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Long-Term Mental Health Among Low-Income, Minority Women Following Exposure to Multiple Natural Disasters in Early and Late Adolescence Compared to Adulthood

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Abstract

Background High impact experiences following a natural disaster have been shown to influence later psychopathology. Individual-level factors such as age may also contribute to a disaster's impact on mental health, though it is unclear whether young age confers a protective effect or represents a period of increased risk as compared to adulthood.

Objective The present study evaluated the influence of adolescent age and hurricane experiences on mental health in the years following multiple hurricanes in the New Orleans region.

Methods 794 women, currently aged 18–45, participating in a cohort study of lifetime adversity and reproductive health completed a survey about hurricane experience and current mental health. Joint associations between disaster experience and age at the time of disaster on depression and post-traumatic stress disorder (PTSD) were evaluated.

Results Compared to women who were adults at the time of the disaster, being in early adolescence resulted in reduced depression and PTSD up to 9-years post-disaster, controlling for hurricane experiences, time since disaster, and income. A similar effect was not observed among older adolescents. Increased endorsement of feeling one's life was in danger and experiencing illness or injury resulted in increased odds of depression, while danger was associated with increased odds of PTSD.

Conclusions Younger age at the time of a natural disaster may confer a protective effect on mental health outcomes post-disaster, even when disaster experiences are considered, potentially representing the importance of parental support and cognitive development on disaster effects.

Keywords Hurricane · Disaster experience · Adolescence · Mental health

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Introduction

Surveys suggest that 13–30 % of individuals will be exposed to one or more natural disasters in their lifetime (Briere and Elliott 2000). Over the past decade, New Orleans, LA and the surrounding areas have been affected by a number of natural disasters, the most well-known being Hurricane Katrina in August 2005. However, even since Katrina, four additional hurricanes, Rita (September 2005), Gustav (August 2008), Ike (September 2008), and Isaac (August 2012), have impacted the population of Southeastern Louisiana, albeit to a lesser extent. The effect of repeated exposure to natural disasters has received little attention in the natural disaster literature (Harville et al. 2011), though existing studies of trauma in general suggest that exposure to several traumatic events is associated with poorer mental health outcomes, especially post-traumatic stress disorder (PTSD) (Brewin et al. 2000; Green et al. 2000; Ozer et al. 2003). Recent studies of exposure to multiple hurricanes suggest that subsequent exposure to a similar, less stressful event may confer some level of resilience following exposure, though multiple experiences with disaster remained associated with worse mental health overall (Harville et al. 2011; Weems et al. 2014). Given this, the population of Southeastern Louisiana appears to offer a unique opportunity to study the potential effects of exposure to multiple natural disasters within a short period of time.

Disaster Experience

While exposure to a natural disaster in and of itself may be stressful, more severe and longer lasting mental health outcomes are often associated with environmental events that involve physical injury, witnessing death or injury of others, threat to life, and property loss (Briere and Elliott 2000; Norris et al. 2002b). In addition, the degree of exposure to a disaster is an important risk factor for developing PTSD (Galea et al. 2005). A recent integrative data analysis of Hurricane Katrina studies suggested that "fear" was most predictive of PTSD, and that pet loss; death of a family member or friend; lacking food, water, or clothing; and lacking medication or medical care were all predictive of general psychological distress (Chan and Rhodes 2014). Similarly, a study following Hurricane Ike found that while increased exposure to Ike-related traumatic events and stressors were both associated with PTSD, traumatic events, such as being robbed or assaulted, were not associated with depression (Tracy et al. 2011). Thus, researchers have suggested that studies of disaster effects should take into account severity characteristics and types of exposure that might vary according to disaster type (Briere and Elliott 2000; Chan and Rhodes 2014), rather than only considering whether or not an individual was exposed to the disaster under investigation.

Age as a Risk Factor

In addition to specific disaster experiences, age at which the disaster occurred may also affect mental health outcomes. Some researchers have suggested that older age may confer protection against ill effects following trauma as result of resilience gained from prior experience and better preparedness (Gibbs 1989; Norris et al. 2002b). Other researchers have speculated that young and middle-age adults may be at the highest risk for mental health problems following a disaster as they perceive the disaster to have the greatest impact on their futures, as opposed to young people who haven't yet started to build their lives (Gibbs 1989). People in this age group are also the most likely to have young children

and be property owners, thereby increasing their stress. Theories of the effect of disaster on children and adolescents are also varied, with some experts suggesting that younger children may be protected from the effects of disaster due to decreased perceptions regarding disaster impact, while others have speculated children may be at increased risk due to the underdeveloped nature of their coping mechanisms and limitations on their ability to act independently (Gibbs 1989; Vogel and Vernberg 1993).

