidity profile, which was a key aim of this study. An alpha level of .05 was set *a priori*. Post hoc power analyses revealed adequate power to detect small effects in the logistic regression models. We examined missing data patterns for all key study variables. Little's (1988) missing completely at random (MCAR) test was used; results suggested data were missing completely at random, $\chi^2(12)=18.66$, $p=.10$.

Results

Sample Characteristics

Adolescent sample characteristics, including demographics and tornado exposure variables, are reported in Table 1.

Prevalence of Comorbid Disorders Following Tornado Exposure

Prevalence estimates and descriptive statistics for comorbid disorders for the full sample, as well as estimates for boys and girls and for adolescents of different ages, are presented in Table 2. Overall, 4.0% of adolescents met criteria for two or more disorders since exposure to the tornado. In comparison, 3.5% met diagnostic criteria for PTSD only (i.e., no MDE, no SUD), 3.2% met criteria for MDE only, and 0.9% met criteria for SUD only.

The most common pattern of comorbidity was PTSD+MDE. Girls were significantly more likely than boys to endorse co-occurring PTSD+MDE and MDE+SUD (Table 2). There were no significant differences between boys and girls in the occurrence of PTSD+SUD or PTSD+MDE+SUD, although estimated prevalence for both comorbidity profiles fell below 1% for both boys and girls.

Adolescents aged 16–17 were more likely than adolescents aged 12–13 or 14–15 to meet criteria for MDE+SUD. There were no other significant differences among age groups for any specific comorbidity profiles.

Separate chi-square analyses were performed within each age group to compare boys and girls on prevalence of each comorbidity profile. Among 12–13-year-olds, girls (5.6%) endorsed a significantly higher occurrence of PTSD+MDE than boys (2.4%), $X^2(1, n=660)=3.90$, $p=.048$, $\varphi=.08$. A similar trend was observed for 14–15-year-olds, whereby girls (4.1%) endorsed a significantly higher rate of PTSD+MDE than boys (1.2%), $X^2(1, n=640)=3.90$, $p=.03$, $\varphi=.09$. No significant gender differences were observed for 16–17-year-old participants for PTSD+MDE. There were no significant gender differences by age group for any other comorbidity profile.

Risk Factors for Post-Tornado Comorbidities

PTSD+MDE—Results of logistic regression analyses to examine risk factors for post-tornado comorbid disorders are summarized in Table 3. Male gender was associated with lower likelihood of PTSD+MDE in the final model (OR=0.47). Although being African American was associated with increased risk of PTSD+MDE in the first step (OR=1.90), this relation was not statistically significant when prior trauma and disaster exposure characteristics were included in the model. No other demographic variables were statistically significant predictors of PTSD+MDE. Prior trauma exposure was positively associated with PTSD+MDE comorbidity (OR=2.51). Whether a caregiver sustained a physical injury was the strongest predictor of PTSD+MDE comorbidity (OR=8.80). Concern for others' safety was also associated with PTSD+MDE (OR=2.45).

PTSD+SUD—The only demographic variable associated with PTSD+SUD comorbidity in the final model was race other than White or African-American (OR=6.87). As with PTSD +MDE, exposure to prior traumatic events was significantly associated with PTSD+SUD (OR=4.01). There was also a significant association for presence at the time the tornado touched down, whereby adolescents whose caregivers reported they were present were at lower risk of PTSD+SUD comorbidity versus not meeting criteria for those diagnoses since the tornado (OR=0.15).

MDE+SUD—Male gender was associated with lower odds of comorbid MDE+SUD since the tornado (OR=0.11). Exposure to prior traumatic events (OR=3.29) was associated with higher odds of meeting diagnostic criteria for MDE+SUD. Presence during the tornado (OR=.15) and the extent of service loss (OR=1.95) were also predictive of MDE+SUD comorbidity.

PTSD+MDE+SUD—No demographic characteristics were associated with PTSD+MDE +SUD comorbidity. Exposure to prior traumatic events (OR=4.78) was significantly associated with greater odds of PTSD+MDE+SUD comorbidity. A significant association was observed between caregiver presence during the tornado and lower odds of PTSD +MDE+SUD (OR=0.05) and loss of services and higher odds of PTSD+MDE+SUD (OR=2.36).

