

Event-related Factors, Altruism, and Substance Use in Traumatization of Hurricane Student Volunteers: A Bayesian Model for the Follow-up

Running Head: Bayesian Analysis of Disaster Traumatization

Wenyi Li¹ & Amy L. Ai²

¹ Department of Department of Educational Psychology & Learning Systems, College of Education, Health, and Human Sciences, Florida State University, Tallahassee, FL, USA

² Institute of Longevity Study and Colleges of Social Work, Florida State University, Tallahassee, FL, USA

Correspondence: Wenyi Li, Department of Department of Educational Psychology & Learning Systems, College of Education, Health, and Human Sciences, Florida State University, Tallahassee, FL, 32306, USA. Tel: 1-870-761-7853. E-mail: wl18x@fsu.edu

Received: February 29, 2024

Accepted: March 31, 2024

Online Published: April 3, 2024

doi:10.5430/ijhe.v13n2p107

URL: <https://doi.org/10.5430/ijhe.v13n2p107>

Abstract

In surging disaster research, trauma psychologists called for more longitudinal investigation on factors related to resilience/lower traumatization for populations exposed to collective trauma. Little research has employed a Bayesian approach, a means with advantages in small samples and dichotomized endpoints. The present study addressed these needs with a two-wave survey on hurricane volunteers to demonstrate pathways to traumatization after deadly disasters. A survey was conducted at three months (Wave-1) and six months (Wave-2) after hurricane Katrina and Rita (H-KR) (N=201). Standardized instruments were used to assess posttraumatic stress symptoms (PTSS) altruism, substance use for coping, and event-related factors in Wave-1 and posttraumatic stress disorder (PTSD) in Wave-2. Bayesian structural equation modeling (Bayesian-SEM) was performed to evaluate the role of altruism and using substances to cope with Wave-2 PTSD. Traumatization was identified in 18% of participants, showing a significant increase in Wave-1 and a 12% decrease, albeit non-significant, in Wave-2. Supported by all Model fit indices, the final solution of Bayesian-SEM showed no direct overtime effect of altruism and substance use, but the indirect effects through the enhancing role of Waves-1 PTSS, on Wave-2 PTSD. Contrary to cross-sectional studies, no protection from peritraumatic positive emotions was observed. These findings emphasize the importance of longitudinal post-disaster research. Given the new evidence on volunteers' traumatization, altruism, and substance use during times of crisis with limited resources, further investigation among volunteers is crucial. The absence of identified protective factors in volunteers raises concerns for future implications in trauma psychology theory, research, and practice.

Keywords: Posttraumatic Stress Disorders and Symptoms; Altruism; Substance Use for Coping; Peritraumatic Emotional Responses; Natural Disasters; Hurricane-related Stressors; and Bayesian Structural Equation Modeling

1. Introduction

Major tropical cyclones, due to extreme climate changes, have exceeded their historical norms globally, demonstrating an increase in both scope and frequency over the past four decades (Beaglehole et al., 2018; Garfin, 2020; Kossin et al., 2020; Wang et al., 2019). For example, Category 5 Hurricane Maria (H-Maria) ravaged Puerto Rico in the autumn of 2017, causing damage surpassing \$90 billion and standing as one of the deadliest natural disasters in U.S. history, with an estimated death toll of nearly 3,000, although some estimates suggest it could be closer to 4,650 (Kishore et al., 2018; Orengo-Aguayo et al., 2019). In the following year, Category 5 Hurricane Michael (H-Michael) struck the Florida Panhandle as the most powerful hurricane on record, resulting in \$25 billion in damages to property, businesses, and infrastructure (Bevan et al., 2019; FEMA, 2020). By autumn 2022, Category-4 Hurricane Ian (H-I) devastated the southwest coast and central Florida, causing estimated damages of at least \$55-65 billion, making it one of the costliest storms recorded (Zahn, 2022). President Biden declared H-I “an American crisis” (Wilner, 2022, para. 1).

Extreme storms result not only in structural and economic damage but also in the collective traumatization of affected populations. A meta-analysis of 39 studies, involving 43,123 typhoon and hurricane survivors and utilizing

cross-continental databases, disclosed the prevalence of posttraumatic stress symptoms (PTSS) and disorders (PTSD) (N=9373, 17.81%; Wang et al., 2019). Conversely, a separate meta-analysis of 27 studies showed significant increases in PTSD and depression rates following natural disasters, while rates of alcohol misuse and anxiety remained unchanged (Beaglehole et al., 2018). Recognizing an uptick in disaster-related research, primarily cross-sectional, trauma psychologists advocated for further longitudinal investigations into factors associated with resilience or reduced traumatization among populations exposed to collective trauma, such as that induced by major disasters (Bonanno et al., 2015). This topic is critical because a recent study, utilizing data from three population surveys, uncovered persistent PTSS even 12 years after the catastrophic Hurricane Katrina-Rita (H-KR; Raker et al., 2019).

Furthermore, research on extreme disasters has extensively investigated post-disaster PTSD (Bonanno et al., 2015; Garfin et al., 2022; Wang et al., 2019). Despite the surging research of examining the effects of hurricane preparedness (Fullerton et al., 2019; Mash et al., 2022), there remains a deficiency in longitudinal investigations that adjust for contextual factors in the context of traumatic natural hazards. Researchers have emphasized the necessity for more findings concerning the long-term effects of risk factors (e.g., substance abuse) and protective factors (e.g., personality strengths) that contribute to both traumatization and recovery (Bonanno et al., 2015).

The current study aimed to fulfill the need for newly acquired follow-up data on the traumatization of student volunteers affected by H-KR, a group that has been understudied in disaster research. Specifically, to address this under-investigated population, we assessed the impact of storm-induced stressors, altruism, and substance use for coping over time on PTSD symptoms, in addition to event-induced stressors and peritraumatic emotional responses. The six-month follow-up survey after the storm was crucial as PTSD symptoms could persist and meet clinical criteria for diagnosis among student volunteers. Additionally, few studies have utilized a Bayesian approach, which offers advantages for analyzing small samples and dichotomized endpoints (e.g., using a PTSD cut-off point). Therefore, the current analysis utilized Bayesian structural equation modeling (Bayesian-SEM).

1.1 Hurricane-(Event)-Related Stressors and Emotional Reactions

Consistently, research on disasters has demonstrated the stressful impact of experiencing catastrophic storms on the traumatization of survivors. H-Maria caused Puerto Rican youths to experience high levels of posttraumatic stress symptoms (PTSS) and depressive symptoms, leading to public health and mental health crises (Orengo-Aguayo et al., 2019). In general, recent studies and systematic reviews have revealed the enduring impacts of exposure to such major catastrophes on PTSD (Beaglehole et al., 2018; Chen et al., 2021; Garfin et al., 2022; Orengo-Aguayo et al., 2019; Wang et al., 2019). A representative-sample study of Florida residents (N=1637) linked repeated direct, indirect, and media exposures to hurricanes Irma and Michael with PTSD, which in turn, was associated with functional impairment. A representative-sample study of Florida residents (N=1637) linked repeated direct, indirect, and media exposures to hurricanes Irma and Michael with PTSD, which in turn, was associated with functional impairment. Their recent survey of a representative sample of Floridians indicated that hurricane-related stressors or storm-exposure factors (loss and/or injury, evacuation) predicted persistent PTSD symptoms from fall 2017 to fall 2018.

Cross-sectional analyses of catastrophic hurricanes have associated event-based stressors and/or negative emotional responses with PTSD and substance use (Lemieux et al., 2010), as well as with depression (Ai et al., 2013). Interestingly, hurricane-induced peritraumatic positive and negative emotions predicted both depression and posttraumatic stress growth (PTG) among survivors of H-Michael in the months following the storm (Ai et al., 2022a). Peritraumatic positive emotions have been shown to play a beneficial role in both natural and man-made disasters (Ai et al., 2011, 2013, 2022a). Over the past two decades, research in positive psychology has consistently demonstrated that positive emotions are fundamental components of and predictors for life satisfaction, flourishing, and resilience (e.g., Cohn et al., 2009; Siltan et al., 2020). The broaden-and-build theory (Fredrickson, 1998; 2013) posits that positive emotions expand one's cognitive awareness, aiding individuals in developing various durable personal resources (e.g., greater mindfulness, increased self-efficacy, acting pro-socially).

