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## Impact of Hurricane Rita on Adolescent Substance Use

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### Abstract

Little systematic research attention has been devoted to the impact of natural disasters on adolescent substance use. The present study examined relationships among exposure to Hurricane Rita, post-traumatic stress (PTS) symptoms, and changes in adolescent substance use from 13-months pre-disaster to seven- and 19-months post-disaster. Subjects were 280 high school students in southwestern Louisiana who participated in a drug abuse prevention intervention trial prior to the hurricane. Two-thirds of participants were female and 68% were white. Students completed surveys at baseline (13 months pre-hurricane) and two follow-ups (seven- and 19-months post-hurricane). Results indicated a positive bivariate relationship between PTS symptoms, assessed at 7-months post-hurricane, and increases in alcohol ( $p < .05$ ) and marijuana use ( $p < .10$ ) from baseline to the 7-month post-hurricane follow-up. When these associations were examined collectively with other hurricane-related predictors in multivariate regression models, PTS symptoms did not predict increases in substance use. However, objective exposure to the hurricane predicted increases in marijuana use and post-hurricane negative life events predicted increases in all three types of substance use ( $p$ 's  $< .10$ ). These findings suggest that increased substance use may be one of the behaviors that adolescents exhibit in reaction to exposure to hurricanes.

### INTRODUCTION

Fall 2005 was one of the most devastating hurricane seasons in recent years for the Gulf Coast of the United States. Hurricane Katrina is widely known to have ravaged New Orleans and other communities in Louisiana, as well as sections of Mississippi and Alabama. It acutely impacted an estimated 700,000 people (Gabe, Falk, & McCarty, 2005), and may prove to be the most costly natural disaster in U.S. history (Bacon, 2005). Less well known are the impacts of Hurricane Rita, which hit southwestern Louisiana 28 days after Katrina and caused widespread destruction of homes and businesses, power outages, and loss of jobs (Los Angeles Times, 2005). One well-documented impact of these hurricanes was a substantial increase in the need for mental health services among residents of all ages, including children, in the most affected communities (e.g., Lamberg, 2006; Madrid, Grant, Reilly, & Redlener, 2006).

Several studies have examined the psychological effects of exposure to hurricanes and other natural disasters on children and adolescents (Garrison et al., 1995; Goenjian et al., 2001, 2005; La Greca & Prinstein, 2002; La Greca, Silverman, & Wasserstein, 1998; Roussos et al.,

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2005; Shaw et al., 1995; Thienkrua et al., 2006; Weems et al., 2007). Posttraumatic stress (PTS) symptoms are the most common type of psychological distress observed, and have been the focus of most disaster-related research on youth (e.g., Lonigan, Shannon, Taylor, Finch, & Sallee, 1994; Shannon, Lonigan, Finch, & Taylor, 1994; Shaw et al., 1995; Vernberg, La Greca, Silverman, & Prinstein, 1996; Yule, et al., 2000). A recent review of research on children's reactions to hurricanes indicated that across studies, one-third to one-half of children in highly affected areas reported moderate to severe symptoms of post-traumatic stress disorder [PTSD] (La Greca & Prinstein, 2002). Moreover, it has been shown that children may continue to exhibit PTSD symptoms two years or more after a natural disaster (Goenjian et al., 1995; Green, Korol, Grace, & Vary, 1991, 1994; La Greca, Silverman, Vernberg, & Prinstein, 1996; Shaw et al., 1995; Yule et al., 2000). The emergence and persistence of PTS symptoms has been associated with female gender, being a minority, having fewer economic resources, having higher levels of objective exposure to the hurricane (e.g., closer proximity to the zone of impact and experience of personal injury, loss of loved ones, dislocation, and/or resource loss), as well as higher subjective exposure (e.g., perceived life threat) (Garrison et al., 1995; Goenjian et al., 2001; LaGreca et al., 1998; Lonigan et al., 1994; Shannon et al., 1994; Shaw et al., 1995; Vernberg et al., 1996; Weems et al., 2007). Other types of psychological distress symptoms and problems that youth exposed to natural disasters may experience, at least in the short term, include depression, anxiety, behavior problems, inattention, disaster-related fears, suicidality, and reduced academic performance (Goenjian et al., 2001; Green et al., 1991; La Greca & Prinstein, 2002; McDermott, Lee, Judd & Gibbon, 2005; Shannon et al., 1994; Thienkrua, et al., 2006).

