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Psychopathology and Resilience Following Traumatic Injury: A Latent Growth Mixture Model Analysis

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Objective: To investigate trajectories of PTSD and depression following traumatic injury using latent class growth curve modeling. ***Method:*** A longitudinal study of 330 injured trauma survivors was conducted and participants were assessed during hospitalization, and at 1, 3, and 6 months follow-up. Acute Stress Disorder (ASD) was assessed during hospitalization using the Acute Stress Disorder Interview (ASD-I), PTSD was measured at all follow-up with the Post-Traumatic Stress Diagnostic Scale (PDS) and depression was measured at hospitalization with the (BSI) and at follow-up with the Center for Epidemiologic Studies Depression Scale (CESDS). Covariates were explored, including coping self-efficacy, anger, education level, and mechanism of injury. ***Results:*** Four latent classes were identified for PTSD and Depression symptoms: chronic distress, delayed distress, recovered, and resilience. When compared to the resilient group, individuals with chronic distress were more likely to have been assaulted, had higher levels of anger, and had less coping self-efficacy. The delayed distress group had lower education levels, higher levels of coping self-efficacy, and higher levels of anger. Individuals in the recovered group had fewer years of education, and higher levels of anger. ***Conclusion:*** The majority of the injured trauma sample demonstrated resiliency, with those exhibiting distress doing so as a delayed, chronic, or recovered trajectory. Coping self efficacy, education, assaultive trauma type, and anger were important covariates of depression and PTSD trajectories. These results are similar to studies of individuals who experienced a major health threat and with survivors from the World Trade Center attacks in the U.S.

Keywords: traumatic injury, resilience, PTSD, depression

Each year approximately 2.5 million people in the United States are involved in a single incident traumatic experience that results in severe injuries requiring care at a level 1 trauma center (Bonnie, Fulco, & Liverman, 1999). The type of traumatic experience can vary from motor vehicle crash (MVC) to home and industrial accident, and assault by gun, knife, or sharp object. Not only are the traumatic experiences themselves shocking, but the injuries are severe and potentially debilitating, affecting extremities and abdominal and thoracic regions of the body, leading to acute and potentially chronic physical impairment. Recent research has demonstrated that quality of life after traumatic injury is related to posttraumatic psychological distress (e.g., Brasel, deRoon-Cassini, & Bradley, in press). In particular, after traumatic injury individuals are at risk for acute stress disorder (ASD) and longer term, posttraumatic stress disorder (PTSD) and depression. PTSD is one of the strongest correlates of post-injury quality of life, especially when compared to individuals who do not have PTSD (Stein, Walker, Hazen, & Forde, 1997; Zatzick et al., 1997). Physical limitations combined with psychological distress potentially can render a trauma survivor significantly impaired, as PTSD has been shown to negatively impact physical health and increase somatic complaints with more frequent physician visits (Friedman, Charney, & Deutch, 1995).

There has been much research on rates of PTSD and depression after single incident trauma. In worldwide studies of community samples of injured trauma survivors, approximately 2−40% reported symptoms consistent with a diagnosis of PTSD up to 12 months after the traumatic injury (Schnyder, Moergeli, Klaghofer, & Buddeberg, 2001; Zatzick et al., 2002). The average raw scores of PTSD symptoms for one study remained at or just below what was considered severe symptom distress from baseline until 1 year posttrauma, but variability of symptoms for each individual across time was not reported. In non-U.S. samples rates of PTSD after traumatic injury vary from 1.9% to 32% (Koren, Arnon, & Kelin, 1999; Schnyder, Moergeli, Klaghofer, & Buddeberg, 2001). Vari-

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ability in reporting often depends on the type of trauma experienced; assault survivors often report higher levels of distress following injury compared with non-assault survivors (Zatzick et al., 2007). Depression is highly comorbid with PTSD in a single incident trauma population, with participants who have symptoms of PTSD having significantly higher levels of depression compared with non-distressed trauma survivors (Shalev, Peri, Canetti, & Schreiber, 1996). In one investigation with a sample of MVC and assault survivors, symptoms of PTSD and depression were strongly positively correlated ($r = .61$, $p < .001$; Zatzick et al., 2002).

Although pathological responses occur after single incident trauma, studies of individual differences have consistently revealed four prototypical trajectories of long-term outcome (Bonanno, 2004; 2005). A predictable minority of exposed individuals will exhibit chronically elevated levels of PTSD and depression for at least several years after the event. However, the most common outcome is typically a relatively stable trajectory of healthy functioning or resilience (e.g., Bonanno, Rennicke, & Dekel, 2005). Other trajectories include a recovery pattern of acute elevations in depression and PTSD symptoms that endure for several months or more before gradually returning to baseline levels, and a delayed pattern of sub-threshold pathology that gradually worsens over time (Bonanno et al., 2005; Buckley, Blanchard, & Hickling, 1996).

These four prototypical trajectories have been documented in single incident trauma samples using a variety of nonparametric and semi-parametric approaches (Bonanno & Mancini, in press). More recently, a number of studies have identified the same trajectories using sophisticated growth modeling approaches, such as Latent Growth Mixture Modeling (LGMM, Muthén, 2004; Muthén & Muthén, 2000). LGMM is an approach that identifies homogenous subpopulations within a heterogenous sample for the purpose of identifying meaningful groups or classes of individual variation across time (Jung & Mickrama, 2007). A critical distinction between LGMM and traditional growth modeling techniques (for example, hierarchical linear modeling) is that LGMM does not assume that participants belong to a single homogeneous population. In relaxing the assumption of a single population, LGMM can identify heterogeneous patterns of responding (or trajectory classes) that represent, in effect, distinct populations (Muthén, 2004). The mean growth curves of these distinct populations can then be modeled separately, allowing for unusual flexibility and precision in identifying the various ways that people exhibit change across time. What permits this flexibility is the simultaneous modeling of latent continuous variables (e.g., intercept and slope) and latent categorical variables (trajectory class assignment). In addition, LGMM allows for the inclusion of covariates that both predict the trajectory classes and influence their shape, offering insight into critical factors that distinguish people who are assigned to one trajectory class over another. A recent study, for example, used LGMM to identify outcome trajectories in a sample of hospitalized survivors of the 2003 bioepidemic of Severe Acute Respiratory Syndrome (SARS) in Hong Kong (Bonanno et al., 2008). This study examined mental health data at 6, 12, and 18 months following hospitalization and found that a four-class solution closely resembling the four prototypical trajectories (resilience, recovery, delayed reactions, and chronic dysfunction) best explained the data. Researchers have not yet examined longitudinal trajectories of adjustment immediately following a single incident trauma.