More specifically, evidence suggests that experiencing peritraumatic or in-the-moment positive emotions—rather than more general positive affect or a positive life outlook—can mitigate negative effects and promote positive mental health outcomes following trauma. For instance, after 9/11, positive emotions mediated depressive symptoms among resilient college students (Fredrickson et al., 2003) and predicted lower PTSS levels at three and six months post-manmade disaster in a prospective survey (Ai et al., 2011). Similar findings were observed during the COVID-19 pandemic, particularly among individuals who had shared positive emotional experiences (Prinzling et al., 2022). Based on this compelling evidence, we expected that peritraumatic positive emotional experiences would

have a similarly beneficial effect on PTSD, in contrast to the detrimental role of peritraumatic negative emotions observed among Hurricane Katrina-Rita volunteers.

1.2 Complex Roles of Altruism

In positive psychology, the Virtues in Action (VIA) framework involves six basic human virtues (i.e., humanity, transcendence, and temperance) which are expressed through 24 trait-like character strengths (Peterson & Seligman, 2004). Altruism is often used as an indicator of character strength *kindness*. Reflecting universal aspects of human morality, kindness signifies deep interpersonal connections among individuals in desperate need of assistance. Altruism embodies an individual's profound moral consciousness and involves personal benevolence, unselfish concern for the welfare of others, and giving without expecting reward (Monroe, 1996). Additionally, altruism, as an internal strength, reflects a selfless desire to live for others in the pursuit of shared goals of happiness and progress (Dixon, 2005).

In the framework mentioned above, character strengths are believed to enhance coping mechanism during challenges and traumatic events, thereby promoting resilience and maintaining quality of life during crises (Peterson & Seligman, 2004). Consequently, altruism is highly valued during times of crisis following collective traumas such as disasters, wars, and other life-threatening emergencies requiring assistance. In a prior study on H-KR, altruism and hurricane-related stressors were both linked to the commendable actions of individuals engaged in volunteer activities and holding professional values (Plummer et al., 2008). An early retrospective study of combat veterans identified altruism as the primary predictor for lower levels of PTSD symptoms, or PTSS (Kishon-Barash et al., 1999). Furthermore, a SEM demonstrated a favorable pathway from altruism to reduced levels of depression among H-KR student volunteers, mediated by optimism (Ai et al., 2013).

Nevertheless, the limited research on altruism following collective trauma has not yielded consistent results among individuals exposed to disasters. For example, in a recent cross-sectional study of H-Michael survivors, altruism was found to be positively associated with higher levels of PTSS (Ai et al., 2022a). The authors attributed this undesirable association of altruism with PTSS to the greater levels of altruism observed among Latinx H-Maria survivors, who experienced more severe stressors, compared to their mostly White Floridian H-Michael counterparts, who had more resources (Ai et al., 2022a). Additionally, as noted by the authors, the collectivist culture of Latinx individuals could also contribute to the traumatization of altruistic helpers during H-Maria. In general, helpers, such as first responders, frontline workers, and volunteers, face tremendous challenges themselves, including sacrificing their own well-being and even their lives. Whether altruism has lasting harmful effects on helpers themselves and mediates the positive role of peritraumatic positive emotions on Wave-2 PTSD remains uncertain. Therefore, further prospective research, like the current study, is warranted to elucidate its complexity.

1.4 The Overtime Impact of Using Substance for Coping

A previous report on natural hazards documented the federal government's indifference toward providing services to and repairing disadvantaged communities (Rivera and Miller, 2007). Additionally, media reports emphasized the severe damages to those communities following Category-5 Hurricanes Katrina in Louisiana (Davidson et al., 2013; Raker et al., 2020). Due to the lack of immediate public services, resources, and support right after major disasters, victims are likely to use whatever tangible means they have to cope with multidimensional challenges and crises (Bistricky et al., 2019; Cherry et al., 2017; Glass et al., 2009). However, not all coping mechanisms are adaptive. For instance, negative coping strategies increase the risk of poor adjustment (Lazarus and Folkman, 1984), and following natural disasters, avoidant coping has been positively associated with PTSS (Bistricky et al., 2019; Brooks et al., 2020) and depression (Appel et al., 2021).

One such negative coping mechanism is substance use. This maladaptive strategy was a critical concern for H-KR volunteers as they prioritized the well-being of evacuees, potentially risking their own traumatization during the catastrophe (Lemieux et al., 2010). When the State disaster relief system was temporarily paralyzed during the unprepared flood caused by H-KR, helpers may have had to resort to the most tangible means to cope. In the literature on substance use, two major frameworks underlie this concern regarding its relationship to the outcome of interest: the self-medication hypothesis (SMH; Khantzian, 1997) and the maladaptive coping assumption (MCA; Carver, 1997). First, SMH presumes that substances may be used in attempt to alleviate suffering from trauma-based painful feelings (Dube et al., 2003; Khantzian, 1997). Mood-altering substances are used either to numb or calm chaotic emotions or to help users dissociate from distress and other negative psychological responses (Brown & Wolfe, 1994; Dube et al., 2003). Second, the MCA assumes that at-risk behaviors—such as substance use—are manifestations of poor coping skills used to manage affective problems (e.g., anger, pain) following exposure to trauma (Carver, 1997).

Maladaptive coping strategies, including substance use, have been associated with detrimental psychological effects, poor quality of Life (QOL), and depression, especially following traumatic events (Appel et al., 2022; Bistricky et al., 2019; Cherry et al., 2017; García et al., 2019; Glass et al., 2009). Such negative coping strategies can mediate the link between peritraumatic responses, triggering trauma appraisals and post-traumatic symptoms (Barlow et al., 2017; Marsac et al., 2016). Interestingly, substance use has been found to have non-uniform roles in PTSD and depression in existing studies on hurricanes, as noted in the above survey on H-MM survivors (Ai et al., 2022a, 2022b), as well as observed in the cross-sectional study on H-KR survivors (Lemieux et al., 2010). Based on the literature, we expected a detrimental effect of this negative coping strategy on PTSD over time in the follow-up of H-KR volunteers.

1.5 The Present Study

Based on the findings from the cross-sectional studies on H-KR and H-MM (Ai et al., 2022a, 2022b; Lemieux et al., 2010), we constructed a hypothetical model (Model 1; Figure 1) to examine the enduring effect of altruism and substance use for coping on traumatization of student volunteers in Wave-2 survey conducted six-months after the storm, while controlling for symptom levels reported in Wave-1 survey (Lemieux et al., 2010). In Wave-2 survey, or the follow-up, a cutoff point was employed for PTSD to provide better guidance for clinical practice and disaster relief work. To address the issue of a small sample size, we utilized Bayesian-SEM which offers computational advantages when dealing with dichotomized factors in small samples (Muthén & Asparouhov, 2012).

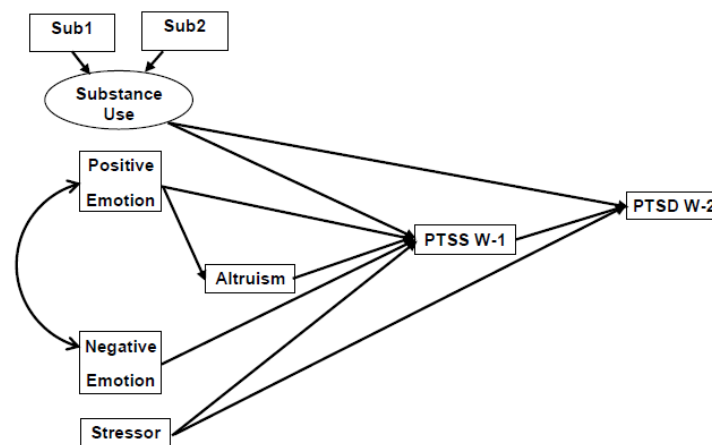


Figure 1. Model 1. Basic Conceptual Model with Concept Structure

Model 1 estimated the direct effects of the primary predictors, altruism, and substance use, on Wave-2 PTSD, considering the overtime effects (Ai et al., 2022a). Drawing from the disaster literature, we expected peritraumatic positive emotions to have a positive impact, while altruism and substance use were anticipated to have a negative impact on coping with Wave-1 PTSS (Ai et al., 2022a, 2022b; Lemieux et al., 2010). We posited a positive pathway from Wave-1 PTSS to Wave-2 PTSD, attributed to enduring traumatization. Furthermore, we suggested positive pathways linking hurricane-related stressors and peritraumatic negative emotions to Wave-1 PTSS (Ai et al., 2022a, 2022b; Lemieux et al., 2010). Bayesian-SEM was utilized to assess both the total and indirect effects of exogenous variables.