Predictors of Comorbid PTSD+MDE versus PTSD or MDE Only

We were only able to examine differential predictors of comorbid PTSD+MDE *vs.* "pure" PTSD or MDE due to low base rates for the other comorbidity categories. No demographic, trauma history, or disaster characteristic variables differentiated between comorbid PTSD +MDE *vs.* any single disorder (i.e., "pure" cases of either PTSD or MDE alone).

Discussion

This was the first study to examine comorbid psychiatric problems in a large, diverse, population-based sample of adolescents recruited from communities affected by major disasters. The first aim of this study was to examine prevalence of comorbidities among PTSD, depression, and SUD among adolescents affected by the Spring 2011 tornado outbreak. Approximately half of the adolescents who met PTSD criteria since the tornado also met criteria for MDE, SUD, or both. This pattern was comparable to a national community sample (Kilpatrick et al., 2003). The most common comorbidity profile was PTSD+MDE, with nearly 1 in 25 adolescents endorsing both disorders. The overall prevalence of PTSD+MDE in this study was lower than those reported in other studies of disaster-exposed children and adolescents (e.g., Fan et al., 2011; Kar & Bastia, 2006; Lai et al., 2012). For instance, Fan et al. (2011) found that 8.6% of adolescents who survived the 2008 Wenchuan earthquake in China—compared to 4.6% here—reported clinically significant symptoms of both PTSD and depression. A potential cause for this disparity is the scale and impact of the disasters. The Chinese earthquake caused nearly 70,000 deaths, hundreds of thousands of injuries, and left nearly 5 million people homeless. Methodological differences may also account for varied comorbidity estimates across studies. Delayed data collection and recruitment of a population-based sample—rather than a higher-risk sample of clinic-referred or displaced youth—may have led to lower prevalence estimates in this study. Alternatively, lower estimates here might reflect differences in measurement rather than actual differences in prevalence. There is evidence that use of established rating-scale cut-off scores to estimate diagnostic prevalence consistently results in inflated prevalence estimates (Ruggiero et al., 2006). Whereas Fan et al. (2011) measured PTSD and MDE via cut-off scores on self-report rating scales, structured interviews were used here.

Although PTSD+MDE was the most common pattern of comorbidity we observed, comorbidity profiles involving SUD were also reported. Specifically, 1.1% of the sample had comorbid PTSD+SUD, and 1.6% of participants endorsed MDE+SUD. Viewed another way, approximately one-quarter of adolescents who met criteria for PTSD (26.9%) or MDE (22.7%) also met the threshold for probable SUD on the CRAFFT. Thus, it is important that clinicians routinely assess for SUD among adolescents presenting for MDE or PTSD following a disaster. Older adolescents were more likely to endorse comorbid SUD, consistent with relatively later ages of onset for substance use and SUD in the general population (Johnston et al., 2013). Little is known about rates of substance use—particularly in conjunction with other disorders—among adolescents following disaster. This study helped address this gap and illustrates the importance of considering substance use in addition to PTSD and MDE in the post-disaster context.

The second aim was to identify risk factors for comorbid disorders. Consistent with prior research, female gender was associated with increased risk for PTSD+MDE and MDE +SUD. There is a substantial body of research on the etiology of gender differences in trauma exposure and PTSD (Tolin & Foa, 2006) and depression, which typically emerge during adolescence (Hankin & Abramson, 2001). The pattern of gender differences observed in this study may reflect this trend and be attributable to factors like sex differences in hormonal stress response or cognitive appraisals and coping styles (Hyde et al., 2008). No gender differences were observed for other comorbidity profiles, and no other demographic factors consistently predicted comorbidity when prior trauma history and disaster exposure characteristics were considered.

