



Anxiety and resilience in the face of natural disasters associated with climate change: A review and methodological critique

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ABSTRACT

In the past two decades, climate change-related natural disasters, such as hurricanes, floods, and droughts have become increasingly frequent and severe, impacting the emotional and psychological well-being of those who are directly or indirectly exposed to them. Despite great interest in understanding differences in anxiety and resilience in response to natural disasters, enthusiasm appears to outstrip empirical clarity, as there remains considerable ambiguity as to determinants of resilient or pathological outcomes following exposure to natural disasters. In addition, there are several major methodological limitations in climate change and related natural disaster research, including the use of univariate analyses, cross-sectional design, and retrospective measures. Keeping these limitations in mind, we first review literature examining the mental health outcomes of natural disasters. Findings suggest that, overall, resilience is more common than pathological outcomes. Second, we use a multi-dimensional framework of resilience to selectively review factors at the event, individual, as well as family and community levels that could help inform resilient or pathological outcomes. Finally, we consider key limitations and future directions for research and practice in the field of anxiety and resilience in response to climate disasters.

Climate change is one of the greatest modern threats to human health and well-being (Costello et al., 2009). The past decade (2010-2019) has been the hottest ever recorded contributing to myriad international climate disasters over the years. In 2017, Australia began one of its worst drought periods in history (2017 - current) followed by an historically devastating bushfire season; California experienced the largest-ever wildfire scorching more than 440 square miles; China, India, Sierra Leone, and Bali fell victim to massive flooding; two category 4 hurricanes (Hurricanes Harvey and Irma) and a category 5 hurricane (Hurricane Maria) pounded Texas, Florida, Puerto Rico, Cuba and the Virgin Islands in quick succession with little opportunity for communities to recover. These events, among a host of others, have killed thousands of people, destroyed power grids, forced evacuation of between 24–40 million people from their homes, and led to an estimated \$306 billion in total economic losses. With the apparent capacity to affect society on all levels, natural disasters are increasingly testing the limits of human suffering, infrastructural fortitude, and economic durability. Individual behaviors and overarching policies continue to influence unprecedented climate change, contributing to increased frequency, intensity, and chronicity of disasters. Developing a comprehensive understanding of

the predictors and consequences of psychological adjustment to these events is paramount.

Many studies examining the psychological impact of climate change have empathized the undeniable universal threat to both individuals and communities. However, methodological limitations prevail, and much of the research conducted on the impact of natural disasters has simultaneously overestimated the psychological burden and underestimated the broader impact that disasters have across multiple domains (for a review, see Bonanno, Brewin, Kaniasty, & Greca, 2010). The current review aims to offer a comprehensive examination of methodologically rigorous studies with a specific focus on natural disasters related to climate change. In doing so, we hope to increase understanding of the protective factors and pathways of resilience at the event, individual, family, and community levels that may exacerbate or mitigate the impact of climate disasters.

1. Capturing mental health outcomes following exposure to acute and chronic events

A growing body of work has emphasized the psychological impact of

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climate change on mental health and well-being by evaluating the impact of various natural disasters through both direct and indirect pathways (for a review, see Bourque & Cunsolo Willox, 2014). However, marked variations in research methods have hampered adequate estimation of the costs of disasters and thus effective resource provision and intervention to bolster psychological health.

Reported PTSD rates have ranged from 10 % (e.g., Mandavia & Bonanno, 2019; Norris et al., 2002; Pollack, Weiss, & Trung, 2016; Xiong et al., 2008), to as high as 50 % (e.g., Galea et al., 2007; Xu & Song, 2011). The wide range in prevalence rates across studies may result from different categorizations of disorders (e.g., PTSS versus PTSD), inconsistent measurement techniques (e.g., screeners to full interviews), disparate study designs (e.g., one-time cross-sectional versus longitudinal), and variations in the timing post-disaster for sample selection. Furthermore, certain studies cited for their reported prevalence rates have been designed with a narrower or specific aspect of mental health in mind. For example, one study constructed to highlight the differential impact of hurricane-related stressors based on location and proximity to the hurricane, included any level of PTSD symptomatology based on a screener tool, and thus led to a report of probable PTSD at 49.1 % (Galea et al., 2007). While some distribution of the reported prevalence rates can be explained by type of disaster, level of exposure, or time elapsed since the onset, the resulting large variation across studies suggests a need to conduct disaster research with a keener methodological eye and a conscious effort to bridge past work to the present era (Bonanno et al., 2010).

Given the complex impacts of climate events and aim to understand the overall impact of climate disaster, many studies have adopted a broader definition of psychological distress (e.g., Ozaki et al., 2018; Schwartz, Gillezeau, Liu, Lieberman-Cribbin, & Taioli, 2017), or focused on a wide range of stress-related psychological outcomes, particularly anxiety, depression, and PTSD (e.g., Agyapong et al., 2020; Labarda, Jopson, Hui, & Chan, 2020; Moosavi et al., 2019; Mulchandani et al., 2020). In the current review, when possible, we emphasized on findings most pertinent to anxiety. However, given the highly comorbid nature among stress-related disorders, we included studies examined related outcomes such as depression and PTSD.

In an effort to more accurately capture the costs of disasters, a number of studies have examined *longitudinal trajectories* of acute-onset climate disaster outcomes. (Galea, Tracy, Norris, & Coffey, 2008; Ginexi, Weihs, Simmens, & Hoyt, 2000; Kristensen, Weisæth, & Heir, 2009; La Greca, Silverman, & Wasserstein, 1998; Mandavia & Bonanno, 2019; Pietrzak et al., 2012; Weems et al., 2010). Acute-onset climate disasters include those which are imminent, discrete, and difficult to anticipate such as floods, fires, cyclones, and hurricanes. Comprehensive reviews indicate that outcome trajectories of these climate disasters form similar patterns to outcome trajectories of other potentially traumatic life events (for reviews, see Bonanno et al., 2010; Bonanno, Westphal, & Mancini, 2011), with a majority of individuals maintaining healthy and normative functioning, or resilience. Notably, clinical levels of psychological distress, such as diagnosable levels of anxiety, depression, PTSD, or grief, have been observed in a minority of exposed individuals, with an estimated ceiling of 30 % and usually considerably lower (Bonanno et al., 2010). Trajectories of psychological adjustment can alternatively be captured using computational modeling approaches, such as *latent growth mixture modeling* (LGMM), to accommodate random effects. Using this approach, a study among Swedish tourists who survived the 2004 Indian Ocean tsunami found the majority (71 %) fell within a resilient trajectory with low PTSD symptoms (Sveen, Arnberg, Arinell, & Johannesson, 2016). Another study revealed that a large majority (83.6 %) showed a resilient trajectory with low depressive and PTSD symptoms even after exposure to both 2008 U.S. economic recession and Hurricane Sandy (Mandavia & Bonanno, 2019).