2. Method

2.1 Participants

Student volunteers were recruited from two universities within the H-KR affected area. Eligible participants were those who were students during the period when their respective institutions were actively involved in disaster relief efforts following H-KR. Their voluntary disaster relief work included donating services, offering accommodations, counseling provision, and assistance in victim shelters (Plummer et al., 2008). Initial analysis indicated no effect of university locations on the primary outcome. Consequently, the sample from both universities was combined for modeling purposes.

Among the 201 participants who completed surveys in both Waves 1 and 2, the mean age was 30.38 years ($SD=9.45$), with 91.0% being female. The age and gender distributions were similar to those of the student populations at two relevant professional schools within the disaster-affected region. Regarding racial identity, African Americans comprised 38.8% and Whites comprised 52.7% of the sample, respectively.

Appropriate identification of research participants is critical to the science and practice of psychology, particularly for generalizing the findings, making comparisons across replications, and using the evidence in research syntheses and secondary data analyses. If humans participated in the study, report the eligibility and exclusion criteria, including any restrictions based on demographic characteristics.

2.2 Procedures

Three months after H-KR and subsequent approval from Institutional Review Boards of two universities in the Gulf Coast area, the study started. The three-month interval between the disaster onset and the study initiation was primarily attributable to the necessity of completing human subject applications and setting up instrumentation at all participating sites. Participation encouragement was facilitated through posters, emails, and direct faculty communication. Researchers at each site disseminated a packet comprising an informed consent letter, consent form, survey, and return envelope.

The questionnaire, requiring approximately 30 minutes for completion, included key constructs within the conceptual model, as well as assessments of peritraumatic emotional reactions to H-KR and demographic information. Returned questionnaires were inputted into the SPSS 18 database at individual sites before being aggregated at a centralized location. Three months after the Wave-1 survey, the Wave-2 survey was conducted, evaluating PTSD for the second time, utilizing the same procedures.

2.3 Measures

All constructs used in the SEM are presented in Table 2.

Posttraumatic Stress Disorder Symptoms (PTSS) and PTSD. PTSS and PTSD were assessed using the 17-item Modified PTSD Symptom Scale (MPSS-SR; Falset et al., 1993). Participants reported the frequency of experiencing each symptom over the preceding month on a 4-point scale. Scores were totaled for each respondent (reliability, $\alpha = .95$, Mean, $M = 31.35$, Standard Deviation, $SD = 12.80$; range = 4-68). PTSS scores were utilized in Wave-1 due to the insufficient three-month duration to establish a proxy for potential PTSD. In Wave-2, a cut-off score of 14 (e.g., total score = 14, coded as "no" for PTSD; total score = 15, coded as "yes" for PTSD; Coffey et al., 2006) was employed as a threshold for clinically significant indications of PTSD.

Substance Use for Coping. Substance use for coping was assessed using two items adapted from the 30-item Brief COPE (Carver et al., 1989): Item-1 inquired about "Using alcohol or other drugs to help me get through it," while Item-2 addressed "Using alcohol or other drugs to make myself feel better." These items were considered maladaptive coping strategies (Bistricky et al., 2019; Glass et al., 2009). Participants indicated the extent to which they utilized these coping strategies since the occurrence of H-KR on a 4-point scale (0 = not at all, 3 = a lot). The composite score was dichotomized (0 = No, 1 to 3 = Yes), with 16.6% and 14.2% of the sample responding "Yes" for item-1 and -2, respectively.

Altruism, serving as an indicator of character strength kindness, was evaluated using the 20-item Self-Report Altruism Scale (Rushton, Chrisjohn, & Fekken, 1981), assessing the extent to which respondents had engaged in different types of altruistic behaviors or actions (e.g., giving money to charity, donating blood, and volunteering). This scale gauged the frequency with which respondents participated in various altruistic behaviors or actions, such as donating money to charity, giving blood, and volunteering. Participants rated each statement on a 4-point scale ranging from 0 (Never) to 4 (Very often; $\alpha=.91$, $M=47.91$, $SD=15.41$).

Hurricane-related stressors. Hazard-specific stressors were measured using an 18-item checklist developed by investigators specifically for post-disaster use (Plummer et al., 2008). Participants indicated the stressors they experienced during the month immediately following HMM (e.g., being an evacuee, or experiencing loss of personal property). Scores were derived by summing the responses, with higher scores indicating a greater number of stressors ($M = 8.25$, $SD = 2.61$, range = 0-17).

Peritraumatic Emotional Responses, serving as one indicator of emotional reaction to H-KR within the during the month following H-KR, was measured using a checklist, Types of Peritraumatic Emotional Responses originally developed for Ai et al.'s (2005a, b) 9/11 study. The instructions were modified to specify the context of H-KR that evoked such emotional reactions. Using a 5-point Likert scale (1=Not at all, 5=A great deal), participants indicated the extent to which they experienced 12 types of emotional reactions (e.g., horror/shock, anger/hatred, fear/worry, gratitude for the international support, compassion toward people of world who have experienced similar tragedy and feeling of relief for the safety of one's beloved persons) along with an additional "Other" item. The first five items were aggregated as negative emotional responses ($\alpha=.82$, $M=12.27$, $SD=4.03$), while the remaining seven items constituted positive emotional responses ($\alpha=.83$, $M=23.69$, $SD=4.05$).

Demographics. Race identity and gender were dichotomized in to 0 and 1(0=Non-White, 1=White; 0=Male, 1=Female).

2.4 Data Analysis

Data were entered into a database utilizing a double-entry system to enhance data quality. Missing values were not imputed, and listwise deletion was employed for all measures in the primary statistical analyses. SPSS 27 was utilized to conduct z-order correlations, which were performed to explore the bivariate relationships among constructs in the theoretical model. Subsequently, the R package blavaan (Merkle & Rosseel, 2015) was employed to estimate the hypothetical Bayesian Structural Equation Model (Bayesian-SEM) to predict Wave-2 PTSD, while adjusting for Wave-1 PTSS (Model 1, as illustrated in Figure 1).

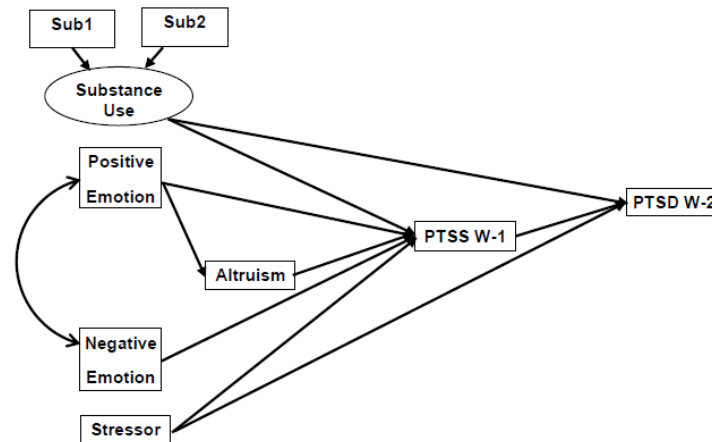


Figure 1. Model 1. Basic Conceptual Model with Concept Structure

Model 1, Substance Use for Coping was represented by a latent factor with two indicators (items 1 and 2). A path was specified from Wave-1 PTSS to Wave-2 PTSD. As the primary focus, two pathways from altruism and Substance Use for Coping to Wave-2 PTSD were evaluated, respectively, to determine if they exhibited longitudinal risk effects. Building upon prior cross-sectional research (Ai et al., 2022a; Lemieux et al., 2010), positive associations between substance use and hurricane-related stressors with Wave-1 PTSS were hypothesized. Altruism was expected to mediate the relationship between peritraumatic positive emotions (Ai et al., 2013, 2022a), though the direction between altruism and Wave-1 PTSS remained uncertain due to mixed findings in the literature. Additionally, a favorable effect of peritraumatic emotion on Wave-1 PTSS was estimated. Lastly, negative, and positive emotions were assumed to be correlated based on previous research findings.