Very little research has focused on substance use as a behavior that youth may exhibit in reaction to exposure to natural disasters, although one might hypothesize such a relationship on the basis of previous research on adults. Higher rates of alcohol and drug abuse have been associated with adults' exposure to a range of traumatic events, such as natural disasters, combat, and the terror events of September 11, 2001 (Vlahov et al., 2002; Ruggiero et al., 2006; Breslau, Davis and Schultz, 2003). In an Australian study, increased tobacco use among young adults was associated with having experienced fire-related traumatic events (Parslow and Jorm, 2006). Research conducted with adults exposed to the terror attacks in New York City on September 11, 2001 showed an increase in the use of cigarettes, alcohol and marijuana following the attacks. Exposed persons who reported depressive symptoms showed greater increases in substance use, suggesting co-morbidity between psychological disruptions and substance use following a disaster (Vlahov, et al., 2002).

Similarly, several studies of adolescents and young adults have shown that a history of various types of trauma, such as sexual abuse, physical abuse, and other victimization, is positively associated with alcohol use, drinking-related problems, cigarette smoking, use of marijuana or other illegal drugs, and substance use disorder (Breslau, Davis, Andreski, & Peterson, 1991; Dembo, Williams, Wothke, Schmeidler, & Brown, 1992; Giaconia et al., 1995, 2000; Hernandez, 1992; Hernandez, Lodico, & DiClemente, 1993; Kaplan et al., 1998; Kilpatrick et al., 2000, 2003). In addition, a few studies have documented the co-morbidity of substance use disorder and PTSD among adolescents exposed to trauma (Giaconia et al., 1995, 2000; Kilpatrick et al., 2000). We found only one study that specifically examined the influence of disaster exposure and disaster-related PTS symptomatology on substance use by adolescents (Schroeder and Polusny, 2004). The findings showed that a higher level of disaster-related PTS symptoms was a significant predictor of adolescents' alcohol consumption following severe tornadoes in rural Minnesota, after controlling for exposure to other types of trauma.

It is important to investigate exposure to natural disasters as a risk factor for adolescent substance use, because substance use persists as a significant social problem in the United States. Epidemiological studies have identified the period from mid-adolescence (average age

14) to young adulthood (average age 22) as one in which many experiment with cigarettes, alcohol, and illicit drugs, and some become regular users (Johnston et al., 2008). For example, data from the 2007 Monitoring the Future study show that, nationwide, the 30-day prevalence of cigarette, alcohol, and marijuana use among early adolescents (8<sup>th</sup>-graders) was 9%, 17%, and 7%, respectively; whereas among late adolescents (12<sup>th</sup>-graders), the prevalence was 22%, 45%, and 18%, respectively (Johnston et al., 2008). In addition, mid-to-late adolescence is a peak risk period for the first onset of alcohol and drug abuse or dependence (Burke, 1991; Warner, Kessler, Hughes, Anthony, and Nelson, 1995).

There is an ongoing need for research that identifies potential risk factors for substance use and abuse, in order to help guide the development of effective prevention strategies. In particular, the influence of disaster exposure on the onset of adolescent substance use has received very little systematic research attention. Moreover, due to the inherent opportunistic nature of disaster research, most studies have not accounted for preexisting factors, such as previous substance use, when examining mental health and behavioral reactions to natural disasters. Longitudinal studies are needed to improve our understanding of the potentially complex interrelationships among pre-disaster functioning, hurricane exposure, PTS symptoms, and substance use in adolescents (Chilcoat & Menard, 2003).

In the present study, we had a unique opportunity to utilize a longitudinal design to investigate these interrelationships because we had pre-hurricane substance use data from a sample of adolescents living in the path of Hurricane Rita. The purpose of the study was to investigate the influence of hurricane exposure and post-exposure PTS symptoms on changes in adolescent substance use from pre-hurricane to two post-hurricane follow-up periods. We hypothesized that increases in substance use would be positively associated with levels of exposure to the hurricane and post-exposure PTS symptomatology.

