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Review

Trajectories of resilience and dysfunction following potential trauma: A review and statistical evaluation

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HIGHLIGHTS

- A review of n = 54 studies demonstrates that resilience is the modal response to major life stressors and potential trauma.
- Resilience, recovery, chronicity, and delayed onset were consistently identified adjustment outcome trajectories.
- Pattern stability across contextual factors indicates that the trajectories are likely phenotypic human stress responses.
- Trait and state factors associated with trajectory membership have implications for risk identification and interventions.
- Trajectory models provide a robust methodology to study clinically relevant responses to stress and potential trauma.

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ABSTRACT

Given the rapid proliferation of trajectory-based approaches to study clinical consequences to stress and potentially traumatic events (PTEs), there is a need to evaluate emerging findings. This review examined convergence/divergences across 54 studies in the nature and prevalence of response trajectories, and determined potential sources of bias to improve future research. Of the 67 cases that emerged from the 54 studies, the most consistently observed trajectories following PTEs were resilience (observed in: n = 63 cases), recovery (n = 49), chronic (n = 47), and delayed onset (n = 22). The resilience trajectory was the modal response across studies (average of 65.7% across populations, 95% CI [0.616, 0.698]), followed in prevalence by recovery (20.8% [0.162, 0.258]), chronicity (10.6%, [0.086, 0.127]), and delayed onset (8.9% [0.053, 0.133]). Sources of heterogeneity in estimates primarily resulted from substantive population differences rather than bias, which was observed when prospective data is lacking. Overall, prototypical trajectories have been identified across independent studies in relatively consistent proportions, with resilience being the modal response to adversity. Thus, trajectory models robustly identify clinically relevant patterns of response to potential trauma, and are important for studying determinants, consequences, and modifiers of course following potential trauma.

1. Introduction

The majority of individuals are exposed to at least one and often several potentially traumatic events (PTE) during the course of their lifetime (Norris, 1992; Ogle, Rubin, Berntsen, & Siegler, 2013). Bereavement, life-threatening medical events, and other major stressors are even more common. The links between these events and the development of psychopathology, such as Posttraumatic Stress Disorder (PTSD) or Persistent Complex Bereavement Disorder (PCBD), is well established (Breslau, Davis, Andreski, & Peterson, 1991; Perkonigg, Kessler, Storz, & Wittchen, 2000; Shear et al., 2011). Of note, however, although diagnoses serve critical functions for assessment and treatment planning, recent research has demonstrated the necessity of moving beyond the exclusive reliance on diagnostic categorization (Galatzer-Levy & Bryant, 2013; Insel et al., 2010). It is well understood, for example, that the majority of individuals who are exposed to a PTE do not develop PTSD (Gradus, 2007). Similarly, only a minority of individuals who lose a spouse or child develop clinical depression or significant functional impairment (Bonanno et al., 2002). Moreover, longitudinal studies of adjustment following potential trauma have identified a range of distinct outcome patterns or trajectories over time that are not adequately captured by use of binary diagnostic categories (Bonanno, 2004; Bonanno et al., 2002). These trajectories include for example gradual recovery (prolonged but ultimately waning distress/disruption in functioning/emergence of psychopathology; e.g., Mayou, Ehlers, &

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Bryant, 2002) sub-syndromal symptomatology (elevated symptoms below the diagnostic threshold; e.g., Cukor, Wyka, Jayasinghe, & Difede, 2010), delayed-onset symptomatology (elevations above the diagnostic threshold that emerge following a significant delay (e.g., Andrews, Brewin, Philpott, & Stewart, 2007), and minimal-impact resilience (stable psychological and physical health from before to after the PTE; e.g., Bonanno, 2004; Bonanno & Diminich, 2013).

Cross-sectional diagnostic classification can overlook or conflate distinct trajectories as the above described populations overlap substantially at any given point in time. Recovery, for example, may be conflated with resilience or chronic stress depending on when it is assessed. Only by charting individuals' trajectory of response can such populations be differentiated. This insight has significant implications for clinical theory and research as these populations have been shown to differ in determinants including biological, psychological, and environmental factors (Bonanno, Mancini, et al., 2012; Galatzer-Levy & Bonanno, 2014; Galatzer-Levy, Burton, & Bonanno, 2012; Galatzer-Levy, Steenkamp, et al., 2014). They also differ in consequences including health and mortality (Galatzer-Levy & Bonanno, 2014; Malgaroli, Galatzer-Levy, & Bonanno, 2017), and treatment effects (Galatzer-Levy, Ankri, et al., 2013).

Increasingly, data-driven modeling approaches have been utilized to identify different trajectories empirically based on similarities in degree of severity and change over time. Modeling approaches such as latent growth mixture modeling (LGMM), latent class growth analysis (LCGA), and related methods attempt to identify latent (unobservable) mixture distributions underlying an observed non-normal distribution. Through an iterative process of model comparison, the optimal number of trajectories and best fitting parameters are identified (Nylund, Asparouhov, & Muthen, 2007). Though mixture distributions have been utilized to identify qualitatively distinct populations since the 19th century (Stigler, 1986), advances in computation power have recently led to a marked proliferation and advancement in the complexity of such models.

Longitudinal studies utilizing this approach with at least three timepoints have identified trajectories of response to PTEs including resilience, recovery, delayed onset, and chronic stress. Studies that examined individuals prospectively (from before to after the event) have demonstrated further heterogeneity within the chronic and recovery trajectories, differentiating those who were functioning either well or poorly before the event and either changed or continued to function the same way after the event (see Fig. 1; Bonanno, 2004; Bonanno & Diminich, 2013; Bonanno, Romero, & Klein, 2015; Bonanno, Westphal, & Mancini, 2011).

The use of trajectory modeling has led to important substantive findings that may otherwise be overlooked. Trajectory models have been shown, for example, to alter estimates of treatment effects (Galatzer-Levy, Ankri, et al., 2013; Gueorguieva et al., 2007; Muthen, Asparouhov, Hunter, & Leuchter, 2011) and to enhance the identification of predictors (Galatzer-Levy, Karstoft, Statnikov, & Shalev, 2014) and consequences (Burton, Galatzer-Levy, & Bonanno, 2015) of clinical intervention. Such models have demonstrated that populations who would otherwise be conflated, such as stress-emergent depression and chronic depression, differ significantly in mortality rates following a PTE (Galatzer-Levy & Bonanno, 2014). Further, rates of resilience have been found to be moderated by various contextual factors, such as coping strategies and style (Bonanno, Kennedy, Galatzer-Levy, Lude, & Elfström, 2012; Galatzer-Levy & Bonanno, 2012), financial stress, physical health (Galatzer-Levy & Bonanno, 2012), and social network size (Galatzer-Levy et al., 2012) (for reviews, see Bonanno et al., 2011; Bonanno et al., 2015). Additionally, the identification of common trajectories across clinical populations and pre-clinical models has enhanced translation, mechanism identification, and treatment target identification (Galatzer-Levy et al., 2017; Galatzer-Levy, Bonanno, Bush, & LeDoux, 2013).

Due to the rapid proliferation of the trajectory approach as a tool to identify common patterns of response to pronounced stressor events, there is great variation in both approach and results. Considerable differences have been observed across studies in sample size, constructs measured, event types, measurement points, and parameter fit. Due to the large number of studies, the influence of these differences in design can be statistically evaluated to determine sources of error and confluence across methods. Commonly observed trajectories and their emergence rates invariant to the above influences would indicate general principles concerning populations in response to potential trauma and significantly disruptive life events.