In Bayesian-SEM, the hypothetical model was estimated using mean scores of all scaled indicators, except for item 1 and 2 from Substance Use for Coping, which utilized categorical scores. All paths between measurement and structural constructs in the hypothetical models were simultaneously estimated, with path coefficients estimated in the presence of residual measurement errors in the equations. In this approach, all paths were tested, and both direct and indirect effects of the antecedent variables on PTSD were calculated (MacKinnon et al., 2002; Shrout & Bolger, 2002).

Moreover, default non-informative priors were applied to the latent variable and all observed variables in the Blavaan package (e.g., $N(0,10)$; Merkle & Rosseel, 2015), and the covariance utilized beta (1,1) as the non-informative prior (refer to Table 2 for specific details). Additionally, the Bayesian SEM model employed three chains in total, with each model adopting 1000 burn-in draws and 5000 sample draws, totaling 6000 draws.

In the current analysis, several model fit indices were utilized. As recommended by Gelman and colleagues (1996), Levy (2011), and Hoofs et al. (2018), Garnier-Villarreal and Jorgensen (2021) summarized and proposed new Bayesian SEM fit indices. They introduced the posterior predictive p-value (PPP) as a measure of overall model fit, which is based on the familiar chi-square model fit statistic, comparing the hypothesized model with a baseline model. This index is commonly adopted in most Bayesian SEM software.

Additionally, Hoofs et al. (2018) introduced the Bayesian variant of the residual mean squared error (BRMSEA) to address issues with PPP rejection of all models when sample size is large (e.g., $N > 1000$). A lower bound of residual mean squared error of approximation (RMSEA) below .05 indicates adequate fit, as suggested by Browne and Cudeck (1993), which is also applied in Bayesian RMSEA.

Furthermore, conventional indices such as the Comparative Fit Index and Tucker-Lewis Index (CFI and TLI; Bentler, 1990) were utilized, with recommended adequate fit values around .95 or higher (Hu & Bentler, 1999). Since missing values were extremely rare in the subsample that participated in both waves, no modifications were made to any cell for any of the measures.

3. Results

3.1 Correlational Analysis

The results of a two-sample proportion Z-score test showed that in Wave-1 18.30% (30 out of 164) of student volunteers experienced PTSS above the cutoff point. In wave 2, the rate decreased to 11.59% (19 out of 180), and the reduction was not significant at level of .05 (Table 1). In Table 1, the following significant correlations were observed. Wave-1 PTSS exhibited significant positive correlations with Substance Use for Coping items 1 and 2, negative emotions, altruism, and stressors. However, it was not significantly correlated with positive emotions. Additionally, significant positive correlations were found between Wave-1 PTSS and Wave-2 PTSD. Positive emotions were significantly and positively associated with altruism.

Table 1. Descriptive Statistics and Correlations.

	Wave-2 PTSD	Sub1	Sub2	Negative emotion	Positive emotion	Altruism	Wave-1 PTSD	Stressor
Wave-2 PTSD	1							
Sub1	.217**	1						
Sub2	.257**	.731**	1					
Negative emotion	.238**	.042	.056	1				
Positive emotion	.029	-.125	-.200**	.324**	1			
Altruism	.098	.034	-.018	.100	.303**	1		
Wave-1 PTSD	.390**	.235**	.319**	.322**	.022	.140*	1	
Stressor	.272**	.085	.028	.275**	.147	.204**	.277**	1
Mean	.136	.166	.142	2.547	3.381	2.122	.473	5.530
SD	.343	.373	.350	.813	.561	.639	.519	3.233

Note: Sub 1 is "Using alcohol or other drugs to help me get through it". Sub 2 is "Using alcohol or other drugs to make myself feel better."

** . Correlation is significant at $p < 0.01$ level. * . Correlation is significant at $p < 0.05$ level.

3.2 Bayesian SEM Analyses

In Figure 2, only significant standardized path coefficients were displayed in bold, as they did not encompass zero in the final model (Model 2). For each of the three chains, we conducted 6000 iterations (including burn-in and sample drawings) of Bayesian SEM. The convergence of the model was assessed by ensuring that univariate $R^2 < 1.10$ for each parameter (Brook & Gelman, 1998). In addition, model convergence was verified by inspecting the trace plots for each parameter in Appendix A. All trace plots exhibited consistent waves for each chain. Despite the small sample size in this study, the Bayesian SEM converged, indicating that the proposed model was correctly specified. The five fit indices all indicated that the model adequately fit the data (Table 2). The posterior predictive p-value was 0.051, suggesting the model adequately fit the data. The CFI (.983) and TLI (.992) exceeded the benchmark criteria of .95. RMSEA was less than .001, falling within the range of good fit.

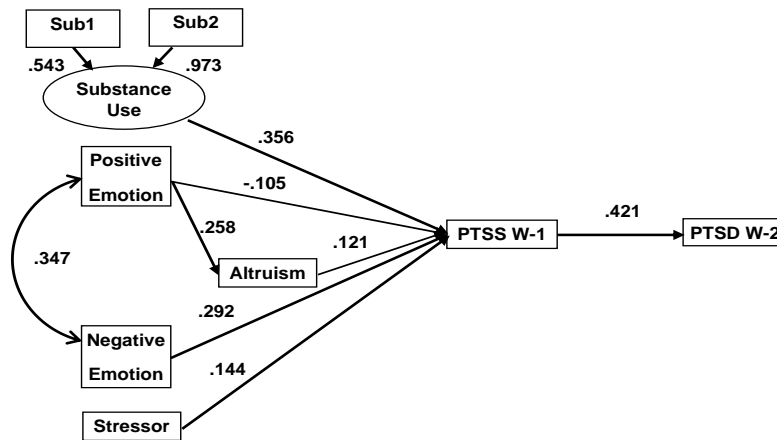


Figure 2. Model 2. Final Solutions with Standardized Loading

The initial estimation of Model 1 using the R blavaan package demonstrated a good fit to the data. Additionally, the modification index suggested that no theoretically plausible paths should be added to improve the model fit further. In other words, no additional direct links among constructs were recommended. Consequently, the original model (Figure 1) was considered partly as the final model, with two non-significant paths removed (both directed from substance use and stressor to Wave-2 PTSD).

Therefore, the final solution (Figure 2, Model 2), including standardized coefficients of all significant paths bolded, indicated that the latent factor, Substance Use for Coping, was adequately measured by its respective indicators, with high standardized factor loading size. Compared with Model 1, however, the two non-significant paths (i.e., both directed from positive emotions and altruism to Wave-1 PTSS) were not bolded in Model 2.

Figure 2 illustrated the significant (bold) paths in Model 2, which were generally consistent with those in the hypothetical Model 1. However, not all significant correlations in the zero-order analysis remained significant paths here. Despite this, all paths of the major constructed manifested in the anticipated directions while adjusting for impacts of peritraumatic emotional responses. As expected, Substance Use for Coping exhibited a direct enhancing effect on PTSS in Wave 1. Similarly, both negative emotions and stressor had direct strengthening effect on Wave-1 PTSS. Additionally, Wave-1 PTSS served as a steppingstone for Wave-2 PTSD. However, some paths did not reach the level of significance as assumed following the Wave-1 SEM, as noted above. Importantly, both predictive variables of major interests, altruism and substance use for coping, did not have a significant direct effect on Wave-1 PTSS.

Table 2 presented the completely standardized direct effects of all antecedent variables on Wave-1 PTSS and Wave-2 PTSD, as well as Substance Use for Coping. Bolded values indicated the 95% credibility interval did not include zero. The latent variable Substance Use for Coping comprised items 1 and 2 from Substance Use for Coping, the standardized loadings were .545 and .973, respectively. In the Bayesian SEM, Wave-1 PTSS (e.g., .421) significantly affected Wave-2 PTSD in the same direction. Substance use for Coping (e.g., standardized loadings = .356), negative emotions (.269), altruism (.121), and stressor all exhibited a significant positive relationship with Wave-1 PTSS. Additionally, there was a significant positive relationship (e.g., .258) between positive emotions and altruism. Lastly, the covariance between negative and positive emotions indicated their significant correlation.