The current investigation was intended to fill the identified gap in the literature by determining the longitudinal trajectories of psychological functioning beginning immediately post-trauma for survivors of single incident traumatic injury. This was a community sample of injured trauma survivors taken to a level 1 trauma center for immediate medical attention. Mechanism of injury included MVC, assault, industrial and home accidents, and falls. Consistent with newly emerging data, we hypothesized that the majority of our sample would exhibit minimal to no symptoms of depression and PTSD during the first 6 months following traumatic injury, but also that we would find evidence for chronic, recovered, and delayed trajectories. A second aim of this study was to identify covariates that help to explain trajectory membership. A number of factors are known to influence adaptation to acute stressors (Brewin, Andrews, & Valentine, 2000). These include demographic characteristics (e.g., gender, education), the nature of the stressor (e.g., degree of exposure), and coping responses (e.g., perceived self-efficacy, emotion regulation). In addition to examining inter-individual variation, we explored each of these factors as potential covariate predictors in our analyses.

Method

Participants

Participants were those who suffered a traumatic injury due to a single incident trauma and were taken to a level 1 trauma center at a large regional medical center in the Midwest ($n = 330$). Two hundred forty-seven of the 330 baseline participants (74.8% response rate) completed the first follow-up assessment (1 month), 212 (64.2% response rate) participants completed the second follow-up (3 months), and 210 (63.6% response rate) completed the third (6 months), which are response rates that are similar to other studies with injured trauma survivors (e.g., 78.8%; Zatzick et al., 2007) The mean age of the entire sample was 40.4 ($SD = 15.8$) years with a range from 18 to 86 years. The majority of the sample was male (67.6%), 62.4% of the participants were Caucasian and 29.7% were African American, with an average of 13.0 ($SD = 2.5$) years of education, ranging from 7 to 25 years.

The majority of participants were injured due to a automobile crash (47.4%), followed by gun shot (16.4%), fall (8.0%), motorcycle crash (6.5%), assault (4.8%), pedestrian struck by vehicle (4.6%), stabbing (4.2%), industrial accident (4.3%), snowmobile (1.6%), falling object (1.3%), and home accident (0.9%). Collectively, 74.6% of the participants were injured due to an accident and 25.4% were injured due to the intention of another human being.

Procedure

Institutional Review Board approval was granted from the participating institution, after which participants were approached for recruitment. Inclusion criteria were: 1) 18 years of age or older; 2) traumatic soft tissue, orthopedic, or internal injury from industrial, motor vehicle, recreational and home accidents, and non-sexual assaults, as the primary diagnosis for admission; and 3) admitted

for more than 48 hours due to the severity of the injury and level of necessary medical care. Individuals were excluded from the study when they: 1) experienced a spinal cord injury with neurological deficit; 2) evidenced cognitive impairment (attention, concentration, language, and memory) secondary to an accident related head injury; 3) were unable to speak English or were unable to communicate due to physical limitations; and 4) self-inflicted the injury. There were 1,457 persons who were admitted to the hospital with acute injuries during the study recruitment period, without a severe brain or spinal cord injury. We attempted to enroll as many participants as possible before they were discharged. Of the total number admitted, 330 agreed to participate (22.6% participation rate) and were interviewed while hospitalized. The limited participation rate was largely due to brief hospital stays that interfered with our study team's ability to recruit individuals, mild concussion that precluded enrollment, and unwillingness to participate. We also missed potential participants due to procedures, surgeries, pain, and family visits. Because these individuals were not enrolled in the study, comparison data is not available to investigate potential variables influencing participation. Enrolled participants completed in-person interviews during hospitalization about demographic and injury characteristics, ASD and depression symptoms, anger, and coping self-efficacy. Telephone interviews were completed at 1 month, 3 months, and 6 months following the traumatic event that averaged approximately 20 minutes. The follow-up interviews were identical and included assessment of depression and PTSD symptoms. If after any of the interviews a participant exhibited high levels of distress or asked for psychological services, we offered referral for treatment.

Measures

The measures used were those included as a part of a larger study. Measures relevant to this report are listed below.

Demographic information. Participants completed several questions related to gender, age, ethnicity, and education level.

Injury characteristics. A single question was used that asked the participants about the mechanism of the injury (e.g., MVC, assault, fall, etc. . .) and responses were recorded as well as classified as either due to an accident (e.g., MVC, industrial accident, home accident, and fall) or due to human intention (e.g., assault, assault with a gun, assault with a knife or sharp object).

Coping self-efficacy. We developed a self report measure of confidence in ability to cope with common experiences/situations following traumatic injury. Ten items evaluated the participant's sense of self-efficacy in managing hospital procedures, obtaining information from staff, coping with anxiety and depression, and resuming a productive satisfying lifestyle. Items were rated on a 10-point Likert scale ranging from "No confidence" to "Very confident." Potential scores could range from 0 to 100, with higher scores indicating greater levels of self-efficacy. In the current study the Cronbach alpha coefficient for the measure was .85.

Anger. The "Feeling Angry Subscale" of the State Trait Anger Expression Inventory-2 (STAXI-2; Spielberger, 1999) was administered to assess anger. The subscale consists of five items assessing feelings of anger and of desire to express anger either verbally or physically toward other persons or objects in the environment. Participants were asked to indicate feelings of anger about their situation "right now" on a 4-point continuum from "not at all" to "very much so." Scores could range from 5 to 20 with higher scores reflecting greater levels of anger. The STAXI-2 has acceptable psychometric properties (Forgays, Spielberger, Ottaway, & Forgays, 1998). The internal consistency for the STAXI-2 is adequate with Cronbach's alphas of .70 −.93 and test-retest reliability at two weeks with correlations of 0.62 to 0.81 (Spielberger, 1999). Cronbach's alpha for this study was .89.