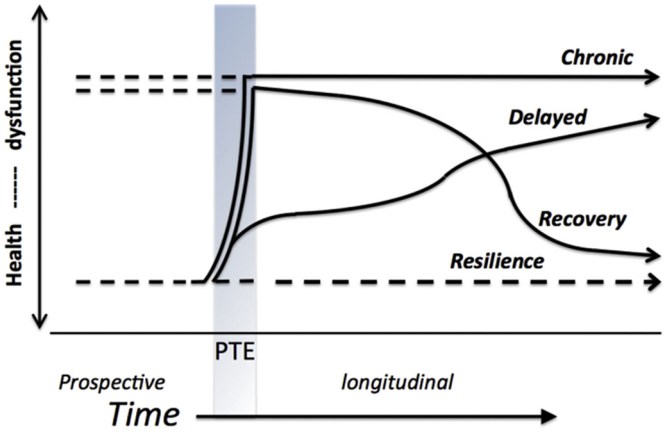

Fig. 1. Commonly observed prospective and longitudinal trajectories of response to potential trauma. Adapted from "Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events?" by B. A. Bonanno, 2004, American Psychologist, 59(1), 20-28.

To address these questions in the current investigation, we examined the consistency of trajectory prevalence in relation to methodology used (e.g., longitudinal vs. prospective designs), the population studied (e.g., chronic adversity vs. single incident PTE), type of stressor (e.g., military PTE, civilian PTE, loss, etc.), the type of outcome measure used (e.g., symptoms of PTSD, anxiety, depression; subjective well-being etc.), and whether participants were drawn from the general population (population samples) or a cohort from a specific locale (cohort sample; e.g., emergency room samples). Finally, we summarized these results and explored common areas and gaps in research regarding predictors, modifiers, and outcomes related to the identified trajectories.

2. Method

2.1. Search strategy and selection criteria

Studies were identified by key word search of online databases (PsycINFO and PubMed) for English language publications available in April 2016. Keywords used included trauma, stress, trajectories, Latent Growth Mixture Modeling (LGMM), Latent Class Growth Analysis (LCGA), and other variations in terminology. The reference section of articles that were selected for inclusion was also reviewed to identify additional relevant studies, yielding a total of 102 studies for preliminary review. Eligible studies examined the prevalence of trajectories of adjustment following a PTE (e.g., war) or major life stressor (e.g., bereavement) using modeling approaches (LGMM vs. LCGA) that require at least three timepoints. Only studies that had a sample > 100, conducted their first post-event assessment within a year (for longitudinal studies[1]) or two years (for prospective studies[2]) of the event, and examined psychological variables as primary outcomes —

[1] Three studies that conducted assessment more than a year post-event were included because they have large, population-based samples with informative data (see Table 1 for more information).

[2] One study that collected data at three-year intervals was included because the event occurred variably within the interval and unlikely occurred three years before post-event assessment. Further, it is a prospective study with a large, population-based sample that provides informative data (see Table 1 for more information).

such as PTSD, psychological distress/well-being, depression, anxiety, and acute stress — were included for analysis. Most longitudinal studies and some prospective studies conducted their first post-event assessment within several months and exclusively within a year of the event. Most prospective studies with large, population-based samples collected data in intervals with the targeted event occurring within an interval at an unspecified time. Studies that primarily focused on body image, self-image and sexuality, and smoking behavior were excluded from the analysis because these outcomes are infrequently studied. Following the exclusion of publications that did not meet criteria, 54 studies were included for review. Of these, three studies contained two subsamples, one study contained three subsamples, one study examined three events, four studies included two primary outcomes, and one study included three primary outcomes (see Table 1 for summary). Consequently, a total of 67 cases were included for statistical analysis.

2.2. Coding of studies

All eligible studies were coded for their unconditional model's sample size, sample type (i.e., population vs. cohort sample), study design (i.e., prospective vs. longitudinal), event duration (i.e., single/acute vs. chronic), type of event or population (e.g., refugee/war, civilian trauma/accidents), primary outcome (e.g., PTSD, depression), types of modeling approach utilized (e.g., LGMM, LCGA), and types of covariates included in the model that are significant (e.g., individual characteristics, psychological variables). Furthermore, trajectories were coded based on their general pattern into broad types, such as resilient, chronic, recovery, and delayed-onset trajectories.

2.3. Calculating pooled prevalence rates

The weighted prevalence rate of each trajectory was calculated across studies utilizing a Freeman-Tukey transformation (Freeman & Tukey, 1950) in MedCalc for Windows, version 17.2 (Schoonjans, 2008). The random effects model was chosen for a more conservative estimate to account for heterogeneity between studies (Borenstein, Hedges, Higgins, & Rothstein, 2009). This approach is recommended (Barendregt, Doi, Lee, Norman, & Vos, 2013) and widely utilized (e.g., Fulton et al., 2015) for meta-analyses requiring pooled frequencies or prevalence instead of effect sizes.

3. Results

We approached the analyses of trajectories in three steps. We first examined existing studies to determine commonly observed trajectories. We compared the prevalence of the most commonly observed trajectories across studies and statistically test for heterogeneity and further determine if heterogeneity is due to sampling bias. We next examined two key sources of bias (sample size and study design). Finally, we examined multiple influences on the estimates of each trajectory. Due to the overlap in these potential sources, we examined their influence using multivariate tests followed by post-hoc univariate tests to better understand overall effects.

3.1. Commonly identified trajectories

Means and standard deviations of the prevalence rate of each trajectory are shown in Table 2. Most studies utilized a cohort sample and longitudinal design, examined single PTEs related to adult civilian trauma or accidents, and focused on PTSD as the primary outcome. Resilient, chronic, recovery, and delayed-onset trajectories were the most frequently reported trajectories, specifically observed in 63, 47, 49, and 22 studies respectively. We further explored these trajectories below in the context of varying sample types, study designs, event duration, PTE types, and primary outcomes. Due to the scope of this study, the remaining eight trajectories with lower observed frequency counts were included in the table but excluded from further analyses.

Overall, of the four trajectories, the resilient trajectory had the highest mean prevalence rate, observed on average in a majority of participants ($M = 0.650$, $SD = 0.180$), followed in prevalence by the recovery ($M = 0.234$, $SD = 0.227$), chronic ($M = 0.117$, $SD = 0.085$), and delayed-onset ($M = 0.097$, $SD = 0.090$) trajectories. In terms of sample type, prevalence rates of the resilient ($M = 0.700$, $SD = 0.121$) and delayed-onset ($M = 0.154$, $SD = 0.177$) trajectories were higher in population-based rather than cohort samples, while prevalence rates of the chronic ($M = 0.122$, $SD = 0.095$) and recovery ($M = 0.251$, $SD = 0.220$) trajectories were higher in cohort rather than population samples.

Cochran's Q test indicated heterogeneity in the prevalence rates of each trajectory: resilient, $Q(62) = 8390.31$, $p < .001$; chronic, $Q(46) = 2934.04$, $p < .001$; recovery, $Q(48) = 8778.90$, $p < .001$; and delayed onset, $Q(21) = 1983.81$, $p < .001$. The I^2 statistic indicated, however, that the vast majority of the variability among the overall proportion for each trajectory (resilient = 99.26%, chronic = 98.43%, recovery = 99.45%, delayed onset = 98.94%) could be attributed to true heterogeneity between studies rather than sampling error. Significant heterogeneity supports the use of random-effects rather than fixed-effects models. Utilizing the random-effects model, the pooled prevalence rate of the resilient trajectory was 0.657 (i.e., 65.7%), 95% CI [0.616, 0.698]. The pooled prevalence rates of the chronic, recovery, and delayed-onset trajectories were 0.106 (i.e., 10.6%) [0.086, 0.127], 0.208 (i.e., 20.8%) [0.162, 0.258], and 0.089 (i.e., 8.9%) [0.053, 0.133] respectively. This indicates that prevalence rates are similar regardless of method but are likely more accurate with pooled estimates providing greater assurance.