Table 2. Summary Statistics of the Posterior Distribution (N=164)

		Estimates	SD	95% CI		SL	R-hat	Prior
Latent Variables								
<i>Substance</i> ~	Sub1	1	NA	NA	NA	.545	NA	N (0,10)
	Sub2	1.175	.114	.937	1.398	.973	1.000	N (0,10)
Regressions								
Wave-2 PTSD~	Wave-1 PTSD	.263	.044	.176	.347	.421	1.000	N (0,10)
Wave-1 PTSD~	Positive emotion	-.096	.070	-.234	.043	-.105	1.000	N (0,10)
	Altruism	.097	.059	-.021	.214	.121	1.000	N (0,10)
	Substance	.386	.085	.224	.559	.356	1.000	N (0,10)
	Negative emotion	.190	.050	.093	.288	.292	1.000	N (0,10)
	Stressor	.023	.012	<.001	.046	.144	1.000	N (0,10)
Altruism	Positive emotion	.294	.088	.121	.466	.258	1.000	N (0,10)
Covariances								
Positive emotion~~	Negative emotion	.157	.037	.088	.235	.347	1.000	Beta (1,1)
Test Statistics								-945.506
PPP								.051
BCFI/BTLI								.983/.992
BRMSEA								<.001

Note: CI is the credible interval, SL is standardized loadings. Sub 1 is Using alcohol or other drugs to help me get through it”. Sub 2 is “Using alcohol or other drugs to make myself feel better. “Bold cases: the estimates lie within the 95% highest probability density interval. PPP: posterior predictive p-value.

Table 3 displayed the standardized indirect effects of positive emotions Wave-1 PTSS. However, the effect between them was not statistically significant, indicating Altruism did not statistically significant mediate the effect between peritraumatic positive emotions and Wave-1 PTSS, and neither factor had no influence on Wave-2 PTSD. Moreover, Table 3 revealed the indirect effects of Substance Use for Coping, stressor, and negative emotions on Wave-2 PTSD, Substance Use for Coping had significant indirect effects on Wave-2 PTSD via Wave-1 PTSS. Similarly, stressor also had a significant indirect effect on Wave-2 PTSD via Wave-1 PTSS. Additionally, negative emotions exhibited a significant positive indirect effect on Wave-2 PTSD via Wave-1 PTSS. However, positive emotions did not enhance the indirect effect on Wave-2 PTSD. Therefore, the total effects of exogenous variables on Wave-2 PTSD were almost all significant, except positive emotions.

Table 3. Total Indirect effects of Exogenous Variables on the Outcomes

Exogenous Variables	Wave 1 PTSS		Wave 2 PTSD	
	Estimates (CI)	Z	Estimates (CI)	Z
Substance use	NA	NA	.102(.039,.194)	.150
Stressor	NA	NA	.006(.001,.016)	.061
Positive Emotion	.029(-.003,.100)	.031	-.025(-.041,.015)	-.249
Negative Emotion	NA	NA	.050(.016,.100)	.123

Note: Bold cases: the estimates lie within the 95% credibility interval. Z: standardized indirect effect.

4. Discussion

Echoing the call for longitudinal investigation on predictors for resilience and post-disaster well-being (Beaglehole et al., 2018; Bonnano et al., 2015; Garfin et al., 2022), the present analysis utilized a prospective design to evaluate the predictors for PTSD six-months after H-KR among student volunteers. To address the issue of sample-size and a dichotomized outcome, we employed a novel, flexible statistical approach (Bayesian SEM) to display pathways. Consequently, all model fit indices met the criteria for the adequate final solution, with the directions of most paths in the final model consistent with those in the hypothetical one. However, the final solution only demonstrated risk factors for PTSD in the follow-up, with no significant protective factors identified. Additionally, an alarming finding highlights the relatively high proportion of H-KR student volunteers who met a threshold close to a clinically meaningful PTSD diagnosis in both Wave-1 and -2 (18% more and 12% less, respectively), without a statistically significant reduction between waves, echoing the findings of Racker et al. (2019).

Elaborating on the major findings, it is crucial to note the rates of PTSD among H-KR student volunteers, as this topic concerning this valuable workforce in disaster relief is often under-addressed. When volunteers were called upon to assist victims and evacuees immediately after H-KR, they were required to prioritize the needs of others over their own well-being (Plummer et al., 2008). Some volunteers were themselves evacuees, while others offered their own homes to host evacuees. Similarly, a study involving Malaysian disaster relief student volunteers (N = 332) found that approximately 91% of them experienced recurring stress throughout their lives, leading to burnout (Chen et al., 2021). Among this group, 96.8% reported experiencing at least some symptoms of PTSD despite expressing satisfaction with their lives. volunteer activities can result in adverse impacts on the health of disaster relief responders due to various factors such as environmental hazards, infectious conditions, dermatologic, gastrointestinal, and respiratory diseases, as well as injuries like burns, fractures, and cuts (Sullivent et al., 2006; Garbern, Ebbeling, & Bartels, 2016). The current analysis underscores the need for further research and assessment in future disaster relief work, highlighting the importance of addressing the well-being of volunteers who play a crucial role in post-disaster recovery efforts.

Second, the final solution of Bayesian SEM suggests that there was no direct lasting impact of altruism on PTSD at the follow-up, contrary to what was shown in the cross-sectional H-MM study (Ai et al., 2022a). In this H-MM case, the discussion surrounding the undesirable relationship between altruism and post-storm pathological outcomes prompted a call for more prospective investigation. From the current analysis, it might be inferred that altruistic actions of student volunteers could be associated with distress in the short-term after catastrophe but may have long-term harm. Stated differently, the positive link between altruism and PTSS in both cross-sectional (H-MM, Ai et al., 2022a) and current prospective surveys could be attributable to the storm-induced stressful contexts. Yet, this follow-up H-KR study did not rule out indirect effects of altruistic actions on Wave-2 PTSD, mediated through their association with Wave-1 PTSS. The finding thereby corroborated the mixed literature about this indicator of character strength kindness in dangerous situations (Ai et al., 2013; Ai et al., 2002a; Kishon-Barash et al., 1999).

The current analysis also revealed no direct lasting impact of Substance Use for Coping on PTSD at the six-month follow-up among H-KR student volunteers, though this negative coping mean was associated with Wave-1 PTSS, as observed in cross-sectional hurricane studies (Ai et al., 2022b; Lemieux et al., 2010). The consistent findings from one-time surveys suggested that catastrophes were often accompanied by the increased use of substance for coping, reinforcing theories on its usage as a negative coping mean. This aligned with the self-medication hypothesis (SMH), which suggested that substances may be used to alleviate trauma-induced painful feelings (Dube et al., 2003; Khantzian, 1997). Additionally, the maladaptive coping assumption (MCA) posits that poor coping skills, such as substance use, may be employed to manage affective problems (e.g., anger, pain) following exposure to trauma (Carver, 1997). Moreover, similar to the findings in altruism-related paths, the Bayesian SEM revealed a significant indirect effect of substance use for coping on PTSD at the follow-up. Taken together, further prospective investigation is warranted to elucidate its true impact on long-term post-storm pathological outcomes.

Moreover, the pathological role of hurricane-related stressors is not new and has been demonstrated in over 100 studies (Garfin et al., 2022). The same holds true for peritraumatic negative emotions (Ai et al., 2022a, 2022b). However, an interesting finding from the current study was the complex role of positive emotions. In the current analysis, both the total and indirect effects of positive emotions on Wave-2 PTSD were null due to an undesirable link between altruism and Wave-1 PTSS, despite their enhancing role on altruism and weakening role on Wave-1 PTSS. Nevertheless, the positive aspect of this emotional reaction to catastrophe was highlighted in correlations between the two types of peritraumatic emotions during both H-M and H-KR, as well as in the beneficial roles of positive emotions. Positive emotions exhibited an indirect favorable effect on low depression three months post

H-KR, mediated through links involving perceived spiritual support, altruism, and positive attitudes in the Wave-1 H-KR study (Ai et al., 2013). This effect was opposite to the detrimental impact of negative emotions. Similarly, positive emotions also demonstrated overall positive influences on well-being (indicated by posttraumatic growth, quality of life, and low depression), mediated by spirituality and hope, among H-M survivors (Ai et al., 2022b).

Contrary to both theory (e.g., broaden-and-build; Fredrickson, 1998) and past findings following man-made disasters (e.g., Ai et al., 2011; Fredrickson et al., 2003), peritraumatic positive emotions did not buffer against Wave-2 PTSD. One plausible explanation may be the sheer amount of devastation caused by the two hurricanes. In less than one month, more than one million people were evacuated, with more than one million housing units damaged, resulting in financial costs of more than \$100 billion (Green & Olshansky, 2012). Thus, it seems reasonable to suggest that the unprecedented nature of the event left even the most positively oriented individuals helpless in the face of the suffering and recovery effort. Another possibility might lie particularly in some unknown aspect in this sample of student volunteers, such as high levels of distress under circumstance of both storms and the onset of a new academic term. Conversely, negative emotions also had opposite effects on H-M outcomes, mediated through Substance Use for Coping. Taken together, it is essential to consider both sides of the coin to reflect the truly complicated patterns in the trajectory of post-disaster reactions.