The most consistent predictor of each post-disaster comorbidity profile was prior exposure to traumatic events. Interestingly, exposure to other potential traumas, and not prior disaster exposure per se, was associated with increased risk for comorbidity. This finding parallels the reliable trend in the literature whereby higher levels of trauma exposure in childhood or adolescence are associated with higher levels of psychopathology (Kilpatrick et al., 2003). Research on polyvictimization suggests that youth who experience multiple types and incidents of trauma are more prone to develop complex clinical profiles marked by comorbidity (Cloitre et al., 2009). This heightened vulnerability is consistent with models that emphasize the impact of increased allostatic load on psychosocial functioning (Beauchaine et al., 2011). Exposure to environmental stressors, including disasters and other traumatic events, may contribute to comorbidity via alterations in shared neural pathways and processes that underlie mood, anxiety, and substance use (Romeo, 2013).

Event-level factors were also significant predictors of comorbid problems. Higher likelihood of comorbid problems (MDE+SUD and PTSD+MDE+SUD) was observed among adolescents whose families experienced greater loss of services. Such disruptions may reduce one’s sense of control in a situation, thus magnifying feelings of fear or despair and increasing risk for more severe psychological distress (Furr et al., 2010). Additionally, adolescents whose parents sustained injuries in the tornado had higher risk of PTSD+MDE compared to parents who were not injured. Injured parents may have diminished capacity to help their children cope with the disaster due to their injuries or their own distress. Alternatively, having a parent injured in the tornado may highlight the seriousness of the storm and the possibility of death. Factors like prolonged loss of services, parental injury, and concern about others’ safety may be proxies for the severity of disaster-related disruption. Thus, current results are consistent with previous studies where personal loss, perceived threat, and disaster severity were associated with elevated psychopathology, including comorbidity (Furr et al., 2010; Goenjian et al., 2001; Lai et al., 2012).

Clinical Implications

Post-disaster mental health screenings should assess prior traumatic stress and specific information about the impact of the disaster for each family to identify adolescents at highest risk for comorbidity. Adolescents with comorbid post-disaster psychiatric problems may benefit from evidence-based treatments that integrate components for multiple problems, such as Trauma-Focused Cognitive Behavioral Therapy (Cohen, Mannarino, &

Deblinger, 2012) for PTSD+MDE. Emerging work suggests integrated therapies also can be effective in addressing complex clinical problems, such as PTSD+SUD, in this population (Danielson et al., 2012).

The scale of many disasters, including demands they place on health care systems, often precludes timely or comprehensive mental health screening of all affected adolescents. Stepped care models offer useful guidance in identifying youth at highest risk for developing psychiatric problems and linking them to appropriate interventions (Zatzick et al., 2011). Widespread, standardized screening via schools, shelters, and similar systems could aid in classifying disaster victims' needs and level of risk to guide referrals to appropriate levels of care. For instance, adolescents with subthreshold symptoms or who demonstrate multiple risk factors for comorbid problems might be directed to online programs or mobile applications designed to provide psychoeducation and coping skills training (Jones, 2014). Such technology-based interventions offer one promising, low-cost option with potential for substantial reach and ready dissemination capacity to disaster-affected communities that could be deployed soon after a disaster (Ruggiero et al., 2012). Youth with more severe psychiatric problems—or whose symptoms are not responsive to low-intensity interventions—could be directed to clinicians for in-person psychotherapy or teletherapy, depending on the local availability of clinicians trained to deliver empirically-supported treatments. More work in this area is needed to ensure adolescents and their families receive necessary care following disasters.

Limitations and Future Directions

This study had several limitations. First, like most disaster mental health studies, we did not measure pre-disaster psychosocial functioning of adolescents and their families. The unpredictable nature of disasters typically precludes the use of prospective designs with pre-disaster assessments. Adolescents in areas affected by tornadoes are under seasonal threat for further disaster exposure. One strategy to address this limitation would be to conduct periodic surveillance assessments of mental health in geographic areas especially prone to disasters (e.g., hurricanes along the U.S. Atlantic coast, tornadoes in "Tornado Alley").