ASD and PTSD. We used the Acute Stress Disorder Inventory (ASDI; Bryant, Harvey, Dang, & Sackville, 1998) to measure the extent to which participants experienced symptoms of ASD at baseline. This is a 19-item dichotomously scored measure of re-experiencing, avoidance, dissociative and anxious arousal following trauma, based on the *DSM–IV–TR* (American Psychiatric Association [APA], 2000). This tool has high sensitivity (91%) and specificity (93%) when compared to clinical interview. This instrument also demonstrates high internal consistency (.90) and adequate test-retest reliability for the four symptom clusters (.80 to .87). Cronbach's alpha for the current study was .83 at hospitalization.

PTSD was evaluated using the Post-Traumatic Stress Diagnostic Scale (PDS; Foa, 1995) during the follow-up assessments. This measure includes 17 questions regarding the 17 symptoms of PTSD (*DSM–IV–TR*; APA, 2000), rated on a 4-point scale ranging from "not at all" to occurring "3-5 or more times a week/almost always" for the past month. All 17 items are summed to create a total score, with a higher score indicating greater PTSD symptom severity, with potential scores ranging from 0 to 51. Internal consistency reliability for the PDS has been reported to be .92, with a test reliability Kappa statistic of .74, indicating adequate agreement (Foa, 1995). Convergent validity with other measures assessing constructs related to PTSD has also been sufficient, ranging from .66 to .80. For the current study Cronbach's alpha was .87, .90, and .91 for 1, 3, and 6 months, respectively.

Depression. The Brief Symptom Inventory (BSI; Derogatis, 2000) depression subscale was used to assess depression at hospitalization. This is a six-item measure of core symptoms of depression with each item rated on a 5-point Likert scale ranging from "not at all" to "extremely" with higher scores indicating greater depression. Internal consistency reliability has been reported to be .84 and .85 with community subjects and psychiatric outpatients respectively. Adequate test-retest reliability has also been demonstrated (.84), as well as adequate convergent validity (.72) for the depression scale. Cronbach's alpha for the current study was .84 at hospitalization.

The revised version of the Center for Epidemiologic Studies Depression Scale (CESD-R; Eaton, Muntaner, Smith, Tien, & Ybarra, 2004) was used at the three follow-up assessments to evaluate depression symptom severity. This commonly used instrument is a psychometrically sound, 20-item scale that assesses frequency of depression symptoms of the past week (Radloff, 1977) that correspond to the *DSM–IV* criteria for major depressive disorder. Scores range from 0 to 80 with respondents indicating how frequently they have experienced symptoms during the "past week or so" on a 5- point scale ranging from "not at all or less than 1 day" to "nearly every day for 2 weeks." Items are summed with higher scores indicating greater depressive symptom severity. The CESD-R demonstrates adequate internal consistency (0.8 – 0.9), test-retest reliability (0.4 – 0.7) and high sensitivity and specificity for people with major depression (Eaton, Muntaner, Smith, Tien,

& Ybarra, 2004). Cronbach's alpha for this measure of depression was .92, .93, .94, at 1, 3, and 6 months, respectively.

Statistical Analysis

To model heterogeneity in these data, we employed latent growth mixture models (LGMMs) as a means of identifying discrete growth trajectories (or classes) and to test predictors of membership in these classes (Muthén, 2004; Muthén & Muthén, 2000). Unlike traditional fixed-effects approaches (for example, multiple regression and analysis of variance), in which the relations among variables are fixed across individuals, latent trajectory approaches model variation in growth parameters, such as intercept and slope, over individuals (Curran & Hussong, 2003). These continuous latent growth parameters incorporate information from multiple indicators (repeated measures of an outcome). A critical component of LGMM is that it does not assume a single population and can test for the presence of multiple groups or classes of individuals that represent distinct multivariate normal distributions. These discrete populations are modeled using categorical latent variables (classes) in combination with continuous latent variables that define a particular growth trajectory within class (for example, intercept and slope).

To identify latent classes of response to traumatic injury, we used Mplus 5.1, which employs a robust full-information maximum-likelihood (FIML) estimation procedure for handling missing data and assumes missing data are unrelated to the outcome variable (missing at random). The appropriateness of FIML is widely endorsed (Enders, 2001; Graham, in press). A majority of subjects had at least three time points of data (68.8%). The percentages of missing data were as follows: two time points, 14.5%; and three time points, 16.7%. To diagnose the impact of missing data, Mplus provides estimates of covariance coverage for each pair of variables in the analysis. In the present study, covariance coverage for each pair of variables did not fall below .56, which is well above the minimum threshold of .10 for model convergence. Before proceeding to the LGMMs, we first standardized the outcome variables at each assessment wave for both PTSD and depression. This step was necessary because time 1 measures were scored on a different scale than subsequent waves. As a result of standardization, participants' change in PTSD and depression should be interpreted in terms of their relative position within the distribution at each wave, not as absolute change on a fixed measurement scale.

The LGMM analyses for depression and PTSD symptoms consisted of three steps. To facilitate model specification, we first used simple growth models to determine the growth parameters for the LGMMs. Second, we compared one- to six-class unconditional LGM models (no covariates), assessing relative fit with conventional indices. The final step was to extend the LGMM to include covariates as predictors of class membership (Muthén, 2004). Based on inspection of modification indices, default specifications of Mplus were retained: Residuals were not allowed to correlate; error variances were allowed to vary over time; and residual variances and covariances were held constant across time (syntax for Mplus analyses are available upon request). We used preliminary logistic regressions to identify potential covariates. Because both the latent class variables and the latent growth factors were regressed on the covariates, each was influenced by the covariates as well as being predicted by them. Because too many covariates can prevent model convergence, we only included a subset of the available predictors suggested by the logistic regressions. In an iterative process, we tested models with different covariates, retaining a final model in which the inclusion of covariates improved the fit of the model and also predicted class assignment. A final step was to test models in which only class assignment was regressed on the covariates and a model in which both class assignment and the growth factors were regressed on the covariates (Muthén, 2004). When regressing the growth factors on the covariates, we examined both class-specific (e.g., predicting slope within class) and class invariant models (e.g., predicting slope across classes). We used log-likelihood chi-square testing to identify the model with superior fit. Finally, in post-hoc analyses, we compared the likelihood that persons were assigned to similar trajectories for both PTSD and depression.