Although a number of studies control for age as a potential confounder, or consider the effects of disaster among a specific age group, there is limited evidence directly comparing mental health distress following disaster across different age groups (Norris et al. 2002b). Studies among children specifically suggest mixed results, with some studies showing increased distress among younger children, while others document diminished effects (Gibbs 1989; Norris et al. 2002b). For example, a recent study of 2011 tornado victims found older adolescents to have increased rates of PTSD compared to younger adolescents, although authors also noted the overall resilience of the adolescents in response to disaster (Adams et al. 2014). Likewise, decreased PTSD symptomology has been noted in younger children compared to older children following exposure to a 1972 dam collapse (Green et al. 1991). Conversely, other studies of PTSD and psychopathology among school-aged children and adolescents following a variety of natural disasters have found younger age to be predictive of increased symptomology (Bokszczanin 2007; Giannopoulou et al. 2006; McDermott et al. 2005; Weems et al. 2010), although some differences in the effect of age have been noted by gender (Bokszczanin 2007). Studies directly comparing mental health in children and adults following disaster are more limited, with one such study describing increased PTSD in adult flood victims as compared to children younger than 18 (Liu et al. 2006). The differential impact of natural disasters on mental health in children and adults warrants further investigation.

The Current Study

The goal of the present investigation was to examine whether disaster experience during early adolescence or late adolescence has a differential impact on mental health relative to exposure as an adult, both alone and within the context of individual-level disaster effects. Associations were assessed following exposure to a number of hurricanes occurring in and around New Orleans from 2005 to 2008. We hypothesized that age at which the disaster occurred would be associated with endorsement of depression and PTSD in the years following the disaster, though it was unclear whether youth would confer an increased risk or a degree of protection. Additionally, we expected distinct types of hurricane exposures to have differential effects on mental health, both within individual hurricanes and cumulatively across hurricanes. It is the hope that this study can contribute to existing literature by further expanding upon knowledge of the effects of age on post-disaster mental health, and adding details to the growing literature regarding the impact of different types of disaster-related experiences. It is thought that considering both age and hurricane experiences across multiple hurricanes is a unique contribution offered by the present study.

Methods

Participants

Pregnant and non-pregnant women of reproductive age were recruited through prenatal, WIC, and general health clinics, as well as community organizations in southeastern

Louisiana, for a large cohort study of the effects of lifetime adversity on reproductive outcomes. To participate in the study, women needed to be between 18 and 45 years of age, and have lived in the Gulf of Mexico region during 2010, the time of the Deepwater Horizon oil spill. The women in the study were primarily young, majority Black (67 % Black, 20 % White, 9 % Hispanic, 3 % Asian), and low-income [yearly income: <$10,000 (31 %), $10,000–14,999 (16 %), $15,000–19,999 (10 %), $20,000–24,999 (10 %), $25,000–34,999 (14 %), $35,000–49,000 (9 %), ≥$50,000 (10 %)]. Most lived in urban or suburban areas, and the majority did not live directly adjacent to the coast. Trained research assistants interviewed the participants about traumatic events across their life and their mental health, and women completed a questionnaire which included information on disaster exposure. Data collection began in 2011, and through July 2014, 794 women had provided information on disaster exposure and age at the time of disaster. Thus, time between hurricane exposure and mental health assessment ranged from an average of 4.9 years (range 3–6 years) for Hurricane Gustav to 7.9 years (range 6–9 years) for Hurricane Katrina.

Approval for the study was provided by the Institutional Review Boards of the participating clinics and Tulane University; all women provided written informed consent.

Disaster Exposure Measures

Hurricane experience was measured with 11 questions based on a study of Hurricane Andrew by Kaniasty and Norris (Norris et al. 1999). Women were asked individually about Hurricanes Katrina, Rita, Ike, and Gustav. Factor analysis has previously been conducted on the measure (Harville et al. 2011) to group questions pertaining to similar aspects of exposure, resulting in three categories: damage (some or more "damage to house", "house flooded", "lost expensive belongings", "lost sentimental items", "damage to car/truck/boat", and some or greater "total property impact"), perceived/experienced danger ("felt life in danger", "walked through floodwaters", and "saw someone die"), and injury ("experienced illness/injury", "someone in household experienced illness/injury", "someone close to you died", and "someone else important experienced illness/injury"). A final question asked whether the respondent had needed to evacuate for the disaster. While some researchers have proposed that factor analysis may not be the most appropriate method for categorizing exposure items in causal indicator models (Netland 2001), it was employed to better characterize the types of experiences that may lead to depression and PTSD following exposure to a natural disaster, as recommended by Chan and Rhodes (2014), rather than to select the scale items.