While trajectory models are ideal for better understanding mental health outcomes after acute-onset climate events, longitudinal studies necessary to support these analyses have proven difficult to conduct

with respect to chronic climate events (Vins, Bell, Saha, & Hess, 2015). Chronic climate-related events, such as droughts, famine, desertification, and pest infections, can span multiple years, result from slow and progressive climate degeneration, and lack the discrete structural markers that often characterize acute-onset climate events and facilitate scientific measurement. As the frequency, severity, and duration of climate disasters steadily increase, the effects of acute-onset and chronic disasters both interact with and reciprocally impact each other, creating further methodological complication. For example, southern Australia's recent drought, which began in 2017, coincided with increasing and record-breaking seasonal temperatures over the past three years, and have undoubtedly contributed to the unprecedented and devastating 2019–2020 bushfire season. Overlooking or failing to account for the progressive impact of a primary chronic climate event, studies often attribute mental health outcomes to the acute event alone (Stanke, Kerac, Prudhomme, Medlock, & Murray, 2013).

Consequently, in lieu of prevalence rates, researchers have conducted qualitative studies to capture themes of worry, generalized anxiety, and hopelessness in samples exposed to chronic climate events (Cunsolo Willox & Ellis, 2018; Polain, Berry, & Hoskin, 2011; Rigby, Rosen, Berry, & Hart, 2011; Sartore, Kelly, Stain, Albrecht, & Higginbotham, 2008). Using large population and census data, Bayesian modelling, and multivariate analyses, a considerable body of research has emerged comparing mental health outcomes between regions affected and unaffected by the chronic climate event (Berry, Hogan, Owen, Rickwood, & Fragar, 2011; Stanke et al., 2013). One such study found an elevated risk of psychiatric hospitalization for depression associated with residence in areas affected by dryland salinity, or the degradation of land by an increase in soil salt concentration (Spelde-winde, Cook, Davies, & Weinstein, 2009). Another study in Brazil, found that individuals living in drought-affected communities reported significantly higher levels of anxiety and emotional distress compared to individuals in non-affected communities (Coelho, Adair, & Mocellin, 2004).

Furthermore, although cross-sectional in nature and therefore carrying inherent methodological limitations, comparative studies have been able to highlight potential risk factors contributing to psychological distress in the wake of chronic climate events. A review of mental health and psychological adjustment following climatic events found that chronic climate events may differentially and disproportionately impact vulnerable populations, such as those living in rural areas, with lower socioeconomic status, and relying on the land for their livelihood (Berry et al., 2011; Vins et al., 2015). Additionally, individuals who endorse a stronger connection to their home landscape or have a strong sense of individual and sociocultural identity related to land-based work may experience prolonged distress due to environmental changes (Albrecht, 2011; Connor, Albrecht, Higginbotham, Freeman, & Smith, 2004).

With wide-spread acknowledgement and consensual scientific evidence on the impacts of climate change, individuals have begun to report higher levels of anxiety about the future, while communities face increased structural and sociocultural burdens (Fritze, Blashki, Burke, & Wiseman, 2008). In recent years, new terms such as eco-anxiety, climate anxiety, and climate-related grief, among others, have emerged as attempts to characterize the complicated and contextual mental health impact that climate change and related disasters can cause (Nobel, 2007; Clayton & Karazsia, 2020). As global temperatures continue to rise, forecasting methods can be used to predict future risk of chronic climate events and related acute-onset events. Given the pervasive and complex impact of acute-onset and chronic climate events, the variability in resulting psychological adjustment warrants exploration of factors at both the individual and community level to better inform resilient and pathological outcomes.

2. Pathways to resilience after natural disasters: characteristics of disaster, individual, family, and community

Basic outcome trajectories following natural disasters form similar patterns to those observed following other potentially traumatic life events, with resilience emerging as the modal response (for a review, see Bonanno et al., 2010). In addition, great variability in symptoms and diagnoses of depression and PTSD is present when measured over time. Identifying factors contributing to such variability is therefore a pressing question with critical implications for identifying vulnerable populations and developing effective prevention and intervention options.

In theory, some factors, characteristics, and conditions may make it more difficult to successfully adjust to and even confer risk for psychopathology, whereas others may promote adaptive adjustment and resilience. *In reality*, however, critical limitations have hindered attempts to identify significant risk and resilience factors. First, the vast majority of studies consider these factors in isolation, and even when multiple factors are investigated, it is common to evaluate the impact of these factors individually through univariate analyses. This practice dilutes crucial external validity, a particularly detrimental limitation for climate disaster research wherein many factors overlap and interact. A second, but equally serious limitation, is that many disaster studies are conducted cross-sectionally or using retrospective self-report measures. Given that natural disasters are highly distressing, these approaches prove particularly problematic; memories of previous disturbing events are ripe for score inflation due to recall bias impacted by current psychological distress. While often the most convenient means of data collection, cross-sectional designs and retrospective measures can significantly confound predictors and outcomes, limiting the utility and generalizability of results.

In this section, we review what we believe to be the most salient, consistent, and methodologically sound results regarding risk and resilience factors following climate disasters (see Table 1, for summary of reviewed findings). In considering distinct dimensions of climate disasters, different pathways of resilience to natural disasters are considered. We outline three key dimensions: 1) **factors of climate disasters**, such as proximal and distal exposure, 2) **individual factors** comprising the variability in demographics, prior experiences, pre-disaster mental illness, economic resources, biological vulnerabilities, personality, coping, emotion regulation, and social support, and 3) **family and community factors** including interpersonal and societal cohesion, community-level socioeconomic status, and rates of employment and crime. Whenever possible, we prioritize evidence from studies that use prospective and longitudinal designs, and studies that attempt to capture how different factors may work together to inform outcomes.