Results

Simple Growth Models

For both depression and PTSD symptoms, we began by estimating a simple growth model. A first step is to identify factor loadings for the time points. In the current study, the interval between measurement points (0, 1, 3, and 6 months) was unequal. Because LGMM is flexible in modeling time (Muthén, 2004), we used factor loadings that corresponded directly to the time interval (specifically, setting the first measurement point to 0 and the last to 6). Using the likelihood ratio chi-square test to determine fit, we examined models with an intercept parameter (no growth), intercept and slope parameters (linear growth), and intercept, slope, and quadratic parameters (nonlinear growth). The linear model provided a significant improvement in fit over the intercept only model for both depression and PTSD symptoms, indicating an overall pattern of change in depression and PTSD symptoms across time. Although the nonlinear growth models did not converge, we anticipated that a multi-class model might reveal quadratic effects nevertheless. To test for this possibility in subsequent LGMM analyses, we used log-likelihood ratio chi- square tests to assess whether a model with quadratic effects provided a superior fit over a linear-only model.

LGMMs for Depression and PTSD

Before testing different class solutions, we varied model parameters to ensure model convergence and inspected modification indices to obtain the best fit. Initial model testing indicated that the slope and quadratic variances needed to be fixed at zero for the models to converge. Log likelihood-ratio chi-square testing of multi-class models showed that a nonlinear model (intercept, slope, and quadratic) provided improved fit over a linear-only model for both PTSD and depression symptoms. Consistent with recommendations for model testing, we compared one- to six-class unconditional models (i.e., no covariates) for depression and PTSD symptoms. To determine the appropriate class solution, we examined the Bayesian, (BIC), sample-size adjusted Bayesian (SSBIC), and Aikaike (AIC) information criterion indices, entropy values, the Lo-Mendell-Rubin likelihood ratio test (LRT: Lo, Mendell, &

Rubin, 2001). We sought a model with lower values for the criterion indices, higher entropy values, and significant *p* values for both the LRT and the bootstrap likelihood ratio test. Generally, it is the totality of these indices, in combination with the interpretability and theoretical coherence of a given class solution, that guides the final model selection (Bonanno, 2004; Muthén, 2003).

PTSD. As shown in Table 1, the information criterion indices showed lower values for each additional class going from two to six classes. This suggested that a six-class solution might be optimal. However, the guidance offered by Lo-Mendell-Rubin test suggested that either a two- or a four-class solution represented a better fit to the data. To adjudicate these different results, we inspected the functional form of each class solution. Of particular note, the four-class solution revealed high and low distress groups but also two theoretically relevant classes (Bonanno, 2004): a) a delayed group in which a pattern of initial moderate symptom elevation was then followed by a sharp exacerbation; and b) a recovering group in which initial symptom elevations declined sharply. These two trajectories have been noted previously and bear on individual differences in acute stress responding (Andrews, Brewin, Philpott, & Stewart, 2007; Bonanno, 2004). The five- and six-class solutions were relatively uninformative, as they simply split the primary trajectories based on intercept values. For the sake of parsimony and interpretability, we selected the four-class solution as optimal.

The next step was to include relevant covariates in the model. Based on initial model testing, we included human intention, level of education, reported self-efficacy, and anger as covariates. In the final model, class assignment was regressed on all of the covariates and the intercept growth parameter (class-invariant) was regressed on self-efficacy and anger. Log-likelihood ratio chi-square testing indicated that inclusion of covariates significantly improved model fit over the unconditional model, $\chi^2(24, N = 317) = 285.92$, $p < .001$. Entropy also increased from .73 to .76, indicating better classification accuracy. As can be seen in Figure 1, the four-class solution identified four distinct trajectories of response to traumatic injury. It is important to note that the figure represents adjusted raw scores, derived by transforming estimated standardized scores into scale values for the PDS. Most of the sample (59%) fell into a category with low initial levels of PTSD symptoms and a flat and non-significant pattern of growth across time. We labeled this pattern *low symptom*. Another trajectory (22%) was characterized by high initial PTSD symptoms and a pattern of increasing symptoms across time. We labeled this pattern *chronic*. A third trajectory (6%) showed a U-shaped pattern of initial elevations, followed by a decrease and then a sharp increase in PTSD symptoms. We labeled this pattern *delayed.* A final trajectory (13%) showed initial increases in PTSD symptoms from baseline to 3 months and then a sharp decrease at 6 months. We labeled this pattern *recovering*. Table 2 shows growth parameter estimates for the four-class conditional model.

Prediction of PTSD trajectories. In addition to improving model fit, the associations of covariates with PTSD class trajectories were of substantive interest. Because the low symptom class comprised the largest number of participants and was a focus of our interest, we designated it as the referent class and used logistic regressions to assess the degree to which the probability of being in the low symptom class was associated with each of the covariates. As can be seen in Table 3, human intention related to the injury was strongly associated with increased probability of membership in the *chronic* group compared to the *low symptom* group ($OR = 5.65$, $p < .001$). Years of education were also associated with decreased probability of membership in the *delayed* ($OR = .56$, $p < .05$) and *recovered* ($OR = .81$, $p < .05$) groups when compared to the *low symptom* group. Interestingly, higher reported self-efficacy at time 1 was associated with increased probability of membership in the *delayed* ($OR = 2.67$, $p < .05$) group compared to the *low symptom* group. In addition, anger at time 1 was associated with increased probability of membership in both the *chronic* ($OR = 1.11$, $p < .05$) and *recovering* ($OR = 5.65$, $p < .06$) groups when compared to the *low symptom* group.

Depression. We applied the same analytic approach to depression symptoms. We were particularly interested in whether a similar class structure would be replicated using depression as an outcome and whether there was concordance in classification across PTSD and depression symptoms. As shown in Table 4, the fit indices showed successive improvements from one to six classes. However, it was noteworthy that the four-class solution for depression replicated each of the primary trajectories identified in the PTSD analyses. On the basis of interpretability and theoretical salience, we selected the four-class solution as optimal. This model served as the basis for subsequent analyses that included covariates. Table 5 shows growth parameter estimates for the four-class conditional model.