Natural disaster exposure was examined for each disaster individually, as well as cumulatively across hurricanes. Hurricane experiences were evaluated as continuous counts of items within each type of exposure in order to assess how increased exposure to individual domains impacted mental health. For cumulative hurricane measures, items within each domain were summed across hurricanes to create an indicator of cumulative experience by type of exposure. High level exposure was also assessed and defined as endorsement of five or more items within the damage domain, two or more items for danger, and three or more items for illness/injury. These cut-points were chosen to ensure sufficient power to facilitate comparison of degree of exposure across hurricanes. For cumulative exposure measures, percent of the population reporting high exposure during any disaster was calculated.

Age at disaster for each hurricane was estimated by subtracting the number of years between the interview date and the date of the disaster from the participant's current age.

For cumulative hurricane exposure measures, age at the first disaster endorsed was used as the age of exposure. Participants were classified as being in early adolescence during the disaster if they were younger than 16 at the time of occurrence, and late adolescence if they were between the ages of 16–18. Age was categorized in order to assess whether mental health outcomes differed by proposed stages of development from adolescence to adulthood. Additionally, a plateau effect into adulthood was hypothesized, supported by a lack of association between age and depression and PTSD among a population of similarly aged adults exposed to Hurricane Ike (Tracy et al. 2011).

The defined categories roughly align with the developmental stages described by the American Academy of Child and Adolescent Psychiatry (AACAP) (2011). AACAP characterizes early (ages 11–14) and mid-adolescents (ages 14–16) (middle school and early high school) as being primarily interested in the present with limited thoughts of the future, and having a tendency to return to childish behavior when stressed. Conversely, late adolescents (ages 17–19, late high school years and beyond) are described as gaining increased concern for the future, and increased emotional stability, concern for others, and self-reliance. Since the hurricanes examined took place over the course of 3 years (2005–2008), participants were aging across exposures; the youngest participant, who was 10 at the time of Katrina, was 13 by the time of the final hurricane. The "early adolescent" category was therefore assigned a slightly higher cut-point in order to ensure that an adequate number of participants remained in the lowest category across disasters to avoid having to change cut-points from earlier hurricanes for later occurrences. A sensitivity analysis comparing those on the younger end of this group (10–13) to those on the higher end (14–15) showed no differences between the groups, though numbers were too small to draw adequate conclusions [n = 110 and n = 69 (Katrina), n = 76 and n = 47 (Rita), and n = 27 and n = 50 (Gustav), respectively].

Mental Health Measures

The Edinburgh Postnatal Depression Index (EDS), which has been validated for use in pregnancy (Cox et al. 1987; Murray and Cox 1990), was used to assess symptoms of depression, as approximately 25 % of the participants were pregnant at the time of interview. The interviewer administered measure consists of ten statements regarding emotions over the previous week (ex. "In the past 7 days, I have been anxious or worried for no good reason"), and the frequency of feeling these emotions. Responses are coded on a scale from 0 to 3, and scores are then summed. A higher score on the scale indicates greater depressive mood. Probable depression was defined as an EDS score greater than 12 (Eberhard-Gran et al. 2001). A high degree of sensitivity (65–100 %) and specificity (49–100 %) has been demonstrated in a number of validation studies, though a slight tendency to over-estimate depression among community samples has been noted (Eberhard-Gran et al. 2001).

Post-traumatic stress disorder (PTSD) was assessed using the Post-Traumatic Checklist (PCL-S), a 17-item instrument that asks about symptoms related to any stressful experience, based on the DSM-IV criteria for PTSD (Weathers et al. 1993). Respondents rate each item from 1 ("not at all") to 5 ("extremely") to indicate the degree to which the person has been bothered by that particular symptom over the past month (for example, "In the past month, have you been bothered by repeated, disturbing memories, thoughts, or images of a stressful experience?") The scale was asked as a general assessment of current symptomology and did not refer to a specific event. Two methods have been proposed for scoring the PCL, both of which have been shown to have good consistency with clinical

diagnosis of PTSD (Weathers et al. 1993). The first method dichotomizes PTSD at an overall score cut-off of 50, while the second method uses the individual scale items to assess PTSD symptomology according to the DSM criteria. Using this method, an item is considered positive if a score ≥ 3 is endorsed, and a respondent is coded as meeting symptom criteria for possible PTSD if at least one symptom of re-experiencing (scale items 1–5), at least three avoidance symptoms (items 6–12), and at least two hyper-arousal symptoms (items 13–17) are endorsed. The scale has been shown to have a high degree of internal consistency (Cronbach's $\alpha = 0.94 - 0.97$), and to correlate highly with other measures of PTSD (Blanchard et al. 1996; Weathers et al. 1993). Test–retest reliability has been reported as high as 0.96 at 2–3 days and 0.88 at 1 week (Blanchard et al. 1996; Ruggiero et al. 2003).