2.1. Factors of climate disasters

While a wide range of mental health outcomes due to climate change have been observed (2011, 2012, Cunsolo Willox et al., 2013; Doherty & Clayton, 2011; Fritze et al., 2008; Page & Howard, 2010; Reser & Swim, 2011; Rubens, Felix, & Hambrick, 2018; Stanke, Murray, Amlôt, Nurse, & Williams, 2012; Swim et al., 2010), research documents a multifaceted relationship between disaster exposure and anxiety-related disorders. Greater exposure is intuitively associated with higher levels of symptoms. However, exposure is definitionally complex. It can be quantified objectively, through the number of stressors that one experiences (e.g., property loss, physical injury, death of a loved one), or measured subjectively, through appraisals of the disasters (Marshall et al., 2007). According to the relative onset to the disaster, proximal exposure, referring to impact during and immediately following the disaster, is heuristically defined here and distinguished from distal exposure, which captures the extended impact of a disaster's aftermath.

2.1.1. Proximal exposure

The number of stressors endured is usually conceptualized as a

measure of proximal exposure to climate disasters. After hurricanes, for example, the number of stressors has been quantified by the number of self-report stressors experienced during and in the immediate aftermath of the hurricane, such as property loss, physical illness or injury, housing adversity, and physical adversity (Hurricane Katrina Community Advisory Group, 2007). The number of stressors was related to depression and PTSD when controlling for other variables (Dai et al., 2017; Lowe, Tracy, Cerdá, Norris, & Galea, 2013; Mulchandani et al., 2020; Nillni et al., 2013; Schwartz et al., 2017), and associated with increased likelihood to exhibit a moderately chronic PTS trajectory after the Indian Ocean tsunami (Johannesson, Arinell, & Arnberg, 2015). After Hurricane Sandy, greater numbers of stressors were also associated with increased perceived need for mental health service in communities with severe building damages (Sampson, Lowe, Gruebner, Cohen, & Galea, 2016) and linked to increased PTS among communities with high unemployment rates (Lowe, Sampson, Gruebner, & Galea, 2016), suggesting that proximal exposure may interact with community factors.

Studies have also linked specific stressors to anxiety and related outcomes. Initial loss and disruption, as well as community violence, were shown to predict chronically distressed over resilient trajectories of PTS in Hurricane Katrina affected youth (Self-Brown, Lai, Thompson, McGill, & Kelley, 2013). Perception of risk and perceived life threat have been linked to post-disaster PTSD among children and adolescents (McDermott, Lee, Judd, & Gibbon, 2005; Yelland et al., 2010), and a greater likelihood of developing generalized anxiety disorder among adults (Moosavi et al., 2019).

2.1.2. Distal exposure

The subsequent economic losses incurred by home and property damage have been related to greater post-disaster distress and increased future-oriented worry (Adeola, 2009; Elliott & Pais, 2006) and associated with elevated rates of PTSD and mood disorders (Galea et al., 2007). In addition, people in poorer households often experience greater difficulty in rebuilding for the future, given that they often experience an economic loss that far exceeds their assets (Morris et al., 2002).

Displacement and relocation from one's home following climate disasters, often confounded with economic loss, can result in physical separation from significant others and profound disruptions of psychosocial resources. After climate disasters, displaced individuals exhibited greater depressive symptoms (Viswanath et al., 2012), and had higher odds of developing anxiety, depression, and PTSD controlling for demographic covariates, especially for those that did not receive sufficient amount of warnings (Munro et al., 2017). However, in a study controlling for age, gender, and traumatic exposure severity that includes measures of economic loss, displacement frequency was no longer associated with depression, anxiety, or PTSD symptoms among a sample of survivors in Eastern Philippines four years after Typhoon Haiyan (Labarda et al., 2020), though more frequent displacement was still associated with worse subjective health and greater stress. Similarly, controlling for demographic and tsunami-related traumatic experiences, displacement did not predict PTSD or depression (Thienkrua et al., 2006). These findings suggest that displacement does not pose risk beyond traumatic experiences and economic loss.

2.2. Individual factors

Natural disasters are unique for everyone affected, partially due to the varying individual contexts in which they occur. These could relatively static (e.g., gender, race, ethnicity, and biological vulnerabilities), or dynamic (e.g., coping and social support).

2.2.1. Age, gender, and race-ethnicity

Both older adults and children may have greater risk for heightened psychological distress post-disasters. Older adults are considered at higher risk due to their pre-disaster health conditions, reliance on others, and relative immobility (e.g., Parker et al., 2016; Cook & Elmore,

Table 1
Selected Summary of Reviewed Findings on Risk and Resilience Factors in Response to Climate Disasters.

Reference	Event Studied	Event Measure	Time Elapsed	Primary Outcomes and Measures	Resilience Factors	Risk Factors
Adeola (2009)	2005 Hurricane Katrina	Survey; 10-item questionnaire on acute personal experiences	6–7 months post disaster	Distress and future-oriented worry by self-made questionnaire		economic loss due to property or home damage
Agyapong et al. (2020)	2016 McMurray Wildfire	NA	18 months post disaster	Depression via PHQ-9; GAD via GAD-7; PTSD via PCL-5		aversive childhood experiences
Alexander et al. (2017)	2005 Hurricane Katrina	11-item checklist of Hurricane Katrina-specific stressful exposures	15 months post disaster	PTSD via Breslau Short Screening Scale		Black Race partially due to pre-hurricane functioning
Ali et al. (2017)	2005 Hurricane Katrina	11-item checklist of Hurricane Katrina-specific stressful exposures	14–17 months post disaster	Depression via CES-D		Black Race (not significant controlling for sociodemographic characteristics, preexisting vulnerabilities, social support, and trauma-specific factors)
Amstadter et al. (2010)	2004 Florida Hurricanes (Charley, Francis, Ivan, and Jeanne)	5-indicator to assess disaster experiences and exposure	6 to 9 months post disaster	GAD via SCID-IV structured interview		NPY gene variant (only under high hurricane exposure)
Amstadter et al. (2013)	2004 Florida Hurricanes (Charley, Francis, Ivan, and Jeanne)	interview on hurricane experiences and exposure	NA	PTSD via DSM-IV		variants of RORA gene
Benight & Harper (2002)	1996 Colorado Fires and Flash Flood	NA	3–8 weeks post disaster (Time 1); 1 year follow-up (Time 2)	PTSD via Stanford Acute Stress Reaction Questionnaire (SASRQ)	coping self-efficacy	
Benight et al. (1999)	1995 Hurricane Opal	Loss of resources scale; 5-item Material damage scale	4–5 months post disaster	general distress via SCL-90-R; trauma-related distress via IES	coping self-efficacy	
Billiot et al. (2019)	Environmental changes (repeated disasters, climate change, pollution)	Online survey; semi-structured interviews; ethnographic observation (over 4 years)	NA	Qualitative interview to assess beliefs around environmental changes		membership in indigenous community/population; cultural and economic connectedness to land
Bistricky et al. (2019)	2017 Hurricane Harvey	HURTE-R	1–3 months post disaster	Depression via PHQ-9; PTSD via IES-R		cognitive and avoidance coping; immediate loss and disruption
Bland et al. (1996)	1980 and 1984 Italy Earthquake	Series of single-item questions related to disaster experience and exposure		Psychological distress via SCL-90-R	prior disaster experience (similar events)	
Bokszczanin (2008)	1997 Polish Flood	8-item binary questions assessing experience during the flood	28 months post disaster	PTSD via Mississippi PTSD Scale - Revised		family conflict; lack of family support
Breslau et al. (2008)	cohort study (not on a specific disaster)	List of qualifying traumatic events	1989 and 10 years after	PTSD via NIMH-DIS		prior trauma (only among those with PTSD)
Brock et al. (2014)	2008 Iowa Floods	Storm32 questionnaire	a few months post disaster	Depression via Inventory of Depression and Anxiety Symptoms (IDAS); PTSD via PCL-17	perceived informational, physical, emotional and tangible support from partners	
Caramanica et al. (2015)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	5 to 12 months post disaster			prior history of PTSD; number of disaster-related events
Chen et al. (2018)	Beijing Air Pollution	NA	pre and post air pollution	Psychological distress via SCL-90-R	reappraisal (only under high levels of suppression); suppression	
Cunsolo Willox et al. (2012)	General Climatic Change	Qualitative interviews (2009–2010)	NA	Well-being		disruptions to sense of place; place-based identities
Dai et al. (2017)	1998 Dongting Lake Flood	Series of single-item questions related to disaster experience and exposure Interview	17 years post disaster	PTSD vis PCL-C; Anxiety via Zung Self-Rating Anxiety Scale general well being	male gender; perceived social support social relationships	number of flood-related stressors (at least 3)