This study has several limitations. First, all factors in the model were assessed via self-report, which cannot substitute a diagnosis made by clinical assessment. Setting a symptom cut point for PTSS was only intended to better inform clinical intervention, not to make a diagnosis of PTSD. Despite the advantage of employing a state-of-the-art statistical tool, Bayesian SEM for testing a theoretical model, the approach does not eliminate alternative models. To minimize alternative solutions, we tested over a dozen models but did not find any that had a better fit while meeting the rationale underlying the hypothetical model. As mentioned previously, this novel tool does have the benefit of addressing the statistical power for the small sample size and dummy endpoints. Ultimately, the findings reveal that no protective factors were identified in the current analysis, even after conducting post hoc analyses on additional factors such as optimism and hope.

Given the acknowledged limitations, the current analysis has provided valuable insights that were not available in cross-sectional studies, which revealed complex risk factors for traumatization and wellbeing (Ai et al., 2022a, 2022b). The different findings regarding altruism and positive emotions between the current study and cross-sectional hurricane studies offer new evidence supporting the exploration both protective and risk factors in prospective studies (Beaglehole et al., 2018; Bonnano et al., 2015; Garfin et al., 2022). When considering self-care and interventions for student volunteers, caution must be exercised regarding the potential costs of altruistic actions and the use of negative coping mechanisms during crises, as evidence in previous studies on other types of heroes and helpers. Future investigations may utilize more valid clinical assessments and larger sample to replicate these findings, particularly giving the increasing impact of climate change on mental health of helpers who play a critical role in delivering the timely disaster relief for victims.

For clinical implications, future research focusing on risk and protective factors using prospective designs and advanced modeling tools will be crucial for enhancing the clinical assessment and intervention of long-term traumatization following disasters. Continuing this line of investigation is imperative, considering the enduring nature of PTSS and PTSD following major disasters like H-KR (Raker et al., 2019), as well as the growing impact on public health globally. As extreme disasters strain government resources, it is essential for researchers and clinicians to pay close attention to the mental health of student volunteers to safeguard their invaluable contributions.

Acknowledgements

We gratefully acknowledge the contribution of two universities for data collection and of Author A. Raney to an earlier version.

References

- Ai, A. L., Cascio, T., Santangelo, L. K., & Evans-Campbell, T. (2005a). Hope, meaning, and growth following 9-11. *Journal of Interpersonal Violence, 20*(5), 523-548. <https://doi.org/10.1177/0886260504272896>
- Ai, A. L., Ladd, K. L., Peterson, C., Cook, C., Shearer, M., & Koenig, H. G. (2010). Long-term adjustment after surviving open-heart surgery: The effect of using prayer for coping replicated in a prospective design. *The Gerontologists, 50*(6), 798-809. <https://doi.org/10.1093/geront/gnq046>
- Ai, A. L., Lemieux, C., Richardson, R., ...& Ellison, C. G. (2013). Character strengths and deep connections following Hurricanes Katrina and Rita: Spiritual and secular pathways to resistance among volunteers. *Journal for the Scientific Study of Religion, 52*(3), 537-556. <https://doi.org/10.1111/jssr.12043>

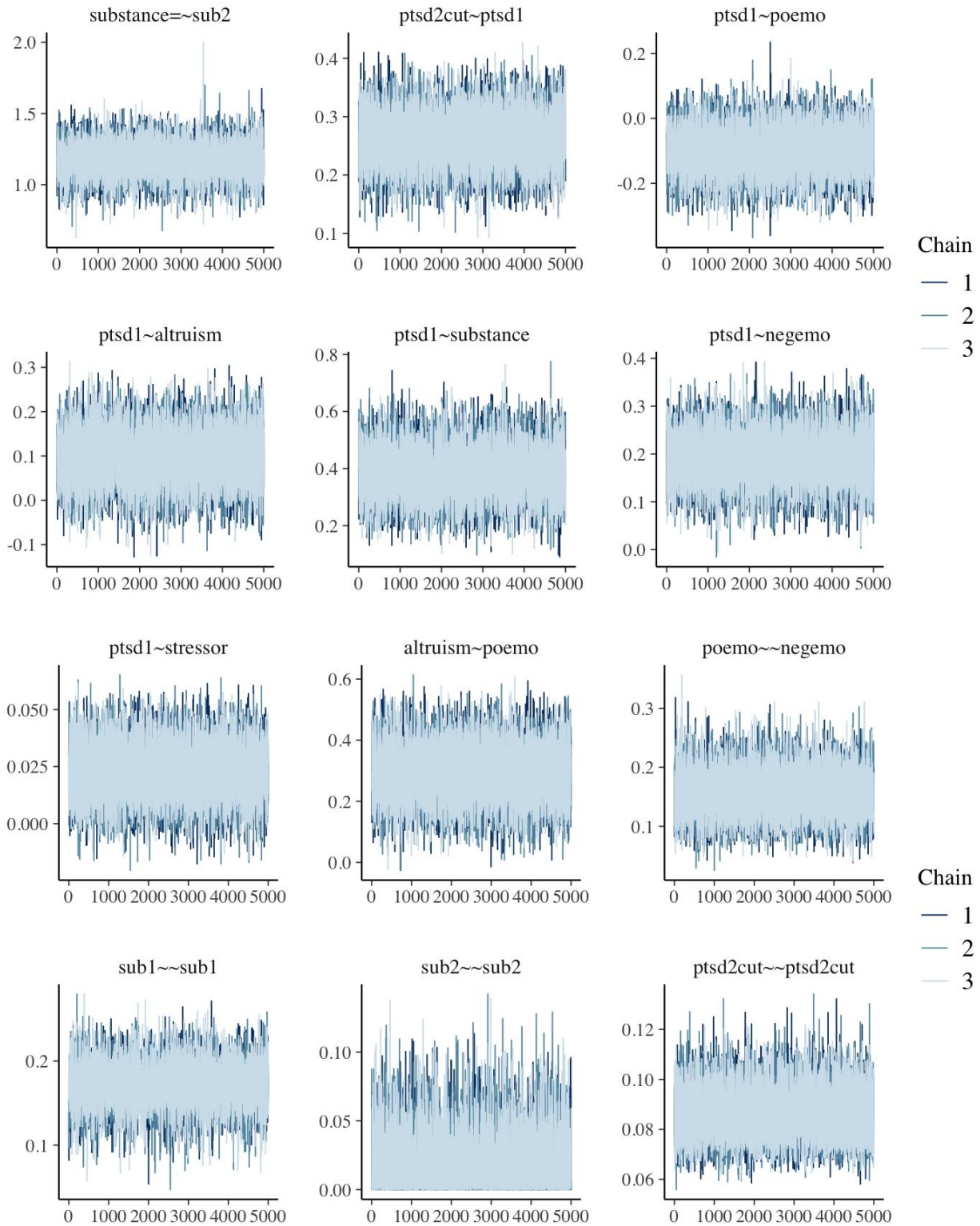
- Ai, A. L., Peterson, C., Bolling, S. F., & Koenig, H. (2002). Private prayer and the optimism of middle-aged and older patients awaiting cardiac surgery. *The Gerontologist*, 42(1), 70-81. <https://doi.org/10.1093/geront/42.1.70>
- Ai, L. A., Renay, A. A., & Appel, H. (2022a). Trauma following Hurricanes Maria and Michael: Complicated roles of hazard-related factors, negative coping strategies, and positive character strengths. *Natural Hazards Research*. <https://doi.org/10.1016/j.nhres.2022.08.004>
- Ai, A. L., Raney, A. A., & Huang, B. (2023). Well-being Following Hurricane Michael: Complex Pathways Involving Substance Use and Character Strengths. *Applied Research in Quality of Life*, 18(1), 435-453. <https://doi.org/10.1007/s11482-022-10083-7>
- Ai, A. L., Plummer, C., Kanno, H., ... & Spigner, C. (2011). Positive traits versus previous trauma: Racially different correlates with PTSD symptoms among Hurricane Katrina-Rita volunteers. *Journal of Community Psychology*, 39(4), 402-420. <https://doi.org/10.1002/jcop.20442>
- Ai, A. L., Tice, T. N., Peterson, C., & Huang, B. (2005b). Prayers, spiritual support, and positive attitudes in coping with the 9-11 national crisis. *Journal of Personality*, 73(3), 763-791. <https://doi.org/10.1111/j.1467-6494.2005.00328.x>
- American Red Cross. (2005, September 19). American Red Cross projects Hurricane Katrina most costly relief effort in its history. Retrieved from <http://www.charitywire.com/charity15/05954.html>
- Appel, H. B., Raney, A. A., & Ai, A. L. (2021). Positive emotional traits and coping related to depression in the aftermath of Category 5 hurricanes. *Traumatology*, 27(4), 455. <https://doi.org/10.1037/trm0000330>
- Aten, J. D., Smith, W. R., Davis, E. B., Van Tongeren, D. R., Hook, J. N., Davis, D. E., Shannonhouse, L., DeBlaere, C., Ranter, J., O'Grady, K., & Hill, P. C. (2019). The psychological study of religion and spirituality in a disaster context: A systematic review. *Psychological Trauma: Theory, Research, Practice, and Policy*, 11(6), 597-613. <https://doi.org/10.1037/tra0000431>
- Beaglehole B, Mulder RT, Frampton CM, Boden JM, Newton-Howes G, Bell CJ. Psychological distress and psychiatric disorder after natural disasters: systematic review and meta-analysis. *Br J Psychiatry*. 2018 Dec;213(6):716-722. doi: 10.1192/bjp.2018.210. Epub 2018 Oct 10. PMID: 30301477.
- Bistricky, S. L., Long, L. J., Lai, B. S., Gallagher, M. W., Kanenberg, H., Elkins, S. R., ... & Short, M. B. (2019). Surviving the storm: Avoidant coping, helping behavior, resilience and affective symptoms around a major hurricane-flood. *Journal of Affective Disorders*, 257, 297-306. <https://doi.org/10.1016/j.jad.2019.07.044>
- Bonanno, G. A., Romero, S., & Klein, S. (2015). The temporal elements of psychological resilience: An integrative framework for the study of individuals, families, and communities. *Psychological Inquiry*, 26, 139-169. <https://doi.org/10.1080/1047840X.2015.992677>
- Brooks, S., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, 7, 434-455. <http://dx.doi.org/10.1080/10618600.1998.10474787>
- Cherry, K.E., Sampson, L., Nezat, P.F., Cacamo, A., Marks, L.D., & Galea, S. (2015). Long-term psychological outcomes in older adults after disaster: Relationships to religiosity and social support. *Aging Mental Health*, 19(5), 430-443. <https://doi.org/10.1080/13607863.2014.941325>
- Cohn, M. A., Fredrickson, B. L., Brown, S. L., Mikels, J. A., & Conway, A. M. (2009). Happiness unpacked: positive emotions increase life satisfaction by building resilience. *Emotion*, 9(3), 361-368. <https://doi.org/10.1037/a0015952>.
- Davidson, T. M., M. Price, J. L. McCauley, and K. J. Ruggiero. 2013. Disaster impact across cultural groups: Comparison of Whites, African Americans, and Latinos. *Am. J. Community Psychol.*, 52(1-2), 97-105. <https://doi.org/10.1007/s10464-013-9579-1>
- Dickey, S. L., Ai, A. L., Hawkins, C., Clark, I., Wedenoja, M., Boone, K., & Raney, A. A. (2023). Psychosocial and physical challenges from a natural hazard: implications for resilience in the Black community. *Natural hazards review*, 24(2), 04023003. <https://doi.org/10.1061/NHREFO.NHENG-157>
- Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology*, 2(3), 300-319. <https://doi.org/10.1037/1089-2680.2.3.300>
- Fredrickson, B. L. (2013). Positive emotions broaden and build. In *Advances in experimental social psychology* (Vol. 47, pp. 1-53). Academic Press. <https://doi.org/10.1016/B978-0-12-407236-7.00001-2>.