Statistical Analysis

Crude associations between early or late adolescent age at the time of each hurricane and type of hurricane experience and depression and PTSD were estimated using logistic regression analysis. Following the initial assessment, the joint association between age group at each disaster and disaster experiences with regard to development of depression and PTSD were analyzed. PTSD was analyzed first using the symptom cluster coding of PTSD, while secondary analyses used the 50 point scale cut-off. Analyses were repeated for cumulative hurricane exposures and age at the time of the first disaster. No issues with multi-collinearity were detected; thus, it was possible to include all disaster experiences in one model. The decision was made a priori to control for time between the disaster and the interview (time between first disaster and interview used for cumulative disaster experiences) and socioeconomic status, as lower socioeconomic status has previously been shown to influence post-disaster mental health (Brewin et al. 2000; Norris et al. 2002b; Tracy et al. 2011). Since income level at the time of the disaster was unknown, self-reported income during the past year (divided into seven categories, ranging from <$10,000 to $\geq$$50,000) was used as a proxy for household income at the time of the disaster. Although not an ideal measure, national analyses suggest a low degree of social mobility in the United States, especially among minority populations (Beller and Hout 2006; Isaacs 2007; Kearney 2006). Thus, an individual's socioeconomic status in adulthood, especially early adulthood, is likely similar to the household income of their parents during childhood. Sensitivity analyses indicated no association between race and any of the experiences or outcomes, and inclusion of race in models did not alter estimates. Moreover, since the majority of the early adolescents were Black, race was not included in final models as estimates became unstable when race was included with other covariates.

Possible interactions between age at disaster and disaster experiences were evaluated using a product term, with $p < 0.05$ as the criterion for accepting the interaction. A mediation analysis was also undertaken to explore whether hurricane exposures mediated the relationship between age and mental health outcomes. An additional sensitivity analysis was conducted to assess whether number of hurricanes experienced was associated with mental health outcomes by including a count of number of hurricanes reported in the final model. Lastly, restricted spline graphs for predicted probabilities of depression and PTSD by age at the time of the first disaster were constructed to evaluate the hypothesized plateau effect among adults. Preliminary review of the data revealed that too few participants who reported exposure to Ike (n = 310) were early adolescents at the time of disaster (n = 33). As a result, models became unstable beyond analysis of crude effects, and thus Hurricane Ike was excluded from further analysis. Analysis was conducted using

SAS 9.3, and a *p* value of 0.05 was considered significant for all analyses. Less than 10 % of data was missing for all disasters; the highest missing data concerned evacuation (Katrina: n = 43, Rita: n = 32, Gustav: n = 34).

Results

Of the 794 women in the original sample, 659 (83.0 %) reported exposure to Hurricane Katrina, 461 (58.1 %) to Rita, and 493 (62.1 %) to Gustav; 671 (84.5 %) reported exposure to at least one hurricane. As shown in Table 1, the mean age at interview for women in all exposure groups was the late 20s (28.8–29.1), making the mean age at disaster exposure the early 20s (21.0–22.9). Slightly more than one-quarter of the women were early adolescents during Katrina and Rita (27.2 and 26.7 %, respectively), while only 15.6 % were early adolescents during Gustav. Proportion of the exposed populations that were in late adolescence during Katrina, Rita, and Gustav were similar (16.7, 16.3, and 16.6 %, respectively). Median damage scores ranged from 1 item for Hurricanes Rita and Gustav (20.0 and 7.0 % high endorsement, respectively) to 5 items for Hurricane Katrina (51.5 % high). Median danger and illness items endorsed was 0 for all hurricanes, although high danger exposure ranged from 6.3 to 14.1 % and high illness exposure ranged from 14.1 to 43.1 % for individual disasters. The majority of participants reported evacuation for all disasters (82.3–85.2 %). Overall, 105 women (15.7 %) screened positive for probable depression and 59 (8.8 %) for PTSD (n = 50, 7.5 % for 50 point cut-off). Rates of depression and PTSD were similar within the hurricane-exposure groups (15.7 and 8.8 % respectively among Katrina-exposed participants, 15.3 and 9.4 % among Rita-exposed participants, and 16.5 and 10.2 % among Gustav-exposed participants).

Crude and adjusted associations between age group at the time of disaster and disaster experiences and depression and PTSD are shown in Table 2. Compared to being an adult during the disaster, early adolescence was found to have a protective effect on depression for both Hurricanes Katrina and Rita (OR 0.46, 95 % CI 0.27–0.80, and OR 0.37, 95 % CI 0.18–0.75, respectively). Associations were strengthened following adjustment for hurricane experiences, time between disaster and interview, and current income, and reached significance for Gustav as well following adjustment (aOR 0.35, 95 % CI 0.18–0.69; aOR 0.37, 95 % CI 0.16–0.83; and aOR 0.37, 95 % CI 0.14–0.97, respectively). Cumulatively, being in early adolescence during the first disaster experienced also reduced odds of depression as compared to adults, controlling for all covariates (aOR 0.37, 95 % CI 0.19–0.72). Trends were similar among late adolescents, but did not reach significance.