Next we included covariates to arrive at a final model for depression. Using human intention, education, self-efficacy, and anger as covariates, we tested different models to arrive at a final solution. We first regressed class assignment on the covariates, which resulted in a significant improvement in fit $\chi^2(12, N = 317) = 152.66$, $p > .001$. Next we added regressions of growth parameters on the covariates to assess their contribution to model

Table 1
Fit Indices for One- to Six-Class Growth Mixture Models for PTSD Symptoms (Unconditional)

	Growth mixture model					
Fit indices	1 Class	2 Classes	3 Classes	4 Classes	5 Classes	6 Classes
AIC	2364.02	2344.64	2237.73	2213.10	2192.71	2175.78
BIC	2394.37	2397.78	2298.41	2288.96	2283.74	2281.99
SSBIC	2368.99	2353.374	2247.66	2225.52	2207.61	2193.17
Entropy	—	.78	.78	.73	.71	.75
LRT *p* value	—	<.001	.30	.14	.19	.60

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; SSBIC = sample size adjusted Bayesian information criterion; LRT = Lo-Mendell-Rubin test.

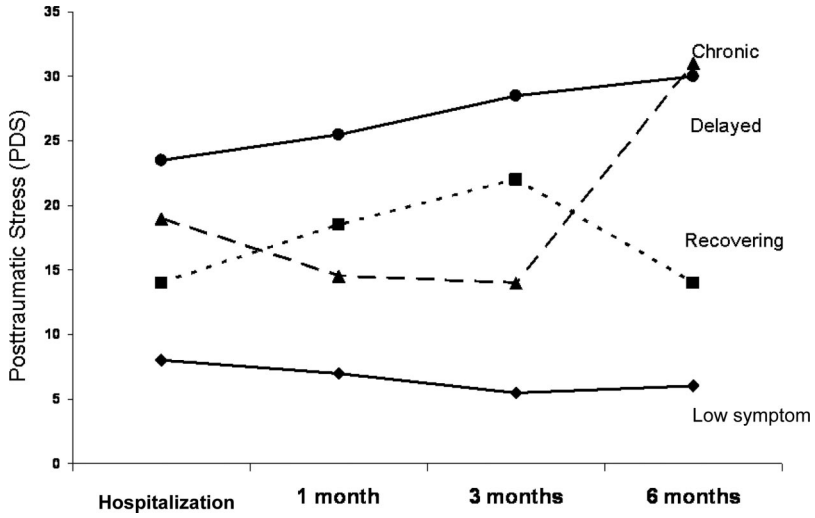

Figure 1. Four-class solution for PTSD symptoms (includes covariates).

fit. In the final model, we regressed class assignment on the covariates and the growth parameters on a subset of the covariates (self-efficacy and anger), further improving model fit, $\chi^2(6, N = 317) = 90.38$, $p > .001$. As shown in Figure 2, the four classes took a very similar functional form to the PTSD trajectories, consisting of participants with a low level of depression symptoms and a slightly declining but largely flat trajectory across time (*low symptom*, 60%); a flat but moderate level of symptoms that increased sharply at 6 months (*delayed,* 17%); sharply elevated symptoms at baseline and a gradual increase across time (*chronic,* 10%); and initial increases in symptoms that declined sharply at 6 months (*recovering*, 14%). Again, note that the graphs in the figure represent adjusted raw scores, derived by transforming estimated standardized scores into original scale values for the CESD-R.

Prediction of depression trajectories. We next explored the influence of covariates. Consistent with the PTSD analyses, we designated the low symptom class as the referent in logistic regression analyses. The overall pattern of results was similar to those obtained for PTSD. As shown in Table 6, human intention was again strongly associated with probability of membership in the *chronic* symptom class compared to the *low symptom* class ($OR = 6.42$, $p < .05$). Less education was also marginally associated with membership in the *chronic* ($OR = .83$, $p < .10$) and *delayed* ($OR = .80$, $p < .10$) classes when compared to the *low symptom* class. When compared to the *low symptom* group, higher levels of anger at Time 1 was associated with significantly increased probability of membership in the *delayed* ($OR = 1.16$, $p < .05$) and *chronic* ($OR = 1.22$, $p < .05$) classes, and marginally associated with membership in the *recovering* ($OR = 1.15$, $p < .10$) class. Higher levels of coping efficacy were associated with a decreased probability of membership in the chronic symptom class ($OR = .62$, $p < .05$) when compared to the resilient class.

Table 2
Growth Factor Parameter Estimates for 4-Class Unconditional Model: PTSD

	Intercept		Slope		Quadratic	
Class	Est.	*SE*	Est.	*SE*	Est.	*SE*
Delayed	.266	.384	−.518	.222	.117	.036
Chronic	.928	.133	.238	.082	−.017	.011
Recovering	−.001	.144	.578	.101	−.094	.014
Low Symptom	−.337	.063	−.138	.033	.017	.004

Note. Est. = Estimate; *SE* = standard error.

Concordance of classification for PTSD and depression. Although the models for depression and PTSD produced similar results in terms of functional forms of the trajectories, it was unclear from the LGMM analyses if class membership was concordant across outcome measures. To assess this possibility, we used chi-square analyses comparing the probability of classification for the same trajectory in PTSD and depression. This analysis revealed a significant, nonrandom distribution across the four outcome patterns, $\chi^2(9, N = 317) = 225.13$, $p < .001$. Follow-up analyses of individual cells compared the frequency probability for each cell relative to chance using Haberman's (1978) standardized, adjusted residuals statistic (HAR). Across 69.7% of the sample, there was concordance for trajectory assignment for both PTSD and depression. More than half of the sample (57.7%) were classified as *low symptom* on both outcome measures, a percentage that was substantially in excess of chance probability, HAR = 13.2, $p < .001$. In addition, persons classified as *chronic* on both outcome measures (4.7%) also occurred in excess of chance, HAR = 5.4, $p < .001$, as did persons classified as *recovering* (5.4%), HAR = 5.6, $p < .001$ and persons classified as *delayed* (1.9%), HAR = 5.6, $p < .001$.