3.2. Influence of sample size and study design

The relationship between sample size and estimates of trajectory membership was evaluated to determine if the size of the sample introduces bias. Table 3 shows correlations between sample size and the mean prevalence rate of each outcome trajectory in the overall sample, and then exclusively in prospective and longitudinal studies. No significant correlations were found between sample size and the prevalence rates of the four trajectories in the overall sample, nor when examining prospective and longitudinal studies separately.

In terms of study design, the resilient trajectory had a higher prevalence rate in prospective studies ($M = 0.737$, $SD = 0.097$), while the chronic ($M = 0.127$, $SD = 0.098$), recovery ($M = 0.294$, $SD = 0.255$), and delayed-onset ($M = 0.110$, $SD = 0.102$) trajectories had higher prevalence rates in longitudinal studies. In terms of event duration, the resilient ($M = 0.661$, $SD = 0.170$) and delayed-onset ($M = 0.099$, $SD = 0.091$) trajectories had higher prevalence rates when single, acute events were examined, while the chronic ($M = 0.136$, $SD = 0.099$) and recovery ($M = 0.336$, $SD = 0.321$) trajectories had higher prevalence rates when chronic events were examined (see Table 4 for statistical comparisons).

3.3. Multiple analyses of factors that distinguish trajectory prevalence

A number of factors differ between trajectory models and may influence the prevalence of trajectory membership including event type, modeling approach, event duration, and primary outcome. To assess the influence of these factors on trajectory prevalence, we first provided descriptive information on each factor's relationship to the prevalence of the most commonly identified trajectories (resilience, recovery, chronic, delayed onset). Next, we conducted multiple analyses of variance (ANOVAs) separately for each trajectory to determine the shared and unique influence of these factors on the prevalence of that trajectory. Finally, we conducted post-hoc analyses related to significant factors to determine univariate effects.

Table 1
Summary of studies included in the review of the prevalence of adjustment trajectories following a PTE or major life stressor.

Reference	Event studied	*N*	Study design	Location	Length of data collection	Number of timepoints	Primary outcome and measure	Modeling approach	Types of significant covariates
Cohort samples									
Armour, Shevlin, Elklit, and Mroczek (2011)	Civilian trauma/accident - Rape	255	Longitudinal	Denmark	12 months	4	PTSD (HTQ-IV)	LGMM	Psychological
Berntsen et al. (2012)	Military deployment	366	Prospective	Denmark	8 months	5	PTSD (PCL-C)	LCGA	Environmental[a],psychological, characteristics[b]
Betancourt, McBain, Newnham, and Brennan (2013)	Children trauma/accident - War	528	Longitudinal	Sierra Leone	7 years	3	Internalizing problems (OMPA)	LCGA	Environmental, psychological, social, characteristics
Betancourt, McBain, and Brennan (2014)	Children trauma/accident - War	528	Longitudinal	Sierra Leone	7 years	3	Externalizing problems (OMPA)	Nagin	Environmental, social
Boasso, Steenkamp, Nash, Larson, and Litz (2015)[c]	Military deployment - Lower tertile	208	Prospective	USA	8 months	4	PTSD (CAPS, PCL-S)	LGMM	
	Military deployment - Middle tertile	192							
	Military deployment - Upper tertile	234							
Bonanno et al. (2008)	Health event - SARS	997	Longitudinal	Hong Kong, China	18 months	3	Psychological functioning (SF-12)	LCGA	Social, characteristics, physical
Bonanno, Kennedy, et al. (2012)[d]	Civilian trauma/accident - Spinal cord injury	233	Longitudinal	Europe	2 years	4	Anxiety (HADS-A) Depression (HADS-D)	LGMM	Psychological, characteristics Psychological, characteristics
Bryant et al. (2015)	Civilian trauma/accident	1084	Longitudinal	Australia	6 years	5	PTSD (CAPS)	LCGA	Environmental, psychological, characteristics, physical
deRoon-Cassini, Mancini, Rusch, and Bonanno (2010)[d]	Civilian trauma/accident	330	Longitudinal	USA	6 months	4	Depression (BSI) PTSD (ASDI @T1, PDS)	LGMM	Environmental, psychological, characteristics Environmental, psychological, characteristics
Dickstein, Suvak, Litz, and Adler (2010)	Military deployment	635	Prospective	USA	9 months	4	PTSD (PCL)	LCGA	Environmental, psychological, characteristics, substance
Elliott, Berry, Richards, and Shewchuk (2014)	Civilian trauma/accident - Spinal cord injury caregiving	128	Longitudinal	USA	12 months	4	Depression (CES-D)	LGMM	Psychological, social, physical
Galatzer-Levy, Madan, Neylan, Henn-Haase, and Marmar (2011)	Civilian trauma/accident - PTE-exposed police work	178	Prospective	USA	36 months	5	PTSD (PCL)	LGMM	Psychological
Galatzer-Levy et al. (2012)	Major life event - College	155	Prospective	USA	3.5 years	8	General distress (SCL-90-R: GSI)	LGMM	Psychological, social
Galatzer-Levy, Brown, et al. (2013)	Civilian trauma/accident - PTE-exposed police work	234	Prospective	USA	48 months	5	General distress (SCL-90-R: GSI)	LCGA	Psychological
Galatzer-Levy, Ankri, et al. (2013)	Civilian trauma/accident	957	Longitudinal	Israel	6 years	5	PTSD (PSS)	LGMM	Psychological, characteristics
Ginzburg and Ein-Dor (2011)	Health event - Heart attack	173	Longitudinal	Israel	8 years	3	PTSD (SASRQ @ T1, PTSDI)	LCGA	Environmental, physical
Hong et al. (2014)	Children trauma/accident - Fire drill accident	167	Longitudinal	Korea	30 months	4	PTSD (CPTSD-RI)	LGMM	Psychological, social, physical
Karstoft, Armour, Elklit, and Solomon (2013)[e]	Military deployment - with combat stress response	369	Longitudinal	Israel	20 years	3	PTSD (PTSDI)	LGMM	Environmental, social
	Military deployment - without combat stress response	306							Environmental, social
La Greca et al. (2013)	Children trauma/accident - Natural disaster	568	Longitudinal	USA	10 months	3	PTSD (CPTSD-RI)	LGMM	Environmental, psychological, social, characteristics
Lai, Tiwari, Beaulieu, Self-Brown, and Kelley (2015)	Civilian trauma/accident - Natural disaster	283	Longitudinal	USA	2 years	4	Depression (BSI)	LCGA	Environmental, social
Lam et al. (2010)	Health event - Breast cancer	303	Longitudinal	Hong Kong, China	8 months	4	Distress (CHQ-12)	LGMM	Psychological, characteristics, physical
Lauterbach and Armour (2015)	Children trauma/accident - Maltreatment	1354	Longitudinal	USA	16 years	9	Anxiety & Depression (CBCL/4–18)	LCGA	Environmental, psychological, social

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Table 1 (*continued*)