Similarly, as compared to experience during adulthood, being in early adolescence at the time of exposure was also found to be protective against PTSD for all three hurricanes (aOR 0.21, 95 % CI 0.07–0.61; aOR 0.14, 95 % CI 0.03–0.61; and aOR 0.09, 95 % CI 0.01–0.70, for Hurricanes Katrina, Rita, and Gustav, respectively). Comparable effects were seen for cumulative exposure as well (aOR 0.22, 95 % CI 0.07–0.66), controlling for hurricane experiences, time between exposure and interview, and income. Late adolescent age did not appear to be protective against development of PTSD as compared to adulthood; however, odds of PTSD were significantly higher for late adolescents as compared to early adolescents for Hurricanes Katrina and Rita, as well as for cumulative exposure. Results were similar when PTSD was evaluated using the 50 point cut-off (Table S1). There were no apparent interactions between age at the time of disaster and hurricane experiences, though slight interaction was noted for danger during Katrina and with regard to depression; effect of danger on depression was stronger among late adolescents (OR

Table 1 Sample characteristics and experiences by disaster

Disaster characteristics	Katrina (n = 659)	Rita (n = 461)	Gustav (n = 493)	Cumulative (n = 671)
Mean age at interview (range)	28.9 (18–45)	29.1 (18–45)	28.8 (18–45)	28.9 (18–45)
Mean age at disaster (range)	21.0 (10–38)	21.2 (10–38)	22.9 (12–9)	21.0 (10–38)
Age group at disaster (n, %)				
Early adolescent (10–15)	179 (27.2)	123 (26.7)	77 (15.6)	179 (26.7)
Late adolescent (age 16–18)	110 (16.7)	75 (16.3)	82 (16.6)	115 (17.1)
Adult (age 19+)	370 (56.1)	263 (57.0)	334 (67.8)	377 (56.2)
Median damage (range)	5 (0–6)	1 (0–5)	1 (0–6)	6 (0–17)
High exposure[a] (%)	51.5	20.0	7.0	50.9
Median danger (range)	0 (0–3)	0 (0–3)	0 (0–3)	1 (0–8)
High exposure[b] (%)	14.1	6.3	6.9	18.3
Median illness (range)	0 (0–4)	0 (0–4)	0 (0–4)	0 (0–12)
High exposure[c] (%)	43.1	19.6	14.1	44.1
Evacuated (%)	85.2	82.3	83.4	91.1
High exposure domains[d] (%)				
0	5.5	15.4	15.8	4.5
1	33.2	57.9	68.4	31.3
2	33.4	17.8	10.9	32.6
3	24.0	6.9	4.3	24.7
4	4.0	2.0	0.6	6.9
Probable depression (%)	15.7	15.3	16.5	15.7
PTSD symptomology (%)	8.8	9.4	10.2	8.8

[a] 5+ damage categories

[b] 2+ danger categories

[c] Any illness

[d] Number of high exposure categories plus evacuation

Table 2 Age at the time of disaster and disaster experiences and depression and PTSD: results of logistic regression modeling