## METHODS

### Subjects and Procedures

Participants were enrolled in high schools that were recruited initially for a dissemination trial of Project Towards No Drug Abuse [TND], an evidence-based substance abuse prevention program (Rohrbach, Grana, Valente, & Sussman, 2006; Sussman, Dent, & Stacy, 2002). Among the 65 schools across the U.S. recruited for the trial, ten are included in the Calcasieu Parish School System, located in the southwestern corner of Louisiana. These Louisiana schools are located in communities that range in size from a “small city” (e.g., Lake Charles, population 70,224 in 2006) to a “town” based on U.S. Census categories (U.S. DoE, 2008).

Calcasieu Parish was in the path of Hurricane Rita on September 24, 2005. Three days prior to the hurricane, all schools in the parish were closed and families were ordered by the governor of Louisiana to evacuate the area. The schools remained closed for five weeks after the hurricane. All schools were able to reopen at their original site, but some classes had to be held elsewhere while roof damage was repaired. The school day was extended for all students, and extra-curricular activities such as football were shortened or canceled for the remainder of the school year.

Ten Calcasieu Parish high schools had been randomly assigned to one of three experimental conditions: program with standard teacher training, program with comprehensive implementation support, or control. In each of the high schools, 9<sup>th</sup>-grade physical education classes - most of which were separated by gender - were selected as the required school subject area for the study. Among the classes taught by each physical education teacher, two were randomly selected to participate in the study. Immediately before the study began, two teachers of male-only classes decided not to participate, resulting in a greater proportion of female-only

classes in the sample. In order to participate in the study, students in the selected classes were required to have active parental consent and provide written assent. This procedure was approved by the Institutional Review Board of the University of Southern California.

At baseline, thirteen months prior to Hurricane Rita (September 2004), a total of 602 students were consented and completed the self-report questionnaire. The questionnaires were administered during regular classroom periods by trained university staff members. During the subsequent three-month period, the Project TND prevention program was implemented in schools assigned to the two program conditions.

In May 2006, at 7 months post-Hurricane Rita, an attempt was made to survey all of the students who had completed the baseline assessment. In addition to completing this first follow-up survey for the original study, subjects were invited to participate in the present study, which involved completing a module of questions about the impacts of Hurricane Rita. Our Institutional Review Board required that we obtain additional active parental consent for completion of the hurricane questions. Of the 602 students who were enrolled at baseline, a total 389 students (64.6%) consented to and completed the first follow-up survey, including the full set of hurricane questions. In May 2007, at 19-months post-hurricane, an attempt was made to administer a second follow-up survey to these 389 students. A total of 296 students (49.2% of the baseline sample) completed the second follow-up. Both follow-up surveys were administered by project staff at school sites during regular classroom periods. The analytic sample for the present paper is the 280 students who completed the baseline and both follow-up surveys (7- and 19-months post-hurricane).

## Measures

**Substance Use**—The primary outcomes in this study were past 30-day use of cigarettes, alcohol and marijuana. At baseline, 7-months post-hurricane, and 19-months post-hurricane participants indicated the number of times they had used each of these substances in the past 30 days, using eight response categories ranging from zero to more than 100 times. Because the distributions of these variables were skewed, a dichotomous variable was created for each substance (0=no use; 1= one or more times). In data analyses, a change score was created for each substance at each follow-up, representing the difference between the dichotomous variable at follow-up and baseline.

**Demographic Characteristics**—Age, gender, and ethnicity were assessed at baseline. Students indicated the one category that best described their ethnic background (Asian, Latino/Hispanic, African-American/Black, White (not Hispanic), American Indian/Native American, Mixed, or Other). For data analyses, we created a dichotomous ethnicity variable (0=non-white, 1= white).