Reference	Event studied	*N*	Study design	Location	Length of data collection	Number of timepoints	Primary outcome and measure	Modeling approach	Types of significant covariates
Le Brocque, Hendrikz, and Kenardy (2010a)	Children trauma/accident	190	Longitudinal	Australia	2 years	4	PTSD (CIES)	Nagin	Psychological, characteristics, physical
Le Brocque, Hendrikz, and Kenardy (2010b)	Civilian trauma/accident - Observing child injury	189	Longitudinal	Australia	2 years	4	PTSD (IES)	Nagin	Psychological, social, characteristics
Lowe and Rhodes (2013)	Civilian trauma/accident - Natural disaster=	386	Prospective	USA	4 years	3	Distress (K6)	LCGA	Environmental, social, resources[f]
Mancini, Littleton, and Grills (2015)[d]	Civilian trauma/accident - Mass shooting	368	Prospective	USA	12 months	4	Anxiety (FDAS-E) Depression (CES-D)	LGMM	Psychological, social, resources Psychological, social, resources
Mason et al. (2010)	Civilian trauma/accident - Burn trauma	1232	Longitudinal	USA	2 years	4	Distress (BSI)	LGMM	Characteristics, physical
Nash et al. (2015)	Military deployment	867	Prospective	USA	16 months	4	PTSD (CAPS, PCL-S)	LGMM	Environmental, psychological
Nugent et al. (2009)	Children trauma/accident - Reported family violence	201	Longitudinal	USA	36–40 months	4	PTSD (NSA-PTSD)	LGMM	Environmental, characteristics
Orcutt, Bonanno, Hannan, and Miron (2014)	Civilian trauma/accident - Mass shooting	689	Prospective	USA	31 months	7	PTSD (DEQ)	LGMM	Environmental, psychological, characteristics
Pérez et al. (2015)	Health event - Breast cancer	102	Longitudinal	Spain	1 year	5	Acute stress reaction (SASRQ)	LGMM	Psychological
Pielmaier, Milek, Nussbeck, Walder, and Maercker (2013)[g]	Civilian trauma/accident - Observing severe TBI Civilian trauma/accident - Observing severe TBI	135	Longitudinal	Switzerland	12 months	3	PTSD (IES-R: Avoidance) PTSD (IES-R: Hyperarousal) PTSD (IES-R: Intrusions)	LGMM	Psychological Psychological Psychological
Pietrzak, Van Ness, Fried, Galea, and Norris (2013)	Civilian trauma/accident - Natural disaster	206	Longitudinal	USA	15 months	3	PTSD (PCL-S)	LGMM	Environmental, psychological, characteristics, resources
Punamäki, Palosaari, Diab, Peltonen, and Qouta (2015)	Children trauma/accident - War	240	Longitudinal	Gaza Strip	11 months	3	PTSD (CRIES-R)	LCGA	Psychological, social
Self-Brown, Lai, Thompson, McGill, and Kelley (2013)	Children trauma/accident - Natural disaster	426	Longitudinal	USA	25 months	4	PTSD (CPTSD-RI)	LCGA	Environmental, social
Self-Brown, Lai, Harbin, and Kelley (2014)	Civilian trauma/accident - Natural disaster	360	Longitudinal	USA	25–27 months	4	PTSD (PDS)	LCGA	Environmental
Steenkamp, Dickstein, Salters-Pedneault, Hofmann, and Litz (2012)	Civilian trauma/accident - Sexual assault	119	Longitudinal	USA	4 months	4	PTSD (PCL-C)	LCGA	Psychological
Population-based samples									
Andersen, Karstoft, Bertelsen, and Madsen (2014)	Military deployment	561	Prospective	Denmark	3 years	5–6 weeks	PTSD (PCL-C)	LGMM	Environmental, psychological
Bonanno, Mancini, et al. (2012)[e,h]	Military deployment - Multiple deployment	4394	Prospective	USA	6 years	3	PTSD (PCL-C)	LGMM	Environmental, characteristics, resources, substance, physical
Bonanno, Mancini, et al. (2012)	Military deployment - Single deployment	3393						LGMM	Environmental, characteristics, resources, substance, physical
Burton, Galatzer-Levy, and Bonanno (2015)	Health event - Cancer	1294	Prospective	USA	8 years	4	Depression (CES-D)	LGMM	Characteristics, physical
Eekhout, Reijnen, Vermetten, and Geuze (2016)	Military deployment	960	Prospective	The Netherlands	5 years	6	PTSD (SRIP)	LGMM	Environmental, characteristics
Galatzer-Levy and Bonanno (2012)	Loss - Spousal bereavement	301	Prospective	USA	7 years	4	Depression (CES-D)	LCGA	Psychological, resources, physical
Galatzer-Levy and Bonanno (2014)	Health event - Heart attack	2147	Prospective	USA	10 years	5	Depression (CES-D)	LGMM	Psychological
Galatzer-Levy, Bonanno, and Mancini (2010)	Major life event - First-time unemployment	774	Prospective	Germany	8 years	8	Life satisfaction (SWB)	LGMM	Environmental, characteristics

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Table 1 (*continued*)

Reference	Event studied	*N*	Study design	Location	Length of data collection	Number of timepoints	Primary outcome and measure	Modeling approach	Types of significant covariates
Galatzer-Levy, Mazursky, Mancini, and Bonanno (2011)	Major life event - Parenthood	2358	Prospective	Germany	9 years	9	Life satisfaction (SWB)	LGMM	Characteristics
Hobfoll, Mancini, Hall, Canetti, and Bonanno (2011)[d]	War - Chronic political violence	764	Longitudinal	Gaza Strip	1 year	3	Depression (PHQ-9)	LGMM	Environmental, social, characteristics, resources
							PTSD (PSS-I)		Environmental, social, characteristics, resources
Johannesson, Arinell, and Arnberg (2015)[i]	Civilian trauma/accident - Natural disaster	3518	Longitudinal	Sweden	6 years	3	PTSD (IES-R)	LGMM	Environmental, psychological, social, characteristics
Maccallum, Galatzer-Levy, and Bonanno (2015)	Loss - Spousal/child bereavement	2512	Prospective	USA	6 years	4	Depression (CES-D)	LCGA	Characteristics, resources
Mancini, Bonanno, and Clark (2011)[j]	Loss - Spousal bereavement	464	Prospective	Germany	9 years	9	Life satisfaction (SWB)	LGMM	Characteristics, resources, physical
	Major life event - Divorce	629							Characteristics, resources, physical
	Major life event - Marriage	1739							Characteristics, resources, physical
Maslow et al. (2015)[i]	Civilian trauma/accident - Terrorist attack (9/11)	16,488	Longitudinal	USA	10–11 years	3	PTSD (PCL-C)	LCGA	Environmental, psychological, social, characteristics, resources
Nandi, Tracy, Beard, Vlahov, and Galea (2009)	Civilian trauma/accident - Terrorist attack (9/11)	2282	Longitudinal	USA	30 months	4	Depression (SCID)	LCGA	Environmental, psychological, social, characteristics
Orcutt, Erickson, and Wolfe (2004)	Military deployment	2913	Longitudinal	USA	6–7 years	3	PTSD (M-PTSD @T1, PCL)	LGMM	Environmental, characteristics
Pietrzak et al. (2014)[i]	Civilian trauma/accident - Terrorist disaster response	10,835	Longitudinal	USA	8 years	3	PTSD (PCL-S)	LGMM	Environmental, psychological, social, characteristics, physical
Zhu, Galatzer-Levy, and Bonanno (2014)	Health event - Moderate to severe chronic pain onset	2172	Prospective	USA	6 years	4	Depression (CES-D)	LGMM	Psychological, characteristics, physical