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Table 1 (continued)

Reference	Event Studied	Event Measure	Time Elapsed	Primary Outcomes and Measures	Resilience Factors	Risk Factors
Drabek & Key (1984)	1966 Topeka tornado		pre and post disaster (unclear when)			
Elliott & Pais (2006)	2005 Hurricane Katrina	NA	1 month post disaster	Recovery as measured by likelihood to return		economic loss due to property or home damage, Black, lower social class non-Hispanic black individuals
Flores et al. (2020)	2017 Hurricane Harvey	Series of single-item questions related to disaster experience and exposure	3 to 5 months post disaster	PTSD via PCL-S		
Galea et al. (2007)	2005 Hurricane Katrina	Survey; 29 questions related to disaster experience and exposure	5–7 months post disaster	PTSD via Trauma Screening Questionnaire		economic loss due to property or home damage
Galea et al. (2008)	2005 Hurricane Katrina	Series of single-item questions related to disaster experience and exposure	18–24 months post disaster	PTSD via CIDI		female gender
Goenjian et al. (2001)	1998 Hurricane Mitch	Hurricane exposure questionnaire	6 months post disaster	PTSD via CIDI; Depression via DSRSS		female gender (not significant after controlling for subjective experience)
Green et al. (1991)	1972 Buffalo Creek Dam Flood	Series of single-item questions related to disaster experience and exposure	2 years post disaster	PTSD via structured interviews	youngest age group	depressed family atmosphere
Gruebner et al. (2016)	2008 Hurricane Ike	Series of single-item questions related to disaster experience and exposure	2–5 months (Time 1); 5–8 months (Time 2); 13–16 months (Time 3) post disaster	PTSD (chronic or delayed trajectories) via PCL-S; Depression via PHQ-9		degree of impact on community due to disaster
Hanigan et al. (2012)	Chronic Australia Droughts	NA	NA	Suicide Risk		identify to the land
Heid et al. (2016)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	4–6 years pre disaster (Baseline); 27 months (Time 1) post disaster	PTSD via PSS-SR	social cohesion, income, positive affect, subjective health	depressive symptoms, negative affect, functional disability, chronic health conditions, pain
Henslee et al. (2015)	2005 Hurricane Katrina	Series of single-item questions related to disaster experience and exposure	18–23 months post disaster	PTSD via CIDI for DSM-IV PTSD module; Depression via PHQ-9	positive religious coping	negative religious coping
Hikichi et al. (2016)	2011 Tohoku Tsunami	Series of single-item questions related to disaster experience and exposure	7 months pre disaster (Baseline); 2.5 years post disaster (Time 1)	Individual risk of PTSD	individual and community-level social cohesion	
Hsiang et al. (2013)	Meta-analysis of climate change in heat and rainfall	NA	NA	Increased conflict		induced migration; reduced community stability
Johannesson et al. (2015)	2004 Southeast Asia tsunami	Survey; 30-item questionnaire on disaster exposure severity	14 months, 3, 6 years post disaster	PTSD via IES-R; General mental health via GHQ-12		number of exposure stressors
Kilmer & Gil-Rivas (2010)	2005 Hurricane Katrina	12-item exposure checklist	1 year (Time 1) & 2 years (Time 2) post disaster	Caregiver PTSS via PCL		child unmet service needs
Kopala-Sibley et al. (2016)	2012 Hurricane Sandy	Survey of hurricane exposure	3 years old, 9 years old, and 8 weeks post disaster	Anxiety by CBCL		high temperamental fearfulness (for those experiencing high stress from the hurricane)
La Greca et al. (1998)	1992 Hurricane Andrew	HURTE-R	15 months pre-disaster (Baseline); 3 months (Time 1) and 7 months (Time 2) post disaster	PTSD via PTSD Reaction Index for children		child pre-disaster level of anxiety; inattention; academic difficulties
La Greca et al. (2013)	1992 Hurricane Andrew	Series of single-item questions related to disaster experience and exposure	3, 7, 10 months post disaster	PTSD via Children's Posttraumatic Stress Disorder Reaction Index		poor emotion regulation
Labarda et al. (2020)	2013 Super Typhoon Haiyan	Series of single-item questions related to disaster experience and exposure	4 years post disaster	Depression, Stress & Anxiety via DASS-21		displacement frequency (not significant controlling for a few covariates)
Lai et al. (2015)	2005 Hurricane Katrina	HURTE-R	3–7 months (Time 1), 12–17 months (Time 2), 19–22 months (Time 3), 25–27 months	Depression via Brief Symptom Inventory (BSI)	maternal perceived social support	