Discussion

Trajectories of Psychological Functioning

The goals of the current investigation were to establish the best fitting trajectories of psychological functioning after single incident traumatic injury and to examine covariate predictors of the trajectories within the same semi-parametric model. Overall, our findings indicate that four trajectories best explain variations in

Table 3
Covariate Prediction of Trajectory Class Membership: PTSD

	Delayed		Recovering		Chronic	
Variable	OR	95% CI	OR	95% CI	OR	95% CI
Human intention$_a$	6.28†	.86–45.68	1.34	.11–16.07	7.67**	2.87–20.49
Education	.52*	.34–.80	.76*	.60–.96	.88	.70–1.09
Self-efficacy T1	2.66*	1.34–5.28	1.13	.69–1.67	.88	.67–1.15
Anger T1	1.05	.86–1.18	1.14*	1.00–1.35	1.10†	1.00–1.20

Note. Low symptom class served as the referent. OR = odds ratio; CI = confidence interval; T1 = baseline.
$_a$ 1 = human intention; 0 = accident.
$^{\dagger} = p < .08$. $^{*} = p < .05$. $^{**} = p < .001$.

functioning during a period beginning at hospitalization and continuing through 6 months post-hospitalization. The majority of survivors demonstrated a relatively stable trajectory of little or no PTSD symptoms at each assessment point, a finding consistent with previous research (e.g., Bonanno, Galea, Bucciarelli, & Vlahov, 2006). Chronic PTSD symptom distress was reported in just over 20% of the sample, while 13% reported initially high levels of PTSD symptoms that were decreasing by 6 months. Finally, a small number of participants reported moderate levels of initial symptoms that ultimately increased by 6 months. This delayed response pattern is of considerable theoretical interest and, to our knowledge, this is the first time that it has been empirically separated from other trajectories of response (Andrews et al., 2007). Moreover, the trajectories identified in the present study bear a striking similarity to those observed in previous studies of acute stressors, including bioepidemic (Bonanno et al., 2008), terrorist attack (Bonanno et al., 2005), and breast cancer (Deshields, Tibbs, Fan, & Taylor, 2006).

The data on depression symptoms evidenced longitudinal patterns similar to those observed for PTSD, with the best-fitting model again producing four trajectories of symptoms. The majority of individuals (60%) had relatively low depression symptoms throughout the entire study period, representing a resilient path following traumatic injury. Interestingly, in contrast to the findings for PTSD, a relatively larger subset of individuals reported moderate levels of depression symptoms that increased over time, representing a delayed course (17%). This pattern, greater delayed elevations in depression compared to PTSD symptoms, was also observed in the study of high-exposure survivors of the 911 terrorist attack (Bonanno et al., 2005), and suggests an important area for further research. An additional 14% of the sample evidenced a recovery trajectory of initially acute depression that declined by the 6-month point. Finally, about 10% of the sample reported high levels of depressive symptoms immediately posttrauma and the severity of these symptoms remained high over time. The rates of chronic depression are similar to other studies of single incident trauma survivors (O'Donnell, Creamer, & Pattison, 2004).

Whether it was symptoms of depression or PTSD, it is important to highlight that the majority of the sample represented a low symptom trajectory after traumatic injury. The participants in this sample suffered traumatic injury to the point that most required surgical intervention at a level 1 trauma center, followed by extensive hospitalization and rehabilitation. Nonetheless, consistent with other studies that define this trajectory as resilience, the standardized raw scores indicated that participants showing the resilient profile had little or no depression or posttraumatic stress (approximately a symptom severity score of 7 to 8) over time (Bonanno, 2004). It is quite remarkable that such a large number of participants reported such low levels of symptom severity. Of course, low symptom levels are only part of the resilience story and further investigation is needed to verify that individuals in this group might also evidence more positive forms of adjustment (e.g., high well-being). Also, research efforts should focus on identifying individuals who are doing well after trauma or injury and what personal characteristics and behaviors contribute to this resilience. Although we investigated a few factors that contribute to resilience in a traumatically injured sample, extensive research is needed to truly understand the nature of human resilience in order to assist those who are doing less well.

Table 4
Fit Indices for One- to Six-Class Growth Mixture Models for Depression Symptoms (Unconditional)

	Growth mixture model					
Fit indices	1 Class	2 Classes	3 Classes	4 Classes	5 Classes	6 Classes
AIC	2469.29	2344.60	2316.54	2267.50	2222.67	2191.68
BIC	2499.66	2390.15	2377.28	2343.42	2313.78	2297.97
SSBIC	2474.28	2352.09	2326.52	2279.98	2237.65	2209.16
Entropy	—	.78	.78	.78	.80	.78
LRT p value	—	<.001	.46	.33	.11	.11

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; SSBIC = sample size adjusted Bayesian information criterion; LRT = Lo-Mendell-Rubin test.

Table 5
Growth Factor Parameter Estimates for 4-Class Unconditional Model: Depression

	Intercept		Slope		Quadratic	
Class	Est.	*SE*	Est.	*SE*	Est.	*SE*
Delayed	.163	.166	.029	.168	.021	.030
Chronic	1.444	.204	.367	.141	−.039	.019
Recovering	.178	.211	.809	.194	−.136	.038
Low symptom	−.310	.053	−.132	.036	.014	.005

Note. Est. = Estimate; *SE* = standard error.

Strikingly apparent in our results were the similar trajectories that emerged for PTSD and depression symptom patterns. It has been well documented that PTSD and depression are highly comorbid in trauma samples (e.g., Breslau, Davis, Peterson, & Schultz, 2000). Posthoc analyses further supported this impression and revealed significant concordance of classification for the same PTSD and depression symptom trajectory. Approximately seven out of every ten persons could be classified in the same symptom trajectory for PTSD and depression. Of the people who were concordant for symptom trajectory, 58% were classified as resilient, 5% had chronic symptoms of both PTSD and depression across the 6 months, 5% had acute symptoms of both disorders, and approximately 2% reported delayed onset symptoms. Also interesting is the timeframe from 3 to 6 months that appears to represent a significant change in course for those who were recovering or experiencing delayed distress. Although speculative, it is possible that in a sample of physically injured participants, a subset of individuals begin to realize at 3 months that they remain substantially physically impaired, with the possibility that their physical limitations may be permanent. Alternatively, it is possible that as time since injury increases psychological functioning improves, after which point individuals are more able to acknowledge their psychological distress. Unfortunately, we could not determine in this study whether people experienced additional trauma or life crises that could have contributed to delayed onset. All of these possible explanations for the delayed course are in need of further study.