**Post-traumatic Stress (PTS) Symptoms**—We used the Adolescent Version of the UCLA PTSD Reaction Index (PTSD-RI; Revision 1) to assess symptoms of post-traumatic stress at seven months post-hurricane (Pynoos, Rodriguez, Steinberg, Stuber, & Frederick, 1998). The PTSD-RI is a self-report instrument that is geared closely to diagnostic criteria for PTSD from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition [DSM-IV]* (American Psychiatric Association, 2002). The measure has been widely used for the assessment of children and adolescents exposed to various types of trauma, including natural disasters (e.g., Garrison et al., 1993; Goenjian et al., 1995; 2000; La Greca et al., 1996; Shaw et al., 1995; Vernberg et al., 1996). Previous research has shown significant associations between scores on the self-report tool and diagnoses of PTSD based on structured clinical interviews, as well as good to excellent test-retest reliability and internal consistency of the items (Steinberg, Brymer, Decker, & Pynoos, 2004). In the present study, we included 17 items

that assess the frequency of DSM-IV PTSD symptoms during the past month (DSM-IV criteria B, C, D: re-experiencing, avoidance/numbing and hyper-arousal, respectively). For each of these items, students were asked to refer to Hurricane Rita and rate the frequency of experiencing the symptom in the past month (5-point scale, 0=never to 4=every day or almost every day).

For data analyses, a *PTSD severity* score was created based on the scoring procedures recommended by the developers of the PTSD-RI (Rodriguez, N., Steinberg, A., & Pynoos, R., 1999), in which frequency ratings for the 17 PTSD symptoms are summed. The method produces a total PTSD severity score ranging from zero to 68.

**Hurricane Exposure**—At seven months post-hurricane, we assessed objective exposure to Hurricane Rita utilizing five items from previous studies (e.g., Goenjian et al., 2001; Schroeder & Polusny, 2004; Vernberg et al., 1996; Weems et al., 2007). These items included whether the subject was hurt, his/her home was damaged badly or destroyed, he/she had to move to a new home because of the hurricane, it was hard to see friends because of relocation, and he/she had to live away from his/her parents for one week or more because of the hurricane. Responses to these items (no=0, 1=yes) were summed to create an *objective exposure* score. To assess subjects' subjective experiences during or just after the hurricane, we used four items from the PTSD-RI (e.g., "At any time during the hurricane, did you think you might die?" "Did you feel very scared, like this was one of your most scary experiences ever?"), with dichotomous response categories (0=no, 1=yes). These items were averaged to create a *subjective exposure* score.

**Post-Hurricane Negative Life Events**—At seven months post-hurricane, subjects were asked to complete an abbreviated version of Wills' Adolescent Negative Life Events Inventory (Wills, 1986; Wills & Cleary, 1996) in which they indicated whether they had experienced each of 18 life events since Hurricane Rita (yes/no response to each). The inventory included 6 events that could have occurred to family members (e.g., "My parents had problems with money") and 12 events that could have occurred directly to the subject him or herself (e.g., "I broke up with my boy/girlfriend"). Responses were averaged to create the *post-hurricane negative life events* score (Cronbach's  $\alpha=.77$ ).

**Post-Hurricane Disruption**—Finally, the seven-month post-hurricane survey included four items from previous research (Vernberg et al., 1996) that assessed the current condition of the subjects' housing (e.g., "Has almost all of the damage to your home now been fixed?" "Are you living in a home that still has a roof that leaks or needs repair?") and family resources ("Is one of your parents now out of work because of the hurricane?"). Responses (0=no; 1=yes) were summed to create the *post-hurricane disruption* score.

### Assessment of Attrition Bias

To assess potential attrition bias, a multiple logistic regression was run to predict with baseline measures the attrition status of the analytic sample at 19 months post-hurricane (N=296), versus participants who were excluded from the analysis because they were lost to follow-up by the 19-month post-hurricane assessment (N=306). Of a set of 15 variables that were assessed at baseline, including demographic variables, drug use and intentions to use, and psychosocial factors, three variables were found to be significantly related to attrition. Relative to those excluded from the analyses, the analytic sample was younger, more likely to be living with both parents, and less likely to use cigarettes (all  $p$ 's  $<.05$ ). Based on the formula predicting actual attrition status at the 19-month post-hurricane follow-up from the set of 15 pretest variables, a propensity-to-attrition score was calculated for each subject in the analysis sample



(Rosenbaum & Rubin, 1984). The Pearson correlation between actual attrition status and the predicted score for propensity to attrition was  $r=0.65$ .