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Table 1 (continued)

Reference	Event Studied	Event Measure	Time Elapsed	Primary Outcomes and Measures	Resilience Factors	Risk Factors
Lai et al. (2018)	2005 Hurricane Katrina	HURTE-R	(Time 4) post disaster 3–7 months (Time 1); 13–17 months (Time 2); 19–22 months (Time 3); 25–27 months (Time 4)	Child PTSD via UCLA PTSD Reaction Index Revised	intact social support (parents, teachers, or peers)	
Lee et al. (2009)	2005 Hurricane Katrina	Series of single-item questions related to human loss, property loss, health status	1 month post disaster	Psychological distress via three dichotomous items	being insured	property loss (home destroyed), human loss
Lowe et al. (2013)	2008 Hurricane Ike	Survey; 7-item questionnaire of immediate stressors to Hurricane	2–5 months (Time 1), 5–9 months (Time 2), 14–18 months (Time 3) post disaster	PTSD via PCL-S; Depression via PHQ-9		number of immediate stressors
Lowe et al. (2015)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	13 to 16 months post disaster	PTSD via PCL-5	employment; education level; economic development	having experienced or witnessed any lifetime traumatic event; high social capital
Lowe et al. (2016)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	13–16 months (Time 1), 25–28 months (Time 2) post disaster	PTS via PCL-5		number of disaster-related stressors on individual or community-level
Lowe et al. (2017)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	13–16 or 25–28 months post disaster	Depression via PHQ-9		negative coping (use of alcohol)
Mandavia & Bonanno (2019)	2012 Hurricane Sandy	7-item self-report measure on disaster experience and exposure	3 timepoints between 2006–2015	PTSD via PSS-SR	education level; employment; perceived social support	having experienced or witnessed any lifetime traumatic event; negative affect; greater community needs
Martin et al. (2016)	2010 Tennessee Flood	Junior High Life Experiences Survey; Flood Events Questionnaire	Pre disaster; 10 days post disaster	PTSD via Child PTSD Symptoms Scale		rumination; disaster exposure, negative peer interactions
McDermott et al. (2005)	2003 Canberra Wildfire	Screening of questions related to disaster experience and exposure	6 months post disaster	PTSD via UCLA PTSD Reaction-Index Revision 1		degree of disaster exposure; perceived threat to life
McFarlane (1987)	1983 Australian bushfire	Series of single-item questions related to disaster experience and exposure	2, 8, and 26 months post disaster	Posttraumatic phenomena via interview questions	maternal response to disaster	
McLaughlin et al. (2009)	2005 Hurricane Katrina	Survey; 30-item checklist related to disaster experience and exposure	5–7 months (Time 1), 7–10 months (Time 2), and 15–19 months (Time 3) post disaster	Serious emotional disturbance via abbreviated Strength and Difficulties Questionnaire GAD via GAD-7		parental psychopathology; low SES
Moosavi et al. (2019)	2016 McMurray Wildfire	Series of single-item questions related to disaster experience and exposure	18 months post disaster			degree of disaster exposure; perceived threat to life; history of anxiety disorder
Mulchandani et al. (2020)	2013–2014 Floods in England	Survey; 21-item on disaster experience and exposure	1 year (Time 1), 3 years (Time 2) post disaster period	PTSD via PCL-6; Depression via PHQ-2		degree of disaster exposure (“flooded” versus unaffected)
Munro et al. (2017)	2013–2014 Floods in England	Survey, 19 questions bespoke exposure assessment	1 year post disaster	Anxiety via GAD-2, Depression via PHQ-2, PTSD via PCL-6	amount of warnings received	displacement
Musa et al. (2014)	2004 Indonesia tsunami/ 2009 Indonesia earthquake	NA	post disaster (unclear when)	Anxiety, Depression, and Stress via DASS-21	older adult (only for stress)	adolescents
Ng et al. (2015)	Prolonged Drought and flooding in Australia	Interviews	past 5 years	Stress; Anxiety; Loss; Fear via qualitative interviews	social connectedness	
Nilni et al. (2013)	2005 Hurricane Katrina	Series of single-item questions related to disaster experience and exposure	1.5–2 years post disaster	PTSD via CIDI; Depression via PHQ-9	education level	number of ongoing hurricane-related stressors
Norris & Murrell, 1988	1981 Kentucky floods	Survey; questions related prior		Anxiety via STAI trait subscale; Distress by a four-item scale	prior experience with flood	

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Table 1 (continued)