Prediction of Trajectories

We were also interested in investigating covariates of interest that informed membership in both PTSD and depression symptom trajectories when considered from within the same LGMM. When the injury was perpetrated intentionally by another human being, this increased the probability that a survivor would exhibit chronic psychological distress versus resilience for both PTSD and depression symptom severity. This supports research by others (Janoff-Bulman, 1992; Zatzick et al., 2007) and demonstrates that the interpersonal nature of violence can have a lasting impact on psychological health. These results support the need to invest more resources in those who are survivors of interpersonal violence in order to improve quality of life.

An increase in years of education appeared to be protective, decreasing the likelihood of delayed or recovered PTSD symptoms when compared to those who are resilient. Yet, level of education did not differentiate between chronic or low symptoms of PTSD, suggesting that education level to a point is protective, but may not be a strong contributor to protect against chronic symptom distress. This pattern is consistent with previous studies that have identified unique predictors of resilience and pathology (e.g., Bonanno, Galea, Bucciarelli, & Vlahov, 2006). To further complicate the picture, education served as marginally protective against depressive symptoms, as higher education increased the likelihood of being resilient, when compared to experiencing chronic or delayed symptoms. A meta-analysis of PTSD risk factors has suggested that greater education has a modest but consistent relationship to less distress (Brewin, Andrews, & Valentine, 2000).

Coping self-efficacy as reported directly after the injury also emerged as an important covariate in our sample. Interestingly, our findings were mixed. On the one hand, we found that higher

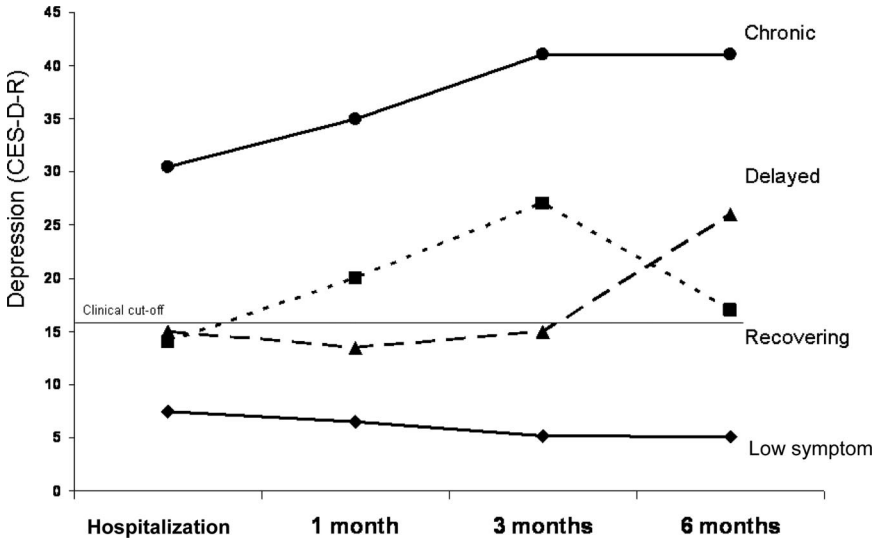

Figure 2. Four-class solution for depression symptoms (includes covariates).

Table 6
Covariate Prediction of Trajectory Class Membership: Depression

	Delayed		Recovering		Chronic	
Variable	OR	95% CI	OR	95% CI	OR	95% CI
Human intention$_a$	2.06†	.40–12.56	5.59	.59–53.01	6.42*	1.43–28.74
Education	.83†	.66–1.03	.81	.56–.1.17	.80†	.62–1.04
Self-efficacy T1	1.04	.74–1.45	.68	.40–1.14	.62*	.43–.90
Anger T1	1.16*	1.03–1.32	1.15†	.98–1.35	1.22*	1.04–1.42

Note. Low symptom class served as the referent. OR = odds ratio; CI = confidence interval; T1 = baseline.
$_a$ 1 = human intention; 0 = accident.
$^{\dagger} = p < .10$. $^{*} = p < .05$.

coping efficacy predicted a decreased likelihood of membership in the chronic trajectory when compared to the resilient trajectory.. On the other hand, having more confidence in one's ability to cope with the traumatic injury was associated with an increased probability of a delayed trajectory of PTSD symptoms when compared to a resilient trajectory. How can we reconcile these findings? Perhaps there is an optimal level of perceived coping efficacy, neither too high nor too low. For example, it is possible that immediately after the potentially traumatic event (PTE) some survivors underestimate the difficulty of coping with a traumatic injury and consequently view their coping efficacy in overly optimistic terms. As they discover that the experience poses greater challenges than expected, including permanent disability and continued pain, their distress would likely increase. This perspective suggests that anticipating that a traumatic injury will pose moderate difficulties may help a person to mobilize coping resources. By contrast, viewing a traumatic injury as beyond one's ability to cope—as suggested by the lower levels of coping efficacy found in the chronic group when compared to the resilient—would likely also lead to less ineffective coping. Indeed, perceiving a stressor as threatening and overwhelming, as opposed to a challenge to be overcome, has been widely shown to lead to more physiological arousal and to less effective behavioral responses to stress (Tomaka, Blascovich, Kibler, & Ernst, 1997).

Anger immediately after the trauma event increased the likelihood that an individual would exhibit acute PTSD symptoms that either remained, as in the chronic distress group, or decreased over time, as in the recovered group, compared with the resilient group. For depression, higher levels of anger at baseline were associated with an increased likelihood of delayed onset symptoms and chronically elevated symptom levels, compared with low levels of depression symptoms. Anger after traumatic experiences has been documented in assaulted trauma survivors (Feeny, Zoellner, Fitzgibbons, & Foa, 2000) and this finding supports that anger is a large component of distress. Moreover, a recent meta analysis found that anger is strongly associated with PTSD symptoms, though the direction of the relationship between these factors has yet to be established (Orth & Wieland, 2006).

Clinical Implications

The findings of this study suggest a number of important clinical implications. First and foremost is the shear prevalence of resilience in this sample. All participants in this study experienced potentially traumatic injuries and had been hospitalized at a level 1 trauma center. Not surprisingly given this level of exposure, 10% of the sample evidenced chronic depression and over 20% evidenced chronically elevated PTSD symptoms. Nonetheless, despite the high proportion of psychopathology, almost 60% evidenced resilience, defined in this study as low symptoms of PTSD and depression. These findings underscore the clear individual variation in response to potential trauma and suggest the crucial importance of recognizing that what may be traumatic for some individuals is not necessarily traumatic for others.