Note. Studies are listed according to sample type and then reference in alphabetical order. @T1 = at first data collection time point. LGMM = latent growth mixture modeling. LCGA = latent class growth analysis. HTQ-IV = Harvard Trauma Questionnaire Part IV (Mollica et al., 1992); PCL-C or PCL = PTSD Checklist – Civilian version (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996); OMPA = Oxford Measure of Psychosocial Adjustment (MacMullin & Loughry, 2004); CAPS = Clinician-Administered PTSD Scale (Blake et al., 1995); PCL-S = PTSD Checklist – Specific version (Weathers, Litz, Herman, Huska, & Keane, 2006); SF-12 = Medical Outcome Study Short-Form Health Survey (Ware, Kosinski, & Keller, 1996); HADS-A and HADS-D = Hospital Anxiety and Depression Scale – Anxiety and Depression subscales (Zigmond & Snaith, 1983); ASDI = Acute Stress Disorder Inventory (Bryant, Harvey, Dang, & Sackville, 1998); PDS = PTS Diagnostic Scale (Foa, 1995); BSI = Brief Symptom Inventory (Derogatis, 2000); CES-D = Center for Epidemiological Studies Depression Scale (Radloff, 1977); SCL-90-R: GSI = General Symptom Index in the Hopkins Symptom Checklist 90 –Revised (Derogatis & Melisaratos, 1983); PSS = PTSD Symptom Scale (Foa & Tolin, 2000); SASRQ = Stanford Acute Stress Reaction Questionnaire (Cardeña, Classen, Koopman, & Spiegel, 1996); PTSDI = PTSD Inventory (Solomon et al., 1993); CPTSD-RI = Child PTSD-Reaction Index (Steinberg, Brymer, Decker, & Pynoos, 2004); CHQ-12 = 12-item Chinese Health Questionnaire (Cheng & Williams, 1986); CBCL/4–18 = Child Behavior Checklist for ages 4–18 (Achenbach, 1991); CIES = Child Impact of Event Scale (Dyregrov, Kuterovac, & Barath, 1996); IES = Impact of Event Scale (Horowitz, Wilner, & Alvarez, 1979); K6 = Kessler Screening Scale for Psychological Distress (Kessler et al., 2003); FDAS-E = Emotional subscale of the Four Dimensional Anxiety Scale (Bystritsky, Linn, & Ware, 1990); NSA-PTSD = National Survey of Adolescents PTSD interview module (Kilpatrick et al., 2003); DEQ = Distressing Events Questionnaire (Kubany, Leisen, Kaplan, & Kelly, 2000); IES-R = Impact of Event Scale–Revised, comprising avoidance, hyperarousal, and intrusions subscales (Weiss & Marmar, 1996); CRIES-R = Children's Revised Impact Event Scale (Dyregrov, Gjestad, & Raundalen, 2002); SRIP = Self-Rating Inventory for PTSD (Hovens et al., 1994); SWB = one question on subjective well-being worded as "How satisfied are you nowadays with your life as a whole?". Responses ranged from 0 (completely dissatisfied) to 10 (completely satisfied) (Galatzer-Levy, Bonanno, & Mancini, 2010); PSS-I = PTSD Symptom Scale Interview (Foa, Riggs, Dancu, & Rothbaum, 1993); PHQ-9 = Patient Health Questionnaire-9 (Kroenke, Spitzer, & Williams, 2001); SCID = Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, Third Edition Revised (Spitzer, 1987); M-PTSD = Mississippi Scale for Combat-Related PTSD (Keane, Caddell, & Taylor, 1988).

[a] Combat exposure and trauma exposure are examples of an environmental covariate.

[b] Demographic characteristics such as gender and levels of education are examples of a characteristics covariate.

[c] Study contained three subsamples categorized by combat exposure.

[d] Studies examined two primary outcomes.

[e] Studies contained two subsamples.

[f] Resources covariate comprises financial and materialistic resources such as income.

[g] Study utilized three PTSD subscales as distinct primary outcomes.

[h] Included in this review although assessment was done at 3-year intervals because deployment occurred variably within the interval and was unlikely three years before post-event assessment, and the study is prospective and has a large, population-based sample with informative data.

[i] Longitudinal studies included in this review although assessment was done more than a year post-event, because these samples are large and population-based with informative data.

[j] Study examined three events.

Table 2
Descriptive statistics of the prevalence rate of each trajectory, with the most frequently observed four trajectories categorized by sample type, study design, event duration, PTE type, and primary outcomes.

Trajectories		Study variables	*n*	Mean Prevalence	*SD*
Resilient	Sample type	Population-based	20	0.700	0.121
		Cohort	43	0.626	0.198
	Study design	Prospective	27	0.737	0.097
		Longitudinal	36	0.585	0.200
	Event duration	Single/Acute	53	0.661	0.170
		Chronic	10	0.588	0.225
	PTE type	Military	13	0.775	0.146
		Civilian trauma/Accidents	29	0.616	0.178
		Refugee/War	0	–	–
		Loss	3	0.644	0.050
		Major life events	5	0.735	0.085
		Children	6	0.520	0.243
		Health events	7	0.650	0.194
	Primary outcome	PTSD	35	0.695	0.183
		Anxiety/Acute stress	3	0.527	0.071
		Depression	11	0.591	0.145
		General distress/Well-being	10	0.650	0.181
		Other psychological functioning	4	0.507	0.192
	Total		63	0.650	0.180
Chronic	Sample type	Population-based	17	0.108	0.067
		Cohort	30	0.122	0.095
	Study design	Prospective	16	0.098	0.049
		Longitudinal	31	0.127	0.098
	Event duration	Single/Acute	40	0.114	0.084
		Chronic	7	0.136	0.099
	PTE type	Military	5	0.094	0.070
		Civilian trauma/Accidents	23	0.117	0.079
		Refugee/War	2	0.238	0.008
		Loss	3	0.122	0.041
		Major life events	4	0.115	0.062
		Children	3	0.028	0.015
		Health events	7	0.137	0.132
	Primary outcome	PTSD	23	0.103	0.081
		Anxiety/Acute stress	2	0.055	0.036
		Depression	12	0.128	0.060
		General distress/Well-being	7	0.143	0.064
		Other psychological functioning	3	0.162	0.224
	Total		47	0.117	0.085
Recovery	Sample type	Population-based	14	0.189	0.247
		Cohort	35	0.251	0.220
	Study design	Prospective	17	0.120	0.089
		Longitudinal	32	0.294	0.255
	Event duration	Single/Acute	39	0.207	0.193
		Chronic	10	0.336	0.321
	PTE type	Military	8	0.131	0.109
		Civilian trauma/Accidents	25	0.241	0.222
		Refugee/War	2	0.762	0.008
		Loss	3	0.145	0.062
		Major life events	2	0.043	0.008
		Children	5	0.320	0.295
		Health events	4	0.183	0.149
	Primary outcome	PTSD	28	0.270	0.256
		Anxiety/Acute stress	2	0.351	0.078
		Depression	9	0.194	0.217
		General distress/Well-being	6	0.114	0.085
		Other psychological functioning	4	0.185	0.195
	Total		49	0.234	0.227

(*continued on next page*)

Table 2 (*continued*)

Trajectories		Study variables	*n*	Mean Prevalence	*SD*
Delayed onset	Sample type	Population-based	5	0.154	0.177
		Cohort	17	0.080	0.038
	Study design	Prospective	6	0.061	0.029
		Longitudinal	16	0.110	0.102
	Event duration	Single/Acute	21	0.099	0.091
		Chronic	1	0.040	–
	PTE type	Military	6	0.062	0.024
		Civilian trauma/Accidents	12	0.116	0.117
		Refugee/War	0	–	–
		Loss	0	–	–
		Major life events	0	–	–
		Children	1	0.056	–
		Health events	3	0.102	0.031
	Primary outcome	PTSD	12	0.064	0.019
		Anxiety/Acute stress	2	0.124	0.006
		Depression	5	0.176	0.171
		General distress/Well-being	2	0.056	0.015
		Other psychological functioning	1	0.120	–
	Total		22	0.097	0.090
Moderate/mild persistent distress	Total		10	0.236	0.169
Improved/Improving	Total		19	0.088	0.031
Worsening	Total		19	0.110	0.090
Delayed benefit from event and then worsening	Total		1	0.040	–
Strong improving during and then worsening post-event	Total		1	0.020	–
Mild improving during and then worsening post-event	Total		2	0.045	0.035
Mild improving during and then mild worsening post-event	Total		1	0.075	–
Lowest PTE exposure	Total		1	0.610	–