Reference	Event Studied	Event Measure	Time Elapsed	Primary Outcomes and Measures	Resilience Factors	Risk Factors
Norris & Uhl (1993)	1989 Hurricane Hugo	experience and flood exposure Series of single-item questions related to disaster experience and exposure	12 months post disaster	Depression and Anxiety via Brief Symptom Inventory (BSI)		familial stress
Nygaard et al. (2016)	2004 Southeast Asia tsunami	Series of single-item questions related to disaster experience and exposure	6 months (Time 1) and 2 years (Time 2) post disaster	PTSD via IES-R	coping self-efficacy	
Oni et al. (2012)	2005 Hurricane Katrina	Series of single-item questions related to disaster experience and exposure	A few months post disaster	PTSD via PCL	positive reframing; humor coping style	instrumental support; venting; behavioral disengagement coping style
Parker et al. (2016)	meta analysis (not on a specific disaster)	NA	NA	PTSD, Depression, Anxiety, Adjustment disorder, Psychological distress		older age (only for PTSD and adjustment disorder)
Ruggiero et al. (2009)	2004 Florida Hurricanes (Charley, Frances, Ivan, or Jeanne)	Interviews	post disaster (unclear when)	PTSD via NWS-PTSD, Anxiety and depression via SCID-IV		Black Race (not significant after controlling for socioeconomic status)
Ruskin et al. (2018)	2012 Hurricane Sandy	Survey; 30-item checklist related to disaster experience and exposure	1–4 years post disaster	Depression via PHQ-4		loss of access to medical care
Sampson et al. (2016)	2012 Hurricane Sandy	Series of single-item questions related to disaster experience and exposure	14–17 months post disaster	Perceived need for services via a single-item question		number of disaster-related stressors
Schwartz et al. (2015)	2012 Hurricane Sandy	Survey; 30-item check list related to hurricane experience	12 to 24 months post disaster	Perceived stress via PSS		Hispanic Ethnicity
Schwartz et al. (2017)	2012 Hurricane Sandy	Survey; 30-item questionnaire of immediate hurricane exposure	11–28 months (baseline) post disaster; 1-year follow-up post baseline	PTSD via PTSD/PCL-S; Depression and Anxiety via PHQ-4		number of property and personal hurricane exposures/stressors
Self-Brown et al. (2013)	2005 Hurricane Katrina	Immediate loss and disruption subscales of the Hurricane-Related Traumatic Events Scale	3 months (Time 1), 13 months (Time 2), 19 months (Time 3), 25 months (Time 4) post disaster	PTSD via UCLA PTSD Reaction-Index Revision 1	peer social support	initial loss due to disaster; community violence
Self-Brown et al. (2014)	2005 Hurricane Katrina	HURTE-R	3–7 months (Time 1); 13–17 months (Time 2); 19–22 months (Time 3); 25–27 months (Time 4)	Child PTSD via UCLA PTSD Reaction Index Revised	Trajectories of maternal PTSD	
Silverman & La Greca (2002)	1992 Hurricane Andrew	HURTE-R	3 (Time 1), 7 (Time 2), and 10 (Time 3) months post disaster	PTSD via PTSD Reaction Index for children	teachers' and self-report academic performance	number of loss or disruption events, perceived life threat, teachers' and self-report anxiety and attention problems
Sirey et al., 2017	2012 Hurricane Sandy	Survey; 29 questions related to disaster experience and exposure	24–33 months post disaster	Depression via PHQ-9		loss of access to medical care (for all age groups), exposure severity (only for younger old adults aged 60–74 years old)
Spell et al. (2008)	2005 Hurricane Katrina	HURTE-R	3–7 months post disaster	Internalizing and externalizing child behaviors via Behavior Assessment System for Children - Second Edition		global maternal psychological distress; maternal PTSD
Sprague et al. (2015)	2009 California Wildfires	Series of single-item questions related to disaster experience and exposure	NA	Post-traumatic growth via Posttraumatic Growth Inventory-Short form	healthy family functioning; access to and integrity of social, emotional, and concrete supports; evacuation	youth perceived fire-related distress; female gender (among youths); low emotional support (among youths)
Swenson et al. (1996)	1989 Hurricane Hugo	Series of single-item questions related to disaster experience and exposure	14 months post disaster	Behavioral problems and trauma symptoms via Pediatric Emotional Distress Scale		Mother's distress
		NA	NA	Depression		

(continued on next page)

Table 1 (continued)

Reference	Event Studied	Event Measure	Time Elapsed	Primary Outcomes and Measures	Resilience Factors	Risk Factors
Tang et al. (2014)	meta-analysis (not on a specific disaster)				education level; employment	female gender; economic loss due to property or home damage
Thienkrua et al. (2006)	2004 Southeast Asia tsunami	Survey; Tsunami-modified version of the PsySTART Rapid Triage System	2 months (Time 1) and 9 months (Time 2) post disaster	PTSD via UCLA PTSD Reaction-Index Child Version; Depression via Birlerson Depression Self-Rating Scale		displacement (not significant controlling for tsunami experience), Tsunami experience
Tuicomepee & Romano (2008)	2004 Southeast Asia tsunami	Tsunami-Related Experiences Index (TRED); Level of Tsunami Exposure Questionnaire	1 year post disaster	Youth behavioral problems via the Thai Youth Self-Report (TYSR)	positive family functioning	
Viswanath et al. (2012)	2004 Southeast Asia tsunami	Interview style questions	First 3 months post disaster	Adjustment disorder via ICD-10		older age; displacement
Wadsworth et al. (2009)	2005 Hurricane Katrina	Series of single-item questions related to hurricane exposure and loss; Life Events Questionnaire	3–6 months (Time 1) and 9–12 months (Time 2) post disaster	PTSD via UCLA PTSD Index	high secondary control coping in the presence of low primary control coping; positive religious coping (particularly for African American individuals)	
Weems et al. (2007)	2005 Hurricane Katrina	Survey of hurricane exposure	17 months pre disaster (Time 1); 6–7 months (Time 2) post disaster	PTSD via PTSD Checklist		pre disaster negative affect
Weems et al. (2010)	2005 Hurricane Katrina	Series of single-item questions related to disaster experience and exposure	24 months (Time 1) and 30 months (Time 2) post disaster	PTSD via PTSD Reaction Index for children	male gender	younger age, disruption to child's home
White et al. (2013)	2004 Florida Hurricanes (Charley, Francis, Ivan, and Jeanne)	Series of single-item questions related to disaster experience and exposure	6 to 9 months post disaster	PTSD via National Women's Study PTSD module		variants of CRHR1 gene
Yelland et al. (2010)	2005 Australian bushfires	Adaption of Hurricane-Related Traumatic Experiences-Revised Scale	11–15 months post disaster	PTSD via UCLA PTSD-RI Child Version		perceived threat to life (perception of risk)
Zhou, (2018)	meta-analysis (not on a specific disaster)	NA	NA	Children with PTSD	positive parental emotionality; warm family environment	parental psychopathology; parent maladaptive coping strategies

Note. Only empirical studies and meta analyses related to resilience and risk factors were included.