An obvious extension of this implication is the need for improved assessment of the factors that might predict who will cope well with potentially traumatic injury and who might possibly benefit from clinical intervention. Of particular relevance is the distinction between individuals with initially elevated psychopathology who eventually recover (i.e, those showing a recovery trajectory) and individuals who evidenced chronically elevated psychopathology. The data on covariates included in our models provides a preliminary means of teasing apart these trajectories. A particularly striking finding was that injuries perpetrated intentionally by another human being were consistently predictive of chronically elevated psychopathology. More specifically, this finding suggests that people who experience acute distress when hospitalized for potentially traumatic injuries are at greater risk for chronic psychological distress if their injury was perpetrated by another person, whereas those with acute distress but not injured intentionally at the hand of another person are more likely to recover. By the same token, anger although a significant covariate in our models, did not offer salient clinical implications about these same trajectory distinctions. People who were excessively angry, for example, were equally likely to exhibit a pattern of chronic PTSD as they were a pattern of acute PTSD followed by gradual recovery.

Another outcome distinction of particular relevance to possible clinical implications is that between individuals showing a stable positive adjustment or resilience and those who have initially low levels of symptoms but then develop delayed reactions. Especially noteworthy here was the role of participants perceptions of their own coping self-efficacy. Participants who experienced delayed elevations in PTSD symptoms had higher coping self-efficacy during hospitalization compared to participants who exhibited consistently low symptom levels. Similarly, participants who experienced delayed PTSD also had fewer years of education compared to the resilient group. We are cautious about making too much of these findings, given the limitations of the measures (see below) and concern that we might unfairly suspect traumatic injury

patients of exhibiting denial. It is also possible that at this very early stage of recovery injury survivors underestimate the extent and implications of their injuries, and thus provide overly optimistic assessments of their initial ability to cope. Nonetheless, these patterns do suggest compelling implications. Excessive belief in one's coping abilities despite the obviously demanding nature of the stressor may place patients at risk for difficulties at later points in their recovery. By the same token, our study suggests that greater education may help to bolster resilience and forestall the appearance of delayed emotional difficulties. Although far from exhaustive, these findings highlight the imperative for further research on factors that might inform different patterns of adjustment in the aftermath of traumatic injury.

Limitations and Conclusion

Although the use of LGMM to identify longitudinal trajectories of adjustment holds many advantages, there are also limitations to this approach. First, despite numerous attempts to follow-up with individuals, we experienced a large dropout of study participants across the 6 months of enrollment, resulting in 36% attrition at the final follow-up. Importantly, 70% of the attrition group was assaulted trauma survivors, which significantly limits generalizability to this population, particularly since past research suggests that assaulted trauma survivors are more at risk for psychological distress compared to nonassaulted trauma groups. In a sample of assaulted trauma survivors only, we may see different trajectories and different variables predicting trajectory membership. Our recruited sample may also present bias, as there were a number of individuals who did not or were unable to participate for reasons such as direct refusal and limited access due to multiple medical procedures. Because these individuals were not assessed, it is possible that they differed with respect to levels of distress and presence or absence of risk factors, yet this information was not obtainable. Further research focused on a more representative sample for longitudinal methodology, with recruitment efforts particularly addressing increased participation for assaulted survivors is needed to address these limitations.

Additionally, although the identification of latent growth classes is largely empirically determined, the selection of a final model requires some conceptual adjudication. As we highlighted, this is an iterative process that is guided by many factors, including fit statistics as well as conceptual and interpretive rationale. Muthén (2004) has advised that covariates should be included when extracting classes and determining the final model. We opted not to use covariates in determining the trajectory class structure because our use of covariates was exploratory and not guided by strong theory. Our goal was to achieve the most accurate and parsimonious explanation of psychological functioning after traumatic injury that was also informed by theory, ultimately leaving this process open to some debate. By the same token, the advantages of LGMM suggest this method is superior to other approaches to individual differences and even to other means of accessing latent growth curves (Muthen, 2004). LGMM is especially well suited for trauma field studies, as it employs a robust maximum-likelihood estimation procedure that can accommodate missing data, allows parameters to vary as random effects across classes, and includes other variables that might influence the shape of the outcome patterns as covariates in the modeling procedures.

Other limitations of our study was that it relied exclusively on interview and self–report of symptoms by the participant, leaving the data open to possible response and presentation biases. There may have been pre-trauma variables, such as psychiatric and trauma history that could have influenced reporting of emotional functioning, along with personality factors that could have influenced perspectives on adjustment to the PTE. Future research is needed that includes the many risk and protective factors documented in the literature as important in distress after trauma to collectively examine their influence. Our use of a coping self-efficacy measure designed specifically for this study population is open to review. The coping self-efficacy measure was designed by experts who work with this population to specifically address the unique experiences that trauma survivors have to cope with after severe injury. However, besides the reported reliability coefficient that demonstrated adequate internal consistency, extensive psychometric information does not exist, presenting a limitation when interpreting the results of this measure.

Finally, our study did not include measures of positive psychological adjustment. Bonanno (2004) argued that resilience is more than the absence of psychopathology and suggested that assessment of resilience should also include the demonstration of healthy psychological functioning. This study measured psychopathology and not levels of well-being and quality of life after traumatic injury. Also, we used resilience as a referent group, and did not seek to differentiate between the distress trajectories, which could have high clinical utility. Studies with injured trauma survivors are needed to investigate both positive and negative functioning trajectories following trauma in the same sample that includes an investigation into the variables that predict both, in order to better understand resilient and psychopathological responses.

In conclusion, this study is the first to prospectively follow injured trauma survivors from a level 1 trauma center to document trajectories of resiliency and psychopathology. The majority of the individuals demonstrated resilient psychological functioning after traumatic injury. However, those who exhibited psychopathology did so in three distinct ways, either having a chronic, delayed, or recovered path of distress. Because quality of life is affected by psychological health and physical outcomes are closely linked to psychological functioning, future research would benefit from a more detailed investigation into the predictors of different distress trajectories, in order to inform clinical intervention and prevention efforts.

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