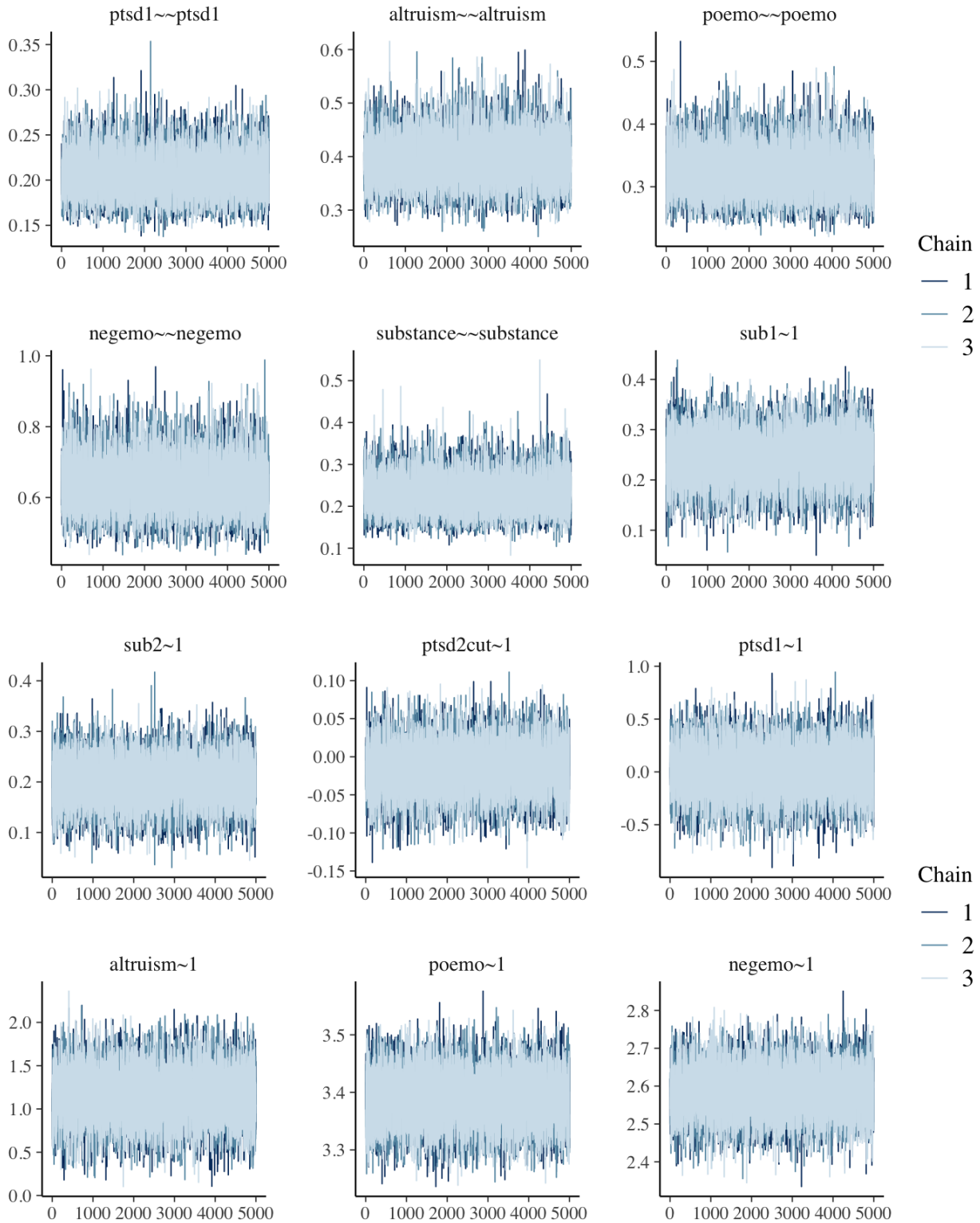
- Fredrickson, B. L., Tugade, M. M., Waugh, C. E., & Larkin, G. R. (2003). What good are positive emotions in crises? A prospective study of resilience and emotions following the terrorist attacks on the United States on September 11th, 2001. *Journal of Personality and Social Psychology*, 84(2), 365–376. <https://doi.org/10.1037/0022-3514.84.2.365>
- Fullerton, C.S, Mash, H.B.H., Wang, L, et al. (2019). Posttraumatic stress disorder and mental distress following the 2004 and 2005 Florida hurricanes. *Disaster Medicine in Public Health Preparation*, 13(1),44–52. doi:10.1017/dmp.2018.153
- Garnier-Villarreal, M., & Jorgensen, T. D. (2020). Adapting fit indices for Bayesian structural equation modeling: Comparison to maximum likelihood. *Psychological Methods*, 25(1), 46–70. <https://doi.org/10.1037/met0000224>
- Gelman, A., Meng, X.-L., & Stern, H. (1996). POSTERIOR PREDICTIVE ASSESSMENT OF MODEL FITNESS VIA REALIZED DISCREPANCIES. *Statistica Sinica*, 6(4), 733–760. <http://www.jstor.org/stable/24306036>
- Garfin, D. R., Thompson, R.R., Holman, A.E., et al. (2022). Association between repeated exposure to hurricanes and mental health in a representative sample of Florida residents. *JAMA Network Open*, 5(6), e2217251. doi: 10.1001/jamanetworkopen.2022.17251
- Glass, K., Flory, K., Hankin, B. L., Kloos, B., & Turecki, G. (2009). Are coping strategies, social support, and hope associated with psychological distress among Hurricane Katrina survivors? *Journal of Social and Clinical Psychology*, 28(6), 779-795. <http://doi.org/10.1521/jscp.2009.28.6.779>
- Green, T. F., & Olshansky, R. B. (2012). Rebuilding housing in New Orleans: The road home program after the Hurricane Katrina disaster. *Housing Policy Debate*, 22(1), 75-99. <https://doi.org/10.1080/10511482.2011.624530>
- Hoofs, H., van de Schoot, R., Jansen, N. W. H., & Kant, I. (2018). Evaluating model fit in Bayesian confirmatory factor analysis with large samples: Simulation study introducing the BRMSEA. *Educational and Psychological Measurement*, 78, 537–568. <http://dx.doi.org/10.1177/0013164417709314>
- James, W. (1910). The varieties of religious experience: A study in human nature. *Longmans Green and Company*.
- Levine, S. Z. (2013). Evaluating the seven-item Center for Epidemiologic Studies Depression Scale short-form: A longitudinal US community study. *Social psychiatry and psychiatric epidemiology*, 48(9), 1519-1526. <https://doi.org/10.1007/s00127-012-0650-2>
- Mash, H., Fullerton, C., Morganstein, J.,...Ursano, R. (2022). Longitudinal study of hurricane preparedness behaviors: Influence of collective efficacy. *Disaster Medicine and Public Health Preparedness*, 16(3), 1046-1052. doi:10.1017/dmp.2020.504
- Merkle, E. C., & Rosseel, Y. (2015). blavaan: Bayesian structural equation models via parameter expansion. *arXiv preprint arXiv:1511.05604*. <https://doi.org/10.48550/arXiv.1511.05604>
- Muthén, B., & Asparouhov, T. (2012). Bayesian structural equation modeling: a more flexible representation of substantive theory. *Psychological methods*, 17(3), 313. <https://doi.org/10.1037/a0026802>
- NCEI (2022). National Centers for Environmental Information. Billion-Dollar Weather and Climate Disasters. Retrieved from <https://www.ncei.noaa.gov/access/billions/>.
- NOAA. Hurricanes in History. National Hurricane Center and Central Pacific Hurricane Center, NOAA. 2020. Retrieved from <https://www.nhc.noaa.gov/outreach/history/> (accessed on 2 April 2020).
- Plummer, C, Ai, A. L., Lemieux, C, Richardson, R., Dey, S., Taylor, P, Spence, S., & Kim, J. (2008). Volunteerism among social work students during Hurricanes Katrina and Rita: A report from the disaster area. *Journal of Social Service Research*, 34(3), 55-71. <https://doi.org/10.1080/01488370802086328>
- Prinzing, M. M., Zhou, J., West, T. N., Le Nguyen, K. D., Wells, J. L., & Fredrickson, B. L. (2022). Staying ‘in sync’ with others during COVID-19: Perceived positivity resonance mediates cross-sectional and longitudinal links between trait resilience and mental health. *The Journal of Positive Psychology*, 17(3), 440-455. <https://doi.org/10.1080/17439760.2020.1858336>
- Raker, E. J., M. C. Arcaya, S. R. Lowe, M. Zacher, J. Rhodes, and M. C. Waters. 2020. “Mitigating health disparities after natural disasters: Lessons from the risk project.” *Health Aff.*, 39(12), 2128–2135. <https://doi.org/10.1377/hlthaff.2020.01161>
- Rivera, J. D., and D. M. S. 2007. “Continually neglected: Situating natural disasters in the African American experience.” *J. Black Stud.*, 37(4), 502–522. <https://doi.org/10.1177/0021934706296190>