Second, assessments took place on average 8–9 months following the tornadoes, requiring retrospective reporting of symptoms. This delay introduced the possibility of recall errors, which would threaten validity of findings. It is often difficult to collect field data immediately following disasters. Less than half the studies on the psychological impact of disasters are conducted within 6 months of events, and over a third of studies are conducted one year or more post-disaster (Furr et al., 2010). Clinicians who serve disaster-affected families face similar challenges. Although mounting full-scale clinical services immediately following disasters may not be possible, current findings support prioritizing resources for targeted screening, evaluation, and treatment with at-risk adolescents based on the demographic, life history, and event-level factors described above.

Third, the study design limited our ability to link specific symptoms to the tornadoes and it is possible that symptoms reported since the tornadoes were related to other traumatic events. The decision to use symptoms reported since the tornado was made to capture patterns of psychopathology likely to be encountered by mental health professionals

responding in the post-disaster context, regardless of etiological vector. Nonetheless, future epidemiological research on psychiatric comorbidities following disasters should include questions to identify disaster-specific symptoms.

Logistical constraints common to large-scale study of this kind precluded assessment of caregiver-reported youth psychiatric problems or measurement of additional psychiatric problems and potential risk and protective factors. Integration of multiple informants' reports could increase validity of diagnoses. Future studies should evaluate co-occurrence of other common trauma-related problems like disrupted sleep, self-harm, and social problems. Given evidence that psychopathology typically predates and confers increased risk for SUD (Couwenbergh et al., 2006; O'Neil et al., 2011), including measures of pre-disaster psychiatric functioning may be especially helpful in predicting comorbid SUD following disasters. Additionally, a history of depression or other forms of psychopathology can also increase the likelihood of post-disaster psychopathology. We could not assess multiple episodes of PTSD, MDE, and SUD in participants' lifetimes, therefore further research is needed to address temporal ordering of comorbidity patterns over time, ideally via multi-wave longitudinal designs. We used a well-validated screening tool, rather than a diagnostic interview, to assess SUD symptoms to balance breadth of assessment with time constraints and participant burden. Future studies on disaster-related SUD and psychiatric comorbidities should include structured interviews for SUD. Numerous strategies were used to bolster the representativeness of our sample. However, as in all survey research, it is possible that non-responders differed from responders in ways that may have influenced the results. Finally, additional research on interactions between mechanisms across levels of analysis is needed to clarify how and why these comorbidities develop and to identify promising targets for intervention.

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Table 1

Demographic and risk factors for PTSD, MDE, and SUD in a sample of disaster-exposed adolescents (*N*=2,000) and caregivers (*N*=2,000).

Characteristic	*n*	%	Mean (*SD*)
Adolescents			
Gender (Female)	2,000	51.0	
Age (range: 12–17 years)	1,997		14.5 (1.7)
Race	1,782		
White/Caucasian)		70.4	
Black/African-American		25.4	
Other		4.2	
Prior traumatic events	1,957		1.0 (1.1)
Caregivers			
Gender (Female)	2,000	73.7	
Age	1,990		45.0 (9.2)
Race	1,977		
White/Caucasian		70.5	
Black/African-American		25.1	
Other		4.4	
Married/partnered	1,997	73.5	
Present during tornado	1,993	90.6	
Physical injury	1,999	2.7	
Concerned about safety of loved ones	1,999	74.8	
Household			
Income > $20,000 / year	1,813	76.0	
Displacement (>1 week)	1,995	9.0	
Property damage	2,000		1.4 (1.6)
Loss of services	1,999		0.6 (1.1)

Note. n =total number of cases with valid data for each variable. Seventy-three percent of participants were from Alabama, 10% were from other Southern U.S. states (Georgia, Mississippi, Tennessee), and 17% were from Joplin, MO and nearby communities.

Table 2

Prevalence of comorbid PTSD, MDE, and SUD since disaster, by gender and by age cohort.