BAS-C = Behavior Assessment System for Children – Second Edition; BSI = Brief Symptom Inventory; BSS = Breslau's Short Screening Scale for DSM-IV Posttraumatic Stress Disorder; CBCL = Child Behavior Checklist; CES-D = Center for Epidemiologic Studies Depression scale; CIDI = Composite International Diagnostic Interview – DSM-IV PTSD Module; CPTSD-RI = Child PTSD-Reaction Index; DASS-21 = Depression, Anxiety, and Stress Scale; DRS = Depression Self-Rating Scale; EEQ-C = Earthquake Exposure Questionnaire, Child Form; GAD-7 = Generalized Anxiety Disorder-7; GHQ-12 = General Health Questionnaire; HURTE-R = Hurricane-Related Traumatic Experiences-Revised; ICD-10 = International Classification of Diseases, Tenth Revision; IDD = Interview to Diagnose Depression; IDAS = Inventory of Depression and Anxiety Symptoms; IES-R = Impact of Event Scale-Revised; NWS-PTSD = National Women's Study PTSD module; M-PTSD = Mississippi Scale for Combat-Related PTSD; PEDS = Pediatric Emotional Distress Scale; PCL-C or PCL = PTSD Checklist – Civilian version; PTSD/PCL-S = Civilian PTSD Questionnaire - Hurricane Sandy Specific; PCL-S = PTSD Checklist-Specific Version; PCL-6 = Abbreviated PTSD Checklist; PCL-5 = PTSD Checklist for DSM-5; UCLA PTSD-RI Revision 1 = UCLA PTSD Reaction Index – Revision 1; PSS = Perceived Stress Scale; PSS-SR = PTSD Symptom Scale Self-Report; SCL-90-R = Symptom Checklist-90-Revised; PHQ-2 = Patient Health Questionnaire – Two Item; PHQ-9 = Patient Health Questionnaire-9; PHQ-4 = Patient Health Questionnaire-4; SDQ = Strength and Difficulties Questionnaire; SQD = Screening Questionnaire for Disaster-Related Mental Health; SASRQ = Stanford Acute Stress Reactions Questionnaire; SCID-IV = Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, Third Edition Revised; TSQ = Trauma Screening Questionnaire; TYSR = Thai Youth Self-Report; Zung SAS = Zung Self-Rating Anxiety Scale.

2009). Several studies have shown that older adults did not exhibit greater depression, anxiety, or PTSD symptoms compared to younger adults, but they did show higher levels of stress or greater likelihood of adjustment disorders following a tsunami (Musa et al., 2014; Viswanath et al., 2012). In contrast, studies on non-climate related disasters have found the beneficial roles of older age on outcomes (e.g., Knight, Gatz, Heller, & Bengtson, 2000; Bonanno, Galea, Bucciarelli, & Vlahov, 2007). This suggests that older adults' richer life experiences (Bonanno et al., 2007) and stress inoculation effects associated with certain prior experiences with disasters (Knight et al., 2000) may not help individuals cope with extremely adverse and rare climate disasters (e.g., Indonesia Tsunami). As such, whether older adults can weather climate disasters with fewer or more costs may depend on the stressors that the climate

disasters present. For example, older adults were able to endure high exposure severity of Hurricane Sandy, but not the loss of access to basic needs like medical care (Ruskin et al., 2018; Sirey et al., 2017).

On the opposite end of the age spectrum, children are considered more vulnerable, showing more extreme psychological impairments and less frequent resilient outcomes compared with adults following natural disasters (for reviews, see Furr, Comer, Edmunds, & Kendall, 2010; Norris et al., 2002). Disaster-related distress and life-disruption, such as missed school, reduced academic achievement, interrupted social connection, and increased exposure to stressors can adversely impact children's functioning (Silverman & La Greca, 2002). After the Indonesia Tsunami, adolescents were significantly more likely than adults to exhibit high levels of depression, anxiety, and stress (Musa

et al., 2014). Even so, among children who experience acute disaster-related distress, the vast majority would remain resilient or recover in one year after the event (La Greca, Silverman, Vernberg, & Prinstein, 1996; La Greca, Silverman, Lai, & Jaccard, 2010; Schwarzwald, Weisenberg, Solomon, & Waysman, 1994; Weems et al., 2010). However, when exposure is prolonged or complicated, there may be more lasting psychological effects (Osofsky, Osofsky, Kronenberg, Brennan, & Hansel, 2009).

In the face of natural disasters, women and girls consistently demonstrate higher levels of distress than do men and boys (Dai et al., 2017; Furr et al., 2010; Norris et al., 2002). In multivariate analyses controlling for possible confounds, researchers examined what might explain these gender effects. When controlling for objective exposure and prior trauma, female gender was still found to predict both greater disaster-related psychopathology and symptoms (Galea et al., 2008; Weems et al., 2010). However, when controlling for subjective experience, gender was no longer a significant predictor of psychological distress (Goenjian et al., 2001). Thus, subjective experience rather than objective exposure may help explain the effects of gender.

Investigations on race-ethnicity and disaster outcomes could be difficult to conduct, given that severely impacted communities are often homogeneous, with over 90 % of the participants belonging to one racial or ethnic group (e.g., Ginexi et al., 2000; Martin, Felton, & Cole, 2016; Mortensen, Wilson, & Ho, 2009). In a few studies of more heterogeneous samples, evidence supporting less resilient outcomes among Black and Hispanic individuals emerged (Alexander et al., 2017; Ali et al., 2017; Flores et al., 2020; Schwartz et al., 2015). Controlling for pre-hurricane distress, education, hurricane exposure, and social support, Black individuals still exhibited a marginally greater likelihood of developing PTSD or depression (Alexander et al., 2017; Ali et al., 2017). However, in a different study controlling for socioeconomic status, the effect of race vanished (Ruggiero et al., 2009), suggesting that economic disparities largely contribute to disproportionate mental health cost among marginalized population. Among Black individuals who survived Hurricane Katrina, lack of insurance and loss of property and acquaintance (Lee, Shen, & Tran, 2009) as well as displacement stress and lack of positive religious coping (Wadsworth, Santiago, & Einhorn, 2009) were associated with worse outcome. In addition to these factors, it is crucial for future research to examine the experience of discrimination as well as aid received, which may shed further light on racial disparities in psychological health after climate disasters (Alexander et al., 2017; Ali et al., 2017).

2.2.2. Economic resources, education, and employment

Access to economic resources is an important resilience factor for those exposed to climate events. Researchers examined the role of socioeconomic status among individuals exposed to disasters and concluded that the lower socioeconomic status was consistently associated with greater distress (Norris et al., 2002). Educational attainment, inherently linked to economic resources, has consistently been identified as a factor influencing post-disaster mental health outcomes. When facing natural disasters, individuals with higher levels of educational attainment and reliable employment are more likely than their counterparts to demonstrate resilient outcomes (Lowe, Sampson, Gruebner, & Galea, 2015; Mandavia & Bonanno, 2019; Tang, Liu, Liu, Xue, & Zhang, 2014). Researchers posit that education may influence risk perception, inform skills and knowledge required in facing disasters, and impact successful access to information and resources (Muttarak & Lutz, 2014). One multivariate study found that educational status was a unique predictor for MDD, but not PTSD, after controlling for the number of stressors, social support, and financial loss (Nillni et al., 2013). Similar to education and economic resources, employment has been found as a resilience factor following climate disasters even when controlling for a few covariates (Lowe et al., 2015; Mandavia & Bonanno, 2019; Tang et al., 2014).