Note. PTE = potentially traumatic event. PTSD = posttraumatic stress disorder. Resilient, chronic, recovery, and delayed-onset trajectories include any trajectory that resembles the prototypical trajectory patterns discussed by Bonanno (2004). The moderate/mild persistent distress trajectory resemble the chronic trajectory but at mild or moderate levels. The improved/improving trajectory includes trajectories that exhibited signs of improvement in primary outcome either before or after an event. The worsening trajectory includes trajectories that exhibited patterns of worsening functioning either before or after an event with no observable positive effects from the event. The delayed-benefit-from-event-and-then-worsening, strong-improving-during-and-then-worsening-post-event, mild-improving-during-and-then-worsening-post-event, and mild-improving-during-and-then-worsening-post-event trajectories exhibit positive effects from the event followed by patterns of worsening functioning. The lowest-PTE-exposure trajectory was observed in one case and differentiated from the resilient trajectory because individuals in this trajectory experienced lower exposure to disaster-related stressors compared to the resilient group in the same study (Lai, Tiwari, Beaulieu, Self-Brown, & Kelley, 2015). All PTE types except for children include only adult participants. Anxiety/Acute stress includes anxiety and acute stress symptoms. General distress/well-being includes general distress and subjective well-being. Other psychological functioning includes internalizing and externalizing problems, anxiety and depression combined, and psychological functioning.

3.3.1. Event type

In terms of event type, the resilient trajectory had the highest prevalence rate when military events were examined ($M = 0.753$, $SD = 0.146$), and the lowest prevalence rate when children were the focus ($M = 0.520$, $SD = 0.243$). The delayed-onset trajectory also had the lowest prevalence rate when children were examined ($M = 0.056$, SD = not applicable because $n = 1$), but it had the highest prevalence rate when adult civilian trauma or accidents were examined ($M = 0.116$, $SD = 0.117$). On the other hand, the chronic ($M = 0.238$, $SD = 0.008$) and recovery ($M = 0.762$, $SD = 0.008$) trajectories had the highest prevalence rates when refugee or war experiences were examined, and the chronic trajectory had the lowest prevalence rate when children were the focus ($M = 0.028$, $SD = 0.015$), while the recovery trajectory had the lowest prevalence for major life events ($M = 0.043$, $SD = 0.008$).

3.3.2. Modeling approach

The number of studies that utilized each modeling approach and observed significant covariates are listed for each primary outcome in Table 4. The majority of studies utilized LGMM to examine trajectories ($n = 46$), followed by LCGA ($n = 18$) and then the analysis developed by Nagin (1999; $n = 3$).

Table 3
Correlation coefficients between sample size and the mean prevalence rates of trajectories in the overall sample, and in prospective and longitudinal studies respectively.

	Outcome trajectories											
	Resilient			Chronic			Recovery			Delayed onset		
	n	*r*	*p*	*n*	*r*	*p*	*n*	*r*	*p*	*n*	*r*	*p*
Overall sample												
Sample size	63	−0.03	0.843	47	−0.21	0.154	49	−0.18	0.229	22	0.16	0.480
Prospective studies												
Sample size	27	0.30	0.136	16	−0.48	0.061	17	0.00	> 0.999	6	0.25	0.629
Longitudinal studies												
Sample size	36	−0.04	0.813	31	−0.20	0.270	32	−0.26	0.158	16	0.12	0.654

Note. Overall sample $N = 67$. Prospective studies $n = 27$. Longitudinal studies $n = 40$.

Table 4
Analyses of Variance (ANOVA) and post-hoc tests for the mean prevalence rate of each trajectory.

	Outcome trajectories																	
	Resilient[a]			Chronic[a]			Recovery			Delayed onset[a]								
	F	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2	*F*	*p*	η^2						
Overall Model	**4.48**	**0.001**	–	1.38	0.247	–	**2.37**	**0.046**	–	**4.30**	**0.010**	–						
Factors																		
Sample type	0.23	0.637	0.003	0.16	0.695	0.003	0.14	0.715	0.002	**11.39**	**0.004**	**0.279**						
Study design	**12.23**	**0.001**	**0.148**	4.02	0.052	0.083	**6.72**	**0.013**	**0.119**	**4.74**	**0.046**	**0.116**						
Event duration	0.11	0.740	0.001	0.07	0.798	0.001	3.23	0.079	0.058	1.66	0.217	0.041						
Modeling approach	0.07	0.789	0.001	3.86	0.056	0.080	0.43	0.516	0.008	4.45	0.052	0.109						
PTE type	0.00	0.992	0.000	0.63	0.432	0.013	1.11	0.298	0.020	0.08	0.777	0.002						
Primary outcome	**10.15**	**0.002**	**0.122**	2.50	0.122	0.052	2.44	0.126	0.043	**9.43**	**0.008**	**0.231**						

Post-hoc *t*-tests	*n*	*M*	*t*	*df*	*p*	*n*	*M*	*t*	*df*	*p*	*n*	*M*	*t*	*df*	*p*	*n*	*M*	*t*	*df*	*p*
Sample type			1.83[b]	56.38[b]	0.073[b]			−0.557[c]	45[c]	0.581[c]			−0.867[c]	47[c]	0.391[c]			0.925[b]	4.109[b]	0.406[b]
Population-based	20	0.700				17	0.108				14	0.247				5	0.154			
Cohort	43	0.626				30	0.122				35	0.220				17	0.080			
Study design			**3.98**[b]	**53.23**[b]	**0.000**[b]			−1.34[b]	44.98[b]	0.186[b]			**−3.47**[b]	**42.63**[b]	**0.001**[b]			−1.17[c]	20[c]	0.257[c]
Prospective	27	0.737				16	0.098				17	0.120				6	0.061			
Longitudinal	36	0.585				31	0.127				32	0.294				16	0.110			
Primary Outcome			−1.25[c]	61[c]	0.215[c]			−1.38[c]	45[c]	0.173[c]			−0.31[c]	47[c]	0.756[c]			0.67[b]	5.15[b]	0.530[b]
PTSD	35	0.695				23	0.103				28	0.270				12	0.064			
Other outcomes	28	0.593				24	0.130				21	0.184				10	0.136			

Note. $N = 67$. $df = 1$ for all factors. Error $df = 56$, 40, 42, and 15 for the ANOVA on the resilient, chronic, recovery, and delayed-onset trajectories respectively. Adjusted $R^2 = 0.252$, 0.047, 0.146, 0.485 for the ANOVA on the resilient, chronic, recovery, and delayed-onset trajectories respectively. Post-hoc tests were only conducted on significant ANOVA results. PTSD = posttraumatic stress disorder. Other outcomes include anxiety/acute stress, depression, general distress/well-being, and other psychological functioning. **Bold** = significant at $p < .05$.

[a] Significant results on Levene's test for homogeneity of variances at $p < .05$, suggesting violation of the assumption.

[b] Equal variances not assumed due to significant results at $p < .05$ on Levene's test for homogeneity of variances.

[c] Equal variances assumed due to non-significant results at $p < .05$ on Levene's test for homogeneity of variances.

3.3.3. Primary outcome

Most studies examined PTSD as the primary outcome ($n = 38$), followed by depression ($n = 12$), general distress/well-being ($n = 10$), other psychological functioning ($n = 4$), and then anxiety or acute stress ($n = 3$).

3.3.4. Covariate predictors

Many studies found psychological ($n = 24$) and environmental ($n = 24$) covariates to significantly influence PTSD outcome trajectories, followed by individual characteristics ($n = 20$) and then social covariates ($n = 12$). Most studies found psychological covariates to significantly influence anxiety or acute stress ($n = 3$) and depression outcome trajectories ($n = 8$). On the other hand, individual characteristics covariates were most frequently found to significantly influence general distress or well-being outcome trajectories ($n = 7$), and social covariates were most frequently found to influence outcome trajectories of other psychological functioning ($n = 4$).