Variable	Depression				PTSD			
	OR	95 % CI	AOR[a]	95 % CI	OR	95 % CI	AOR[a]	95 % CI
Katrina								
Age at Katrina[b]								
Early adolescent	**0.46**	**0.27–0.80**	**0.35**	**0.18–0.69**	**0.24**	**0.09–0.61**	**0.21**	**0.07–0.61**
Late adolescent	0.55	0.29–1.04	0.55	0.28–1.11	1.10[*]	0.57–2.14	1.14[*]	0.55–2.37
Adult	Ref.	–	Ref.	–	Ref.	–	Ref.	–
Damage	**1.16**	**1.03–1.32**	1.05	0.91–1.22	1.16	0.99–1.36	1.06	0.88–1.29
Danger	**1.47**	**1.15–1.89**	1.17	0.85–1.61	**1.65**	**1.22–2.24**	1.36	0.93–1.99
Illness	**1.68**	**1.43–1.98**	**1.51**	**1.24–1.84**	**1.61**	**1.32–1.96**	**1.39**	**1.09–1.76**
Evacuation	0.77	0.43–1.38	0.93	0.47–1.83	0.57	0.29–1.12	0.79	0.36–1.73
Rita								
Age at Rita[b]								
Early Adolescent	**0.37**	**0.18–0.75**	**0.37**	**0.16–0.83**	**0.12**	**0.03–0.52**	**0.14**	**0.03–0.61**
Late Adolescent	0.56	0.26–1.21	0.65	0.28–1.52	1.15[*]	0.53–2.46	1.38[*]	0.59–3.21
Adult	Ref.	–	Ref.	–	Ref.	–	Ref.	–
Damage	**1.20**	**1.05–1.37**	1.03	0.87–1.23	**1.29**	**1.10–1.52**	1.20	0.98–1.47
Danger	**2.55**	**1.79–3.62**	**1.86**	**1.22–2.85**	**2.28**	**1.53–3.41**	**1.61**	**1.01–2.59**
Illness	**2.03**	**1.52–2.71**	**1.60**	**1.13–2.27**	**1.71**	**1.23–2.37**	1.19	0.80–1.77
Evacuation	0.64	0.34–1.19	0.69	0.34–1.41	0.76	0.35–1.66	0.73	0.29– 1.79
Gustav								
Age at Gustav[b]								
Early Adolescent	0.49	0.22–1.06	**0.37**	**0.14– 0.97**	**0.10**	**0.01– 0.73**	**0.09**	**0.01– 0.70**
Late Adolescent	0.52	0.25–1.09	0.46	0.20– 1.05	0.56	0.21– 1.47	0.54	0.19– 1.50
Adult	Ref.	–	Ref.	–	Ref.	–	Ref.	–
Damage	**1.21**	**1.06–1.39**	0.97	0.81–1.17	**1.34**	**1.14–1.58**	1.15	0.93–1.43
Danger	**2.15**	**1.52–3.05**	**1.66**	**1.05–2.61**	**2.40**	**1.57–3.68**	**1.88**	**1.11–3.21**
Illness	**2.44**	**1.73–3.44**	**1.98**	**1.31–2.98**	**1.97**	**1.35–2.89**	1.27	0.80–2.01
Evacuation	**0.53**	**0.29–0.95**	0.64	0.33–1.27	0.84	0.42–1.70	0.74	0.34–1.65
Cumulative hurricane exposures								
First disaster[b]								
Early adolescent	**0.46**	**0.26–0.79**	**0.37**	**0.19–0.72**	**0.23**	**0.09–0.60**	**0.22**	**0.07–0.66**
Late adolescent	**0.52**	**0.28–0.98**	0.54	0.27–1.09	1.04[*]	0.54–2.01	1.28[*]	0.62–2.62
Adult	Ref.	–	Ref.	–	Ref.	–	Ref.	–
Damage	**1.09**	**1.03–1.14**	1.01	0.94–1.09	**1.13**	**1.06–1.20**	1.08	0.98–1.18
Danger	**1.44**	**1.26–1.65**	**1.26**	**1.06–1.50**	**1.54**	**1.32–1.80**	**1.34**	**1.10–1.64**
Illness	**1.38**	**1.25–1.52**	**1.25**	**1.11–1.40**	**1.31**	**1.17–1.46**	1.11	0.97–1.27
Evacuation	0.91	0.74–1.12	0.87	0.68–1.11	0.94	0.72–1.23	0.84	0.62–1.14

Bold values are statistically significant ($p < 0.05$)

[a] Adjusted for other variables under subheading plus time between disaster and interview and current income

[b] Age groups defined as: Early Adolescent (ages 10–15), Late Adolescent (ages 16–18), Adult (ages 19+)

[*] Late teen significantly different from early teen at $p < 0.05$

2.52, 95 % CI 1.12–5.66) as compared to early adolescents (OR 0.55, 95 % CI 0.20–1.51) and adults (OR 1.17, 95 % CI 0.80–1.72) ($p = 0.06$).

With regard to type of disaster experience (Table 2), crude analyses suggested that increased endorsement of exposure to damage, danger, and illness were all associated with higher odds of depression. However, following adjustment for age at the time of the disaster, time between disaster and interview, and income level, only danger and illness experiences remained associated with increased odds of depression for Hurricanes Rita and Gustav (aOR 1.86, 95 % CI 1.22–2.85 and aOR 1.60, 95 % CI 1.13–2.27; aOR 1.66, 95 % CI 1.05–2.61 and aOR 1.98, 95 % CI 1.31–2.98, respectively). Similar effects were seen for cumulative damage and illness exposures across hurricanes (aOR 1.26, 95 % CI 1.06–1.50 and aOR 1.25, 95 % CI 1.11–1.40). For Hurricane Katrina, only increased illness exposure was associated with depression (aOR 1.51, 95 % CI 1.24–1.84). Effects on PTSD were similar, with increasing illness exposures associated with PTSD among Katrina only, controlling for age at exposure, time between disaster and interview, and income (aOR 1.39, 95 % CI 1.09–1.76), and higher danger endorsement associated with increased PTSD for Hurricanes Rita and Gustav, as well as cumulatively (aOR 1.61, 95 % CI 1.01–2.59; aOR 1.88, 95 % CI 1.11–3.21; and aOR 1.34, 95 % CI 1.10–64, respectively). Results were similar, though slightly attenuated, when PTSD was evaluated using the 50 point cut-off score (Table S1).