### Data Analysis

For both post-hurricane follow-ups, first we examined the separate relationship between each predictor variable and change in each type of substance use, controlling for baseline substance use, the propensity-to-attrition score, and the experimental condition to which the students' school was assigned (program vs. control). In each regression model, the substance use outcome variable was the score representing change from the pre-hurricane baseline to the 7- or 19-month follow-up. In the second step, those variables that were at least marginally significant predictors of the substance use outcome in the bivariate models ( $p<0.10$ ) were retained in a multiple regression model that regressed change in the outcome on the respective set of predictors, controlling for baseline substance use, attrition, and experimental condition. It should be noted that no effects of the intervention were found at either the 7- or 19-month post-hurricane follow-up; therefore, experimental condition was treated as a nuisance variable that was controlled for in the analyses. All models were conducted using SAS PROC MIXED, Version 9.1.3 (SAS Institute, 2006), which takes into account the nesting of subjects within schools and generates appropriate standard errors for the parameter estimates.

## RESULTS

Table 1 presents the descriptive statistics for the variables of interest. The majority of subjects were female (67.9 %) and white (68.4%), and they had a mean age of 14.4 years ( $std=0.8$ ) at baseline. On average, participants reported exposure to one of the five objective features of Hurricane Rita that we assessed. The two most prevalent objective features they experienced were their "home was badly damaged or destroyed" (34.9%) and they "had to live away from parents for more than one week" (24.2%). Participants reported an average of two of five subjective features of exposure assessed, with two most common being "I felt like what was happening did not seem real in some way" (59.1%) and "I felt scared, like this was one of my most scary experiences ever" (50.8%). More than two-thirds (68%) of subjects reported experiencing at least one post-hurricane negative life event. The five most common negative life events that had occurred since the hurricane were money problems among the subject's parents (29.6%), breaking up with one's girl/boyfriend (28.6%), frequent arguments with parents (25.0%), getting bad grades (24.6%) and a serious illness in the family (24.6%). The average PTSD severity score among subjects was 8.0 ( $sd=9.0$ ) on a scale that ranged from zero to 68.

Table 2 shows the patterns of change in 30-day substance use from 13 months pre-hurricane to 7- and 19-months post-hurricane. With regard to cigarette use, the majority of subjects were non-users at baseline and at 7-months and 19-months post-hurricane (75.7% and 75.3%, respectively). However, 15% of subjects were non-users at baseline, but reported cigarette use at 7-months and 19-months post-hurricane. The pattern of change in use status was similar for marijuana. Most subjects were non-users at baseline and at 7- and 19-months post-hurricane (86.4% and 87.5%, respectively); however 9% and 8% of subjects changed from non-use to use at 7-months and 19-months post-hurricane, respectively. The pattern of change in alcohol use from baseline to post-hurricane was the same for both follow-ups, with 47% of subjects reporting non-use of alcohol at baseline and follow-up, 18% of subjects reporting use at baseline and follow-up, and 25% of subjects changing from non-use to use status at follow-up.

Table 3 shows separate associations between each of the predictor variables and change in each substance use outcome. Objective exposure to the hurricane was associated with increases in use of cigarettes and marijuana from baseline to 7-months post-hurricane, and increases in use of marijuana from baseline to 19-months post-hurricane ( $p$ 's  $<.05$ ). Subjective exposure was

not a significant predictor of change in use of any of the substances. Post-hurricane negative life events were associated with increases in all three types of substance use from baseline to 7-months post-hurricane, and increases in cigarette and alcohol use from baseline to 19-months post-hurricane ( $p$ 's  $<.05$ ). The PTSD severity score was positively associated with increases in alcohol and marijuana use at 7-month follow-up and marijuana use at the 19-month follow-up ( $p$ 's  $<.05$ ).

Table 4 shows the results of the multivariate analyses for each substance use outcome at each wave of follow-up, in which all of the predictor variables that had a significant bivariate relationship with the outcome were entered simultaneously. As shown, objective exposure remained a predictor of increases in marijuana use from baseline to both the 7- and 19-month post-hurricane follow-up ( $p <.05$  and  $p <.10$ , respectively). Also, post-hurricane negative life events was retained as a predictor of increases in all of the substance use outcomes, except increases in marijuana use from baseline to 19-months post-hurricane. When other hurricane-related variables were controlled, PTSD severity did not remain a significant predictor of changes in substance use status.