3.3.5. Group comparisons

Multiple Analyses of Variance (ANOVAs) and follow-up univariate analyses are shown in Table 5. Results demonstrated an overall significant effect for the resilience ($F(6, 42) = 4.48$, $p = .001$), recovery ($F(6, 42) = 2.37$, $p = .046$), and delayed-onset ($F(6, 42) = 4.30$, $p = .010$) models, but not the chronic model ($p = .247$). Study design had a significant effect on the prevalence rates of the resilient ($p = .001$), recovery ($p = .013$), and delayed-onset ($p = .046$) trajectories. The type of primary outcome had a significant effect on the prevalence rates of the resilient ($p = .002$) and delayed-onset ($p = .008$) trajectories. Sample type had a significant effect on the prevalence rate of the delayed-onset trajectory only ($p = .004$). It should be noted that the assumption of homogeneity of variance was violated in the ANOVA models for all trajectories except for the recovery trajectory, indicating heterogeneity in the effects across cases. Since all independent factors are binary, independent-samples *t*-tests were conducted post-hoc to elucidate the significant results.

Post-hoc *t*-tests showed significant prevalence rate differences for the resilient and recovery trajectories between prospective and longitudinal studies (see Table 4). Specifically, the mean prevalence rate of the resilient trajectory was significantly higher by 0.152 (i.e., 15.2%) in prospective studies compared to longitudinal studies ($p < .001$). By contrast, the mean prevalence rate of the recovery trajectory was significantly higher in longitudinal studies by 0.174 (i.e., 17.4%; $p = .001$). Contrary to the significant ANOVA result, the prevalence rate of the resilient trajectory was not significantly different when PTSD was examined as opposed to other primary outcomes. Similarly, no significant group differences were found for the delayed-onset trajectory.

4. Discussion

The rapid proliferation of the trajectory approach as a tool to identify common patterns of response to pronounced stressor events has resulted in an impressive body of evidence, but also considerable variation in both approach and results. Variations have been observed across studies in sample size, constructs measured, event types, measurement points, and parameter fit. In order to make sense of these variations, in the current investigation we statistically evaluated confluence/divergence in identified trajectories across studies, as well as estimates of their population prevalence. Further, we examined causes of heterogeneity and tested for the presence of bias in those estimates. Finally, we reviewed the state of research on determinants, modifiers, and outcomes related to identified trajectories to provide synthesis and guide future research by identifying knowledge gain and gaps.

Results indicated a high level of consistency across studies in the general structure and number of trajectories. Four trajectories were observed at the highest frequency including resilience ($n = 63$), recovery ($n = 49$), chronic stress ($n = 47$), and delayed onset ($n = 22$). Among them, delayed onset was least frequently observed, and even when identified, had low prevalence rates, reflecting its rarity in the population. For example, although delayed onset was mostly identified in studies that examined adult civilian trauma and accidents, it was only identified in nine out of 22 relevant studies. Further, delayed onset was not identified in studies of rape (Armour, Shevlin, Elklit, & Mroczek, 2011; Steenkamp, Dickstein, Salters-Pedneault, Hofmann, & Litz, 2012), nor in a study where 84.1% of the sample experienced a motor vehicle accident (MVA; Galatzer-Levy, Bonanno, et al., 2013). In fact, even when delayed-onset PTSD was identified among studies where a large proportion of the sample experienced a MVA, its prevalence rate was 8% or lower (Bryant et al., 2015; deRoon-Cassini et al., 2010). By contrast, delayed onset was most prevalent in a study examining depression in New York residents after the September 11 terrorist attack, but group membership was associated with various pre-

Table 5
Frequency counts of modeling approaches and significant covariates for each primary outcome.

		Primary outcome					Total
		PTSD	Anxiety/Acute stress	Depression	General distress/Well-being	Other psychological functioning	
Modeling approach	LGMM	27	3	8	8	0	46
	LCGA	9	0	4	2	3	18
	Nagin (1999)	2	0	0	0	1	3
	Total	38	3	12	10	4	67
Covariate	Psychological	24	3	8	3	2	40
	Environmental	24	0	4	2	3	33
	Social	12	1	5	2	4	24
	Characteristics	20	1	7	7	2	37
	Financial/Materialistic resources	6	1	4	4	0	15
	Substance	3	0	0	0	0	3
	Physical	8	0	4	5	1	18

Note. PTSD = posttraumatic stress disorder. LGMM = latent growth mixture modeling. LCGA = latent class growth analysis. Anxiety/Acute stress includes anxiety and acute stress symptoms. General distress/well-being includes general distress and subjective well-being ratings. Other psychological functioning includes internalizing and externalizing problems, anxiety and depression combined, and psychological functioning. Psychological covariates include variables such as mental health history, anxiety, depression, subjective units of distress, attachment style, and coping style. Environmental covariates include variables such as trauma/stressor exposure, combat experience, frequency of stressful life events, and daily hardship. Social covariates include variables such as social support, family relations, and social network size. Characteristics covariates include demographic variables such as age, gender, race/ethnicity, education, military rank, and marital status. Financial/materialistic resources covariates include variables such as employment status, income, access to social benefits, and loss of material resources. Substance covariates include variables such as alcohol consumption and smoking status. Physical covariates include variables such as physical health, injury location, injury severity, and health complaints.

event factors (e.g., stressors, trauma, lifetime depression) and lower levels of social support (Nandi, Tracy, Beard, Vlahov, & Galea, 2009). Together, these results indicate that delayed onset occurs infrequently, likely under more specific circumstances and involves exposure to pre-event and post-event stressors.

Other trajectories including worsening ($n = 19$) and improving ($n = 19$) were observed less consistently. These less frequently observed trajectories likely do not reflect statistical estimation errors, but rather differences in the populations and types of events under study. For example, worsening trajectories dominated in studies with multiple stressor events, indicating that an ongoing increase in stress indices may be the result of repeated stressors over time. Similarly, the improving trajectory was only observed in a minority of studies when prospective data was available. As such, the identified trajectories predictably varied depending on sample characteristics in a manner similar to treatment studies, which consistently failed to identify a resilient trajectory due to their exclusion of such individuals who do not need treatment.

Importantly, findings demonstrated that the severity of an event is not a key contributor to consistency in trajectory prevalence. For example, studies examining more severe events such as spinal cord injury (Bonanno, Kennedy, et al., 2012), displacement after a natural disaster (Self-Brown, Lai, Harbin, & Kelley, 2014), and police officers exposed to life threat (Galatzer-Levy, Madan, et al., 2011) have found higher rates of resilience (at 66.1%, 66%, and 88.1% respectively) compared to less severe stressors such as college transition, where resilience rate was 62.9% (Galatzer-Levy et al., 2012). This suggests that psychological (Bonanno, Kennedy, et al., 2012; Galatzer-Levy & Bonanno, 2014; Galatzer-Levy, Bonanno, et al., 2013; Galatzer-Levy et al., 2012) and biological factors (Galatzer-Levy et al., 2017; Galatzer-Levy, Steenkamp, et al., 2014) may have a stronger influence on the development of individual differences in response to stress more than the level of objective severity of an event.