Disorder	Total *n*=2000	Male *n*=981	Female *n*=1019	Analysis of Gender Difference			12–13 Years *n*=662	14–15 Years *n*=645	16–17 Years *n*=693	Analysis of Age Difference		
	%	%	%	X^2 (*df*=1)	*p*	*φ*	%	%	%	X^2 (*df*=2)	*p*	Cramer's *V*
PTSD only	3.5	3.6	3.5	.02	.90	.00	2.4	4.7	3.5	4.90	.09	.05
MDE only	3.2	2.0	4.2	7.81	.007	.06	2.3	2.7	4.4	5.49	.06	.05
SUD only	0.9	1.2	0.5	2.24	.16	.03	0.2	0.8	1.6	8.41	.02	.07
PTSD+MDE	3.7	2.8	4.6	4.48	.03	.05	3.7	2.5	4.8	4.82	.09	.05
PTSD+SUD	1.1	1.1	1.1	.01	.93	.00	0.6	0.9	1.8	4.22	.12	.05
MDE+SUD	1.0	0.4	1.6	6.82	.01	.06	0.4	0.6	1.9	8.32	.02	.06
PTSD+MDE+SUD	0.7	0.4	0.9	2.37	.12	.03	0.4	0.4	1.2	3.17	.21	.04

Note. PTSD=post-traumatic stress disorder, MDE=major depressive episode, SUD=substance use disorder.

Table 3

Hierarchical logistic regression of characteristics predicting since-disaster comorbid PTSD, MDE, and SUD in adolescents.

	Step					Final model				
Risk factor	***B***	***SE***	***W***	**OR**	**95% CI**	***B***	***SE***	***W***	**OR**	**95% CI**
Regression A: PTSD+MDE (*n*=1,561)										
Step 1										
Gender	−.40	.26	2.37	.67	[.41–1.12]	−.75	.28	7.08	.47**	[.27-.82]
Age	.06	.07	.66	1.06	[.92–1.22]	−.02	.08	.08	.98	[.84–1.14]
African-American	.64	.28	5.35	1.90*	[1.10–3.29]	.24	.31	.62	1.27	[.70–2.32]
Other race	.48	.54	.81	1.62	[.57–4.65]	.19	.57	.12	1.21	[.40–3.66]
Income <$20,000	−.42	.28	2.29	.66	[.38–1.13]	.08	.31	.07	1.09	[.59–2.00]
Step 2										
Prior natural disaster	−.51	.31	2.73	.60	[.33–1.10]	−.53	.32	2.73	.59	[.31–1.11]
Prior traumatic events	.87	.11	58.24	2.38***	[1.91–2.98]	.92	.12	58.15	2.51***	[1.98–3.18]
Step 3										
Time since tornado						.04	.06	.46	1.04	[.93–1.16]
Present during tornado						−.50	.46	1.18	.61	[.25–1.49]
Physical injury						2.17	.53	17.01	8.80**	[3.13–24.72]
Concerned about others						.90	.41	4.83	2.45*	[1.10–5.45]
Displacement						.05	.51	.01	1.06	[.39–2.88]
Property damage						−.04	.10	.14	.96	[.79–1.17]
Loss of services						.15	.13	1.29	1.16	[.90–1.50]
Regression B: PTSD+SUD (*n*=1,566)										
Step 1										
Gender	−.35	.63	.30	.71	[.21–2.45]	−.64	.73	.78	.53	[.13–2.19]
Age	.24	.19	1.64	1.28	[.88–1.85]	.11	.23	.22	1.11	[.71–1.75]
African-American	−.64	.84	.59	.53	[.10–2.73]	−.96	.93	1.07	.38	[.06–2.37]
Other race	1.68	.75	5.06	5.35*	[1.24–23.06]	1.93	.86	5.05	6.87*	[1.28–36.88]