## DISCUSSION

To our knowledge, this is the first longitudinal study to examine relationships between exposure to a major hurricane and changes in substance use behaviors among adolescents from pre- to post-disaster. Previous studies have shown that exposure to other types of trauma, such as sexual and physical abuse, are associated with the use of cigarettes, alcohol, and illegal drugs in adolescence and young adulthood (Breslau et al., 1991; Giaconia et al., 1995, 2000; Hernandez, 1992, Hernandez et al., 1993; Kaplan et al., 1998; Kilpatrick et al., 2000, 2003). Also, research has documented co-morbidity between psychological distress and substance use disorder among adolescents following exposure to trauma (Giaconia 1995, 2000; Kilpatrick et al., 2000). Our study differed from these studies in that we focused on the mid-adolescent period (mean age of 14 years at baseline), our dependent variables were past 30-day use of substances rather than substance use disorder, and we examined changes in substance use behaviors over a 32-month period ranging from 13 months pre-hurricane to 19 months post-hurricane.

At both post-hurricane follow-ups, we found a positive bivariate association between PTS symptoms and post-hurricane marijuana and alcohol use, after accounting for pre-hurricane use levels. When PTS symptomatology was considered collectively with other hurricane-related predictors, it did not remain a significant predictor of changes in substance use. Thus, in contrast to Schroeder and Polusny (2004), our study did not provide support for a significant relationship between PTS symptomatology and adolescent post-hurricane alcohol use when hurricane exposure was controlled. However, methodological differences between the studies must be considered when comparing results. A primary strength of the present study is the use of a longitudinal design with two post-hurricane assessments, which allowed us to examine the impact of hurricane exposure and PTS symptoms on changes in substance use from pre- to post-hurricane. In this respect, the present study contributes uniquely to the field of disaster research, which typically has consisted of cross-sectional or single follow-up designs with a few notable exceptions (e.g., Goenjian, et al., 2005).

We found that post-hurricane negative life events, such as arguments with parents, illness in the family, and money problems were significant predictors of increased use of all three substances - marijuana, cigarettes, and alcohol. It is likely that major life events after a disaster influence and magnify adolescents' stress reactions, although these events are not necessarily related to the disaster itself (La Greca et al, 1996; McFarlane, 1987). The adolescent stress and coping literature indicates that negative life events are associated with negative affect,

psychological distress and substance use (Wills, Vaccaro & McNamara, 1992; Newcomb, Huba & Bentler, 1986.) It appears that negative life events cause negative affect or psychological distress, which leads to substance use in order to relieve the negative affect (Wills, 1986; Wills, Vaccaro & McNamara, 1992; Newcomb, Huba & Bentler, 1986).

Overall, our findings suggest that although PTS symptoms may co-occur with adolescent substance use following exposure to disasters, they may not mediate the effects of hurricane exposure and the related negative life events that may occur, on substance use behaviors. Conceptual models of the effects of disasters on adults posit that psychological distress, such as depression and PTSD, mediates the relationship between disaster exposure and resultant resource loss, and drug use (e.g., Freedy, Saladin, Kilpatrick, Resnick, & Saunders, 1994, LaGreca et al., 2002). Although we did not conduct an analysis to determine mediation, our finding that PTS severity did not predict changes in substance use when exposure to the hurricane and post-hurricane negative life events were controlled, suggests that additional factors and processes should be investigated as potential mediators of the effects of hurricane exposure on adolescent substance use.

Several limitations of the present study should be noted. First, hurricane exposure and PTS symptoms were assessed seven months after Hurricane Rita. Ideally, these assessments would have occurred within eight weeks post-hurricane. Researchers who study the impacts of natural disasters face challenges similar to those who live in the areas affected by the disaster; that is, when the local infrastructure (in our case, the schools attended by our subjects) is damaged, it is difficult to conduct research. As a result of the timing of the survey, our estimates of hurricane exposure are subject to the potential biases involved in collecting retrospective measures (e.g., Feinberg, Loftus, & Tanur, 1985). Conclusions regarding PTS symptoms should be qualified in light of the potential biases on recall of negative experiences due to current anxious or depressed mood (Brewin, 1996). Furthermore, we did not assess PTSD per se, so we are not able to make diagnostic conclusions. However, because we employed a measure of PTSD that assesses symptoms in all three diagnostic categories (re-experiencing, avoidance/numbing and hyperarousal) and we were able to observe sufficient variability in several of the types of PTS symptoms, we were able to engage in a reasonable analysis of effects.