Some significant sources of variability in estimates were observed. Firstly, it was found that military personnel exposed to war were more likely to be resilient than other populations. This is important given the large veteran population and the emergence of new wars around the world. These results point to additional important questions that can be further investigated to explain these high rates of resilience. One reasonable explanation is that military personnel demonstrate higher rates of resilience because of the training they received to prepare for potential trauma as well as the support they received following a PTE (Bonanno, Mancini, et al., 2012; Mobbs & Bonanno, 2018). High rates of resilience were also observed among police and firefighters who were similarly prepared and cared for (Galatzer-Levy, Mazursky, et al., 2011). It is worth noting, however, that although veterans and continuously serving military personnel from the same population showed highly similar PTSD trajectories, veterans were slightly but significantly less likely to be in the resilient trajectory and more likely to be in the chronic PTSD trajectory (Porter et al., 2017). What's more, recent studies have called attention to myriad stressors that characterize the transition from soldier to veteran status not captured by PTSD symptoms (Castro, Kintzle, & Hassan, 2014; Mobbs & Bonanno, 2018; Morin, 2011). These include, for example, grief due to war-related deaths, loss of meaningful identity, and difficulties adapting to the demands of civilian life (Mobbs & Bonanno, 2018).

It is also noteworthy that the military studies, and in fact the vast majority of studies we reviewed, measured responses to a single, discrete PTE. Due to the obvious practical difficulties, few studies have been able to examine resilience following exposure to multiple PTEs. However, data that are available indicate that the prevalence of resilience remains high even with multiple PTEs. For example, the prevalence of resilience following combat deployment was nearly identical for military personnel with single versus multiple deployments (Bonanno, Mancini, et al., 2012). The prevalence of the resilient trajectory was also nearly identical among individuals who had suffered one versus multiple acute, life-threatening medical events within the same time period (Morin, Galatzer-Levy, Maccallum, & Bonanno, 2017). On the other hand, the minimal-impact resilience trajectory was found to be less frequent in the context of chronic stress. For example, Hobfoll, Mancini, Hall, Canetti, and Bonanno (2011) reported generally elevated distress and trajectory patterns more akin to recovery than resilience among a population exposed to chronic political violence and mass casualty.

Children overall were observed to have a lower probability of resilience. Interestingly, children are less likely to follow a chronic trajectory as well. Among children, there was a higher proportion of recovery, though resilience remains the modal response in children. In this regard, it is important to note, apropos the above discussion, that research on children has typically focused on chronic stressors, which were found to increase the prevalence of the recovery trajectory. In the context of chronic stress, this recovery pattern has also been conceptualized as an emergent form of resilience (Bonanno & Diminich, 2013).

Finally, studies that lacked prospective data were found to consistently underestimate rates of resilience, indicating that there is selection bias in longitudinal studies. This bias may not affect the ability to test hypotheses about these populations. However, claims about estimates of rates should be made based on prospective studies, as they control for the observed selection bias. Importantly, the resilient trajectory was the only trajectory to show a higher prevalence and incidence in prospective studies, indicating that this is likely a true population, not a statistical artifact.

By reviewing moderating factors related to trajectories, it is evident that psychological constructs related to emotional functioning (e.g., coping ability, attitudes, personality), demographic characteristics, and environmental factors underlie individual differences in trajectories of response to aversive events. For example, coping flexibility (Galatzer-Levy et al., 2012), coping strategies and style (Bonanno, Kennedy, et al., 2012), perceived self-efficacy (deRoon-Cassini et al., 2010), optimism (Galatzer-Levy & Bonanno, 2014; Lam et al., 2010), and neuroticism (Berntsen et al., 2012) moderated trajectory group membership by differentiating individuals who exhibit resilience or chronic stress over time from others. Similarly, demographic characteristics such as age, gender, and education level (Galatzer-Levy, Ankri, et al., 2013; Orcutt, Erickson, & Wolfe, 2004; Pietrzak, Van Ness, Fried, Galea, & Norris, 2013), and environmental factors such as the level of exposure to trauma or stressors (e.g., financial stress) before or after the event (Andersen, Karstoft, Bertelsen, & Madsen, 2014; Bryant et al., 2015; Galatzer-Levy & Bonanno, 2012) have been found to moderate group membership across various contexts. This indicates that the identified trajectories have important substantive differences. Importantly, these results indicate that individual characteristics and environmental stressors before or after an event may impact the response to potential trauma more than the object nature of the event itself. This has implications for the identification of risk as well as treatment, as individuals who follow distinct trajectories differ in observable characteristics and vary in psychological abilities and life experiences that are relevant to coping and treatment success.

4.1. Limitations and future directions

This study presents with limitations. Firstly, although the vast variety of variables such as events studied, sample types, and outcome measures included in this review illustrate the diverse contexts as well as specific conditions in which certain trajectories are consistently observed, they also represent inconsistency and potential confounding factors in the literature that preclude clearer comparisons between variables (e.g., events that differ in severity) to identify more specifically contexts in which particular trajectories are more prevalent. In many instances, the comparisons made may resemble comparisons between apples and oranges. Nevertheless, given the diversity of studies

and the variety of categories across which studies are distributed (e.g., seven categories of PTE), there is no preliminary evidence for particular confounding variables that are currently observable, and none from which conclusions can be drawn. More importantly, such inconsistencies highlight the robustness of resilience, for despite contextual differences, resilience was consistently observed with the highest prevalence. Further, these inconsistencies provide opportunities for clarification that future research can undertake.

There are also limited examples in the current literature where direct behavioral or biological constructs are examined in relation to trajectories (Galatzer-Levy et al., 2017; Galatzer-Levy, Steenkamp, et al., 2014). As studies in this area emerge, there is increasing evidence that biological factors involved in stress regulation impact the development of individual differences in response to potential trauma. Research into biological determinants is steadily increasing as prior studies are being re-analyzed to examine trajectories as an outcome rather than traditional outcomes, and new data sources are being collected explicitly with trajectory analyses in mind (Reijnen et al., 2018; Vermetten, Baker, & Yehuda, 2015).

Another limitation is that trajectory models have focused primarily on the use of self-report measures. This presents with at least three limitations. First, these measures are collected infrequently, limiting the ability to detect points of inflection where change occurs. Second, these measures are dependent on individuals' subjective report. Finally, these measures are often multidimensional, limiting their value for mixture modeling that attempts to identify underlying populations based on a mono-dimensional index. A number of studies in animals and humans have demonstrated that the trajectory modeling approach identifies similar stress response phenotypes when using direct indices of behavior and physiology (Galatzer-Levy et al., 2017; Galatzer-Levy, Steenkamp, et al., 2014). Further, new developments in digital phenotyping where smartphone data is used to develop real-time behavioral indices provide a promising new avenue to measure behavior directly in real time without the use of self-report (Onnela & Rauch, 2016; Torous, Onnela, & Keshavan, 2017). Understanding how digital behavior clusters into clinically relevant patterns in response to stress and potential trauma represents a particularly promising future direction.

A final limitation of current efforts is that studies have focused very little on the effects of trajectory membership. A small number of studies have shown that individual differences in trajectory membership are tied to important outcomes including health, mortality, and employment (Galatzer-Levy & Bonanno, 2014; Galatzer-Levy, Bonanno, & Mancini, 2010; Malgaroli et al., 2017). These findings emerged exclusively from large population studies that indexed such outcomes. Future research generally should focus on indexing consequences of resilient and pathological responses to stress and trauma, rather than focusing primarily on clinical presentation as the only outcome of interest. These areas of research represent fertile ground, as they are key areas of interest among researchers who examine stress pathology and resilience.

5. Conclusion

Collectively, these results indicate that people follow common trajectories of response following major life stressors and potential trauma, and that resilience is the most common response. This is true regardless of the index of severity or the particulars of the event. This observation has broad implications for the behavioral sciences, as it indicates that individuals are heterogeneous in their response to adversity, and that the majority adapt successfully to such adversity. Research that conflates distinct populations, either through the use of diagnoses or averaging, may provide limited understanding on the diversity of human responses and preclude the ability to predict or influence individuals' adjustment trajectory following adversity.

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Contributors

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Conflict of interest

There are no conflicts of interest related to the analysis of this study and preparation of this manuscript.

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