- R Core Team (2022). R: A language and environment for statistical computing. *R Foundation for Statistical Computing, Vienna, Austria*. URL <https://www.R-project.org/>.
- Raker, E. J., Lowe, S. R., Arcaya, M. C., Johnson, S. T., Rhodes, J., & Waters, M. C. (2019). Twelve years later: The long-term mental health consequences of Hurricane Katrina. *Social Science & Medicine*, *242*, 112610. <https://doi.org/10.1016/j.socscimed.2019.112610>
- Sampson, R. J., Raudenbush, S. W., & Earls, F. (1997). Neighborhoods and violent crime: A multilevel study of collective efficacy. *science*, *277*(5328), 918-924. <https://doi.org/10.1126/science.277.5328.918>
- Scheier, M. F., & Carver, C. S. (2018). Dispositional optimism and physical health: A long look back, a quick look forward. *American Psychologist*, *73*(9), 1082-1094. <http://dx.doi.org/10.1037/amp0000384>
- Scheier, M.F. & Carver, C.S. (1985). Optimism, coping, and health: Assessment and implications of generalized outcome expectancies. *Health Psychology*, *4*, 219-247. <https://psycnet.apa.org/doi/10.1037/0278-6133.4.3.219>
- Scheier, M. F., Swanson, J. D., Barlow, M. A., Greenhouse, J. B., Wrosch, C., & Tindle, H. A. (2021). Optimism versus pessimism as predictors of physical health: A comprehensive reanalysis of dispositional optimism research. *American Psychologist*, *76*, 529-548. <https://psycnet.apa.org/doi/10.1037/amp0000666>
- Silton, R. L., Kahrilas, I. J., Skymba, H. V., Smith, J., Bryant, F. B., & Heller, W. (2020). Regulating positive emotions: Implications for promoting well-being in individuals with depression. *Emotion*, *20*(1), 9 -97. <https://doi.org/10.1037/emo0000675>.
- Snyder, C. R., Sympson, S. C., Ybasco, F. C., Borders, T. F., Babyak, M. A., & Higgins, R. L. (1996). Development and validation of the State Hope Scale. *Journal of Personality and Social Psychology*, *70*(2), 321-335. <https://doi.org/10.1037/0022-3514.70.2.321>
- Waddell, S. L., Jayaweera, D. T., Mirsaedi, M., Beier, J. C., & Kumar, N. (2021). Perspectives on the health effects of hurricanes: a review and challenges. *International journal of environmental research and public health*, *18*(5), 2756. <https://doi.org/10.3390/ijerph18052756>
- White, A., & Murphy, T. B. (2014). BayesLCA: An R Package for Bayesian Latent Class Analysis. *Journal of Statistical Software*, *61*(13), 1-28. <https://doi.org/10.18637/jss.v061.i1>
- Wilk, S., & Vont, E. (2008). Private prayer among Alzheimer's caregivers: Mediating burden and resiliency. *Journal of Gerontological Social Work*, *50*(3/4). https://doi.org/10.1300/J083v50n3_09
- Wilner, M (2022, September 30). Biden calls Hurricane Ian an 'American crisis'. *Tampa Bay News*. <https://www.tampabay.com/hurricane/2022/09/30/biden-calls-hurricane-ian-an-american-crisis/>
- Wang Z, Wu X, Dai W, et al. The Prevalence of Posttraumatic Stress Disorder Among Survivors After a Typhoon or Hurricane: A Systematic Review and Meta-Analysis. *Disaster Medicine and Public Health Preparedness*. 2019;13(5-6):1065-1073. doi:10.1017/dmp.2019.26

Appendix A

Trace plots for each parameter.





Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).