Second, our sample was comprised of adolescents who reported low levels of exposure to the objective and subjective features of Hurricane Rita that we assessed. Because Hurricane Katrina had devastated an adjacent area one-month prior to Hurricane Rita, we speculate that many of the subjects' families followed government directives to evacuate during Hurricane Rita (CNN, 2005; Houston Chronicle, 2005; Washington Post, 2005). Therefore, our sample may not have experienced the intensity of hurricane impact that has been reported in previous studies of children (e.g., Goenjian et al., 2001; Shaw et al., 1995; Hsu, Chong, Yang, Yen, 2002). As a result, our ability to detect relationships between hurricane-related factors and substance use behaviors may have been compromised. For example, the possibility of the development of post-traumatic stress symptomatology among our subjects may have lower than that among youth who stay in their homes during a severe storm, which may explain the relatively low PTS symptom severity scores we observed.

Third, our sample was predominantly female and white, thus limiting the external generalizability of the findings presented. Posttraumatic stress reactions have been found to occur in higher rates among female disaster victims (Goenjian et al., 2001; Shannon et al., 1994; Vernberg et al., 1996; Weems et al., 2007); thus, it is possible that the relationships between hurricane-related factors and post-hurricane substance use may apply to females more than males. In future papers, the interactions between demographic characteristics and PTS symptoms, hurricane exposure and substance use will be investigated.



In conclusion, the disaster research field would benefit greatly from more longitudinal studies that take into account preexisting behaviors among victims. In addition, future research in this area should focus on longitudinal assessments of the impacts of natural disasters on not only substance use, but other adolescent risk behaviors such as unprotected sexual activity.

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**Table 1**  
Univariate Descriptions of Variables of Interest

Variable	Mean (Std. Dev.) or Percent
<i>Demographic Characteristics<sup>a</sup></i>	
Age (years)	14.4 (0.8)
Gender (% female)	67.9
Ethnicity (%)	
White	68.4
African American	24.0
Asian	1.5
Latino	0
Native American	1.1
Mixed	3.6
Other	1.5
<i>Hurricane-Related Factors</i>	
No. of objective features of exposure <sup>b</sup> (1–5)	0.9 (1.0)
No. of subjective features of exposure <sup>b</sup> (1–5)	2.0 (1.6)
PTSD severity <sup>b</sup> (0–68)	8.0 (9.0)
Post-hurricane negative life events <sup>b,c</sup> (%)	67.9
Post-hurricane disruption <sup>b</sup> (1–4)	0.9 (0.7)
<i>30-Day Substance Use at 7-Months Post-hurricane</i>	
Cigarettes (%)	23.4
Alcohol (%)	43.7
Marijuana (%)	11.5
<i>30-Day Substance Use at 19-Months Post-hurricane</i>	
Cigarettes (%)	22.7
Alcohol (%)	43.8
Marijuana (%)	10.8

NOTES.

<sup>a</sup> Assessed at baseline (13 months pre-hurricane)

<sup>b</sup> Assessed at 7 months post-hurricane

<sup>c</sup> Percent that experienced at least one negative life event since the hurricanes



**Table 2**Changes in Past 30-Day Substance Use Status<sup>a</sup> from Baseline to 7-Months and 19-Months Post-Hurricane (in percents)

	Status at 7-Months Post-Hurricane		Status at 19-Months Post-Hurricane	
	Non-user	User	Non-user	User
<b>Status at Baseline (13 month pre-hurricane)</b>				
<b>Cigarettes</b>				
Non-user	75.7	15.1	75.3	15.5
User	1.1	8.1	2.6	6.6
<b>Alcohol</b>				
Non-user	47.6	25.6	47.8	25.4
User	8.4	18.4	8.5	18.4
<b>Marijuana</b>				
Non-user	86.4	9.2	87.5	8.1
User	1.8	2.6	1.8	2.6

## NOTES

<sup>a</sup>Status: Use (at least once) or non-use (not once) during the past 30 days.