Mediation analyses suggested that age at the time of disaster, both individually and cumulatively across hurricanes, was associated with reported levels of damage and illness, but not with danger or evacuation, which is important as danger was the type of experience most predictive of depression and PTSD in multivariate analyses. Additionally, very little change in the beta estimates was observed between crude and adjusted measurements for age following adjustment for hurricane experiences. Thus, while partial mediation is possible in the present study, it is not thought to account for the total effect of age of mental health following disaster. Inclusion of a count of the number of disasters experienced in final models suggested that number of hurricanes itself was not associated with mental health outcomes, although all other effects described previously remained significant.

Restricted spline function graphs for the predicted probability of depression and PTSD by age at the time of the first disaster is shown in Fig. 1. The spline graph for depression suggests an increasing probability of depression with age, with a slight leveling off seen in the late 20s to early 30s. An earlier plateau effect was noted for PTSD (early 20s), with a slight downturn seen in the mid to late-20s. These graphs lend support to the assumption that predicted probabilities for depression and PTSD do not increase linearly as a function of age, and may flatten out at some point in early adulthood.

Discussion

Results of the present study suggest that being in early adolescence at the time of a natural disaster, in this case, Hurricanes Katrina, Rita, and Gustav, may be protective against development of depression and PTSD following exposure. As compared to being an adult at the time of the disaster, women who were younger than 16 at the time of Katrina, Rita, and Gustav had decreased odds of depression and PTSD, which persisted even after controlling for disaster experiences, time between disaster and interview, and socioeconomic status. Similar associations were seen when risk was considered across cumulative hurricane experiences. Although a trend towards decreased risk was also noted among late
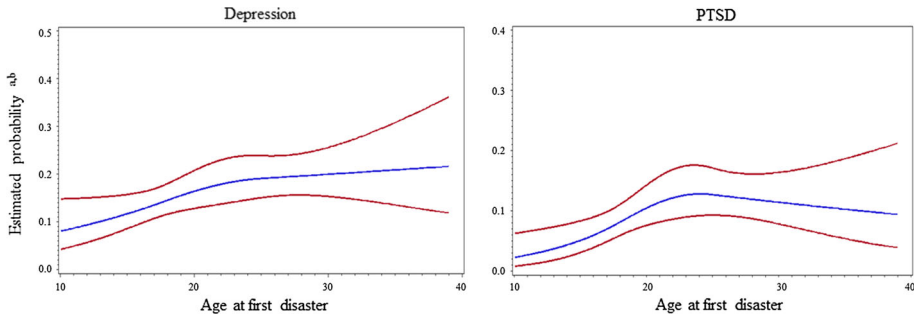
Fig. 1 Restricted spline function graph of the unadjusted predicted probabilities of depression and PTSD by age at first disaster. [a]Knots set at ages 15, 18, and 25, [b]Top and bottom lines represent 95 % CIs

adolescents, odds of depression were not significantly different from adults. As expected, higher endorsement of more severe hurricane experiences, mainly danger and illness, increased odds of depression and PTSD, both for individual hurricanes and cumulatively across disasters.

Findings from the current investigation are in line with a number of prior studies suggesting decreased psychopathology among younger children and early adolescents following exposure to a natural disaster (Adams et al. 2014; Green et al. 1991; Liu et al. 2006). However, they also stand in contrast to others that found younger age to be a risk factor for increased symptomology (Bokszczanin 2007; Giannopoulou et al. 2006; McDermott et al. 2005), further adding to the heterogeneity of existing research (Gibbs 1989; Norris et al. 2002b). One issue in comparing findings across studies is the difference in how age groups are defined (Gibbs 1989). Our "early adolescent" group is older than populations studied in other investigations, as all participants in the present study were adults at the time of recruitment. Thus, findings are likely not applicable to younger children. Additionally, our reference group of adults is comprised of young adults of childbearing age only, a group often considered to be at the highest risk for poorer mental health outcomes following disaster (Gibbs 1989). The present analysis did not take into account whether or not participants had children at the time of the disaster, as presence of children would likely not have been an issue among the majority of adolescents, and restricting analysis to adults without children would have excluded a significant proportion of the adult population, further limiting the generalizability of the study.

Nevertheless, even given these limitations, it seems reasonable that younger age may confer some protection against development of disaster-related psychopathology. First, as compared with adults, and to a lesser extent later adolescents, early adolescents may not fully comprehend the widespread impact of a natural disaster on the community at large, thereby decreasing impression about the severity of the event. Additionally, parents may succeed in shielding children and young adolescents from the full nature of the disaster and provide them with coping support, a theory which has been supported by prior research (Prinstein et al. 1996). For this reason, researchers have suggested that providing support to parents may be the most effective means of addressing distress among children following a disaster (Norris et al. 2002a). Unfortunately, we were unable to account for the effect of parental involvement and social support in this population as close caregiver contact at the time of disaster was unknown. The lack of association among older adolescents compared

to adults, and the differences between early and late adolescents with regard to PTSD, may reflect the salience of late adolescence as a time of cognitive development (Blakemore and Mills 2014), and the ability of older adolescents to more fully comprehend the extent of these disasters.