	Step					Final model				
Risk factor	***B***	***SE***	***W***	**OR**	**95% CI**	***B***	***SE***	***W***	**OR**	**95% CI**
Income <$20,000	−1.29	.64	4.08	.28*	[.08-.96]	−.79	.74	1.16	.45	[.11–1.92]
Step 2										
Prior natural disaster	−.30	.75	.16	.74	[.17–3.21]	−.36	.83	.18	.70	[.14–3.58]
Prior traumatic events	1.27	.29	18.76	3.54***	[2.00–6.28]	1.39	.34	17.22	4.01***	[2.08–7.74]
Step 3										
Time since tornado						−.03	.13	.06	.97	[.76–1.24]
Present during tornado						−1.92	.93	4.22	.15*	[.02-.92]
Physical injury						−15.09	>50	.00	–	–
Concerned about others						.64	.97	.43	1.90	[.28–12.71]
Displacement						.45	1.62	.08	1.57	[.07–37.64]
Property damage						−.53	.32	2.66	.59	[.31–1.11]
Loss of services						.49	.33	2.10	1.62	[.84–3.13]
Regression C: MDE+SUD (*n*=1,566)										
Step 1										
Gender	−1.74	.92	3.62	.18	[.03–1.06]	−2.17	.96	5.12	.11*	[.02-.75]
Age	.35	.20	3.00	1.42	[.96–2.10]	.25	.23	1.20	1.29	[.82–2.03]
African-American	.42	.67	.39	1.52	[.41–5.69]	.37	.72	.27	1.45	[.35–5.94]
Other race	.40	1.29	.09	1.49	[.12–18.53]	−.27	1.38	.04	.77	[.05–11.44]
Income <$20,000	−.86	.65	1.74	.42	[.12–1.52]	.00	.76	.00	1.00	[.23–4.40]
Step 2										
Prior natural disaster	−.92	.73	1.59	.40	[.09–1.67]	−1.11	.82	1.82	.33	[.07–1.65]
Prior traumatic events	1.09	.26	17.06	2.96***	[1.77–4.96]	1.19	.29	17.55	3.29***	[1.89–5.75]
Step 3										
Time since tornado						−.13	.13	.93	.88	[.68–1.14]
Present during tornado						−1.89	.92	4.21	.15*	[.03-.92]
Physical injury						−14.61	>50	.00	–	–
Concerned about others						.03	.87	.00	1.04	[.19–5.66]

	Step					Final model				
Risk factor	***B***	***SE***	***W***	**OR**	**95% CI**	***B***	***SE***	***W***	**OR**	**95% CI**
Displacement						−15.62	>50	.00	–	–
Property damage						−.54	.34	2.54	.58	[.30–1.13]
Loss of services						.67	.31	4.58	1.95*	[1.06–3.59]
Regression D: PTSD+MDE+SUD (*n*=1,567)										
Step 1										
Gender	−1.36	.95	2.04	.26	[.04–1.65]	−1.91	1.06	3.27	.15	[.02–1.18]
Age	.23	.23	1.08	1.26	[.81–1.97]	.10	.30	.11	1.11	[.62–1.98]
African-American	−.32	.88	.13	.73	[.13–4.12]	−.33	.97	.12	.72	[.11–4.82]
Other race	.54	1.30	.17	1.71	[.14–21.81]	.20	1.49	.02	1.22	[.07–22.56]
Income <$20,000	−.95	.78	1.48	.39	[.08–1.79]	.35	1.02	.12	1.42	[.19–10.44]
Step 2										
Prior natural disaster	−.57	.87	.42	.57	[.10–3.15]	−53	1.00	.28	.59	[.08–4.18]
Prior traumatic events	1.40	.36	15.53	4.06***	[2.02–8.14]	1.57	.42	13.97	4.78***	[2.10–10.86]
Step 3										
Time since tornado						−.10	.16	.40	.90	[.66–1.24]
Present during tornado						−2.96	1.07	7.68	.05**	[.01-.42]
Physical injury						−13.85	>50	.00	–	–
Concerned about others						−.02	1.13	.00	.98	[.11–8.92]
Displacement						−15.60	>50	.00	–	–
Property damage						−.38	.39	.93	.68	[.32–1.48]
Loss of services						.86	.37	5.39	2.36*	[1.14–4.88]

Note. W=Wald statistic; OR=odds ratio; CI=confidence interval; PTSD=posttraumatic stress disorder; MDE=major depressive episode; SUD=substance use disorder. n's vary across models due missing data.

* $p < .05$,

** $p < .01$,

*** $p < .001$.