Table 3  
 Separate Associations between the Independent Variables and Change in Substance Use Outcomes<sup>a</sup> from Pre-Hurricane Baseline to 7-  
 Months and 19-Months Post-Hurricane

Predictor	Change in 30-day Use from Baseline to 7-months Post-Hurricane			Change in 30-day Use from Baseline to 19-months Post-Hurricane		
	Cigarettes	Alcohol	Marijuana	Cigarettes	Alcohol	Marijuana
	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)
Age	0.01 (0.07)	-0.03 (0.06)	-0.04 (0.06)	0.10 (0.06)	0.04 (0.06)	0.01 (0.06)
Gender (male)	-0.03 (0.07)	-0.03 (0.06)	-0.09 (0.06)	0.04 (0.07)	0.03 (0.06)	-0.06 (0.06)
Ethnicity (white)	0.16 (0.07) <sup>*</sup>	0.11 (0.06) <sup>†</sup>	-0.05 (0.06)	0.02 (0.07)	0.03 (0.06)	0.00 (0.07)
Objective exposure <sup>b</sup>	0.13 (0.06) <sup>*</sup>	0.03 (0.06)	0.17 (0.05) <sup>**</sup>	0.10 (0.06)	0.09 (0.06)	0.12 (0.06) <sup>*</sup>
Subjective exposure <sup>b</sup>	0.07 (0.06)	0.07 (0.06)	0.06 (0.06)	0.05 (0.06)	0.07 (0.06)	0.02 (0.06)
PTSD Severity <sup>b</sup>	0.06 (0.06)	0.11 (0.06) <sup>†</sup>	0.11 (0.06) <sup>*</sup>	0.06 (0.06)	0.08 (0.06)	0.11 (0.06) <sup>†</sup>
Post-hurricane negative life events <sup>b</sup>	0.17 (0.06) <sup>**</sup>	0.14 (0.06) <sup>*</sup>	0.18 (0.05) <sup>***</sup>	0.12 (0.06) <sup>*</sup>	0.13 (0.06) <sup>*</sup>	0.07 (0.06)
Post-hurricane disruption <sup>b</sup>	-0.04 (0.06)	0.02 (0.06)	-0.03 (0.06)	-0.04 (0.06)	0.01 (0.06)	0.07 (0.06)

NOTES.

<sup>†</sup> p < .10,

<sup>\*</sup> p < 0.05,

<sup>\*\*</sup> p < 0.01,

<sup>\*\*\*</sup> p < 0.001

<sup>a</sup> All dependent and independent variables were standardized to mean=0 and std=1. For each substance use outcome and predictor, a multiple regression model was conducted regressing the change score (use status at follow-up minus use status at baseline) on the predictor, controlling for propensity-to-attrition score and experimental condition.

<sup>b</sup> Log transformation was performed on the raw score.

**Table 4**  
 Summary of Multiple Regression Analysis of Predictors of Change in Drug Use Outcomes <sup>a</sup> from Pre-Hurricane Baseline to 7-Months and 19-Months Post-hurricane

Predictor	Change in 30-day Use from Baseline to 7-months Post-Hurricane		Change in 30-day Use from Baseline to 19-months Post-Hurricane	
	Cigarettes	Alcohol	Marijuana	Alcohol
	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)	Std. Beta(se)
Substance use at baseline	-0.19 (0.08) *	-0.50 (0.06) ***	-0.31 (0.06) ***	-0.48 (0.06) ***
Age	--	--	--	--
Gender	--	--	--	--
Ethnicity (% white)	0.16 (0.07) *	0.12 (0.06) †	--	--
Objective exposure <sup>b</sup>	0.09 (0.06)	--	0.13 (0.06) *	--
Subjective exposure <sup>b</sup>	--	--	--	--
PTSD <sup>b</sup>	--	0.06 (0.06)	0.02 (0.06)	0.09 (0.06)
Negative life events <sup>b</sup>	0.15 (0.06) *	0.11 (0.06) *	0.14 (0.06) *	0.13 (0.06) *
Post-hurricane status <sup>b</sup>	--	--	--	0.06 (0.06)

NOTES.

† p < .10,

\* p < 0.05,

\*\* p < 0.01,

\*\*\* p < 0.001

<sup>a</sup> For each model, the change score was regressed on baseline substance use, predictors found to be at least marginally significantly related to the outcome in the bivariate analysis, experimental condition, and the propensity-for-attrition score.

<sup>b</sup> Log transformation was performed on the raw score.