In addition, our findings regarding the effect of specific hurricane experiences on psychopathology are consistent with prior studies as well (Briere and Elliott 2000; Galea et al. 2005; Norris et al. 2002b). Overall, more severe experiences, especially with regard to danger and illness, increased odds of both depression and PTSD for all hurricanes evaluated, when considered jointly with age at the time of the event, time between the disaster and the interview, and current income. These findings are supported by recent studies showing increased psychopathology and need for mental health services among children and adolescents who report more severe experiences during a disaster (Osofsky et al. 2009; Udwin et al. 2000). Additionally, the lack of interaction between age and hurricane experiences suggests that severity of the impact of the disaster is an important predictor of mental health, regardless of the age of the individual at the time of the disaster.

Whereas many disaster-related studies have evaluated the impact of disaster experience on mental health in the period immediately following the disaster, a number of clinicians have stressed the importance of looking at the long-term health effects of disaster on mental health (Dominici et al. 2005; Gibbs 1989). These researchers emphasize that while the nature of secondary impacts will vary substantially by disaster and location, it is crucial for any epidemiologic analyses to capture the array of significant impacts, especially in the medium to long-term, and since many of these secondary effects may last for years beyond the disaster itself, long-term follow-up of the population is important (Dominici et al. 2005). Given this, a potential strength of the present study is the evaluation of mental health effects up to 9 years following the disaster. A recent study of the lingering effects of Hurricane Katrina among minority youth found that symptoms of PTSD measured at 2 and 2.5 years post disaster did not significantly decline over time and remained stably elevated following the hurricane (Weems et al. 2010). Prior studies have also suggested that the long-term effects of natural disasters on mental health among children exposed to disaster may continue into adulthood (Bolton et al. 2000; Yule et al. 2000), although effects may be tempered by more recent adult stressors (McFarlane and Van Hooff 2009).

Additionally, the present study provided us the opportunity to look at mental health effects across disasters. The consistency of the findings across disasters provides support that it is not the time between the hurricane and the outcome that is the primary driver of the associations, but is more likely related to experiences and circumstances surrounding the disaster. While cumulatively increased exposure to damage and illness increased poor mental health outcomes, age at first disaster remained protective. A possible explanation for this is that early initial exposure may better equip a person for coping during later disasters, leading to reduced long-term effects, especially when later disasters are perceived as being less severe than earlier exposures (Harville et al. 2011; Weems et al. 2014).

A limitation of the study that should be noted is that this investigation includes women aged 18–45 only, so it is unclear whether these findings would be applicable among men or older adults as well. However, women and girls have repeatedly been shown to have increased distress following disaster, as compared to men and boys (Gibbs 1989; Green et al. 1994; Norris et al. 2002a), so it is thought this study represents a higher-risk population. In addition, the study population is primarily Black, which may also limit generalizability.

Also of note, all mental health outcomes were self-reported, though the scales used have been validated as self-report measures during interviews (Blanchard et al. 1996; Cox et al. 1987; Eberhard-Gran et al. 2001; Ruggiero et al. 2003; Weathers et al. 1993). Additionally, we cannot be certain that the PTSD symptoms reported by the respondents were due to their hurricane experiences, as the PCL-S was asked without specifying a particular reference event. Furthermore, we were unable to consider an individual's propensity towards mental health issues or their mental health prior to the disaster, which may influence disaster response (Green et al. 1994; Norris et al. 2002a). However, the significant impact of discrete experiences suggests associations beyond individual risk. Likewise, since the data was collected years after the disasters, it cannot be ascertained whether reported exposures were influenced by the respondent's mental health at the time of the interview, although age at the time of the interview would not be subject to reporting bias. In spite of this, a study among youth exposed to Hurricanes Katrina and Gustav found relatively high stability in reports of exposure to Katrina years following the disaster among children who had high Gustav exposure, whereas reports decreased among those with low Gustav exposure (Weems et al. 2014). Thus, it is thought that reports of exposure should be fairly accurate overall, and, if anything, may be underreported among participants who had less stressful experiences in later disasters.

In conclusion, the present investigation suggests that those who were early adolescents at the time of the disaster were less likely to report depression and PTSD in the long-term relative to those who were adults, even when salient disaster experiences were considered. Findings were replicated across a number of hurricane exposures in the region, and cumulative hurricane experiences did not alter this association. Further, the study supports an association between specific hurricane-related experiences and mental health a number of years post-disaster, both within individual disasters and cumulatively across exposures. Replication of these associations in other populations may provide the opportunity for more targeted interventions among adolescents in order to minimize the long-term effects of large-scale natural disasters on mental health.

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