2.2.3. Prior exposure and pre-existing mental illness

Research has presented mixed findings between prior exposure to trauma and subsequent disaster outcomes. Some studies suggest that prior exposure to traumatic life events sensitizes individuals to be more heavily impacted by subsequent trauma (Breslau, Peterson, & Schultz, 2008; Post & Weiss, 1998). For example, participants with more aversive childhood experiences exhibited a greater likelihood of developing MDD and GAD 18-months after the Fort McMurray wildfire (Agyapong et al., 2020). However, data supporting stress sensitization are largely based on retrospective rather than prospective measures of traumatic events, and thus is confounded with current distress and pre-existing mental illness. In some cases, no relationship was identifiable between the occurrence of previous traumatic life events and later development of PTSD among those that did not experience PTSD following previous trauma (Breslau et al., 2008). Moreover, prior exposure could even buffer against subsequent natural disasters when the experiences are similar in nature (Bland, O'Leary, Farinaro, Jossa, & Trevisan, 1996; Norris & Murrell, 1988). These findings support stress inoculation but only when the climate disasters and prior exposures are similar in nature.

Many studies have found that pre-existing distress may pose increased risk for psychopathology following natural disasters (Breslau et al., 2008; Caramanica, Brackbill, Stellman, & Farfel, 2015). A prospective study found that the persistence of depressive symptoms following the 2008 recession magnified the negative impact of Hurricane Sandy, but the recession alone did not seem to impact depressive symptoms following Hurricane Sandy (Mandavia & Bonanno, 2019). In a different study, pre-existing chronic health conditions and feelings of distress during Hurricane Sandy independently predicted PTSD group membership (Heid, Christman, Pruchno, Cartwright, & Wilson-Genderson, 2016). Individuals with a history of anxiety disorders had a higher odd of developing PTSD and GAD 18 months after the major wildfire in Fort McMurray (Moosavi et al., 2019). Similarly, La Greca et al. (1998), found that children' pre-disaster levels of anxiety, inattention, and academic difficulties predicted greater PTSD symptoms three months after Hurricane Andrew.

2.2.4. Biological vulnerability

Biological vulnerabilities involving stress regulation and neuro-protective processes have been linked to PTSD symptoms and diagnosis following natural disasters. White et al. (2013) linked variants of corticotropin-releasing hormone receptor 1 gene (CRHR1), which regulates the hypothalamic-pituitary-adrenal (HPA) axis, to PTSD symptoms and diagnosis in adults exposed to 2004 Florida Hurricanes. After correcting for multiple tests, they identified two variants (rs12938081 and rs4792887) that were associated with PTSD symptom elevation. Another study linked variants (rs8042149) of retinoid-related orphan receptor alpha gene (RORA), a gene that initiates neuroprotection after trauma and disease, to heightened PTSD symptoms following the same disaster (Amstadter et al., 2013). In addition to genetic effects, one study showed the interaction between variant (rs16147) of Neuropeptide Y (NPY), a gene that has been found to be anxiolytic, and objective hurricane exposure, such that rs16147 was associated with increased anxious symptoms only under conditions of high exposure (Amstadter et al., 2010). Together, these findings support the gene-environment interaction in the etiology of anxiety and related disorders following natural disasters. One limitation in this line of research, however, is the lack of evidence examining the potential cumulative or overlapping effects of the gene variants.

2.2.5. Personality, coping, and emotion regulation

Personality traits and individual differences in coping and emotion regulation have been considered as important factors informing disaster outcomes. We suggest caution, however, that variances accounted for by personality traits are sometimes overestimated, likely due to a lack of consideration and measurement of person by situation interaction

(Mischel, 1969). Given the assumption that trait measures are stable over time, many studies have adopted cross-sectional designs. This is problematic, however, in that trait measures can actually exhibit variations over time (Roberts & Mroczek, 2008). Keeping these limitations in mind, we mainly focus on studies adopting prospective designs that measure personality, coping, and emotion regulation before the onset of the disaster, or multivariate studies that control for at least some covariates.

Neuroticism and negative emotionality have emerged as risk factors for maladjustment following natural disasters. Neuroticism refers to a general disposition toward negative affectivity and tendency to be emotional or hostile (John & Srivastava, 1999). In a study incorporating both prospective design and multivariate analyses, Mandavia and Bonanno (2019) found that negative affect, a trait dimension similar to neuroticism, was higher among those eventually showing incremental depression following the 2008 Recession and Hurricane Sandy. Controlling for gender, pre-disaster mental health, and the number of hurricane-related stressors, similar findings emerged in an adolescent sample exposed to Hurricane Katrina (Weems et al., 2007). In a longitudinal study adjusting for symptom levels at the age of nine, higher levels of stress from Hurricane Sandy predicted elevated anxiety symptoms only in adolescents high in temperamental fearfulness (measured when they were three), suggesting that specific facets of negative emotionality could intensify the long-term impact of hurricane exposure on anxiety symptoms (Kopala-Sibley et al., 2016).

Psychological constructs related to coping and emotion regulation have been linked to disaster outcomes. Coping self-efficacy, the belief that one can succeed in maintaining control over the challenges imposed by stressors, is an important predictor of climate disaster outcome. Studies have consistently linked disaster-specific coping self-efficacy (Benight & Harper, 2002; Benight et al., 1999) and general coping self-efficacy (Nygaard, Hussain, Siqveland, & Heir, 2016) to better psychological adjustment. Rumination, a form of repetitive negative thinking (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008), has been linked to heightened risk for depression and psychological distress (Martin et al., 2016). Similarly, heavier reliance on cognitive and avoidance coping was associated with worse outcomes (Bistricky et al., 2019). On the contrary, positive reframing and humor coping styles were found as particularly adaptive after Hurricane Katrina, whereas the habitual use of instrumental support, venting, and behavioral disengagement coping predicted more PTSD symptoms (Oni, Harville, Xiong, & Buekens, 2012). In a sample of children exposed to Hurricane Andrew, those who exhibited poor emotional regulation were more likely to show chronically distressed than resilient trajectory (La Greca et al., 2013). Interestingly, religious coping produced both positive and negative effects on psychological adjustment: looking to God for strength and guidance was associated with increased quality of life and reduced depression and PTSD, whereas viewing climate disaster as a punishment by God had an opposite effect on mental health outcomes (Henslee et al., 2015). After Hurricane Sandy, depressed residents were more likely to use alcohol and nonmedical prescriptions as a way of coping (Lowe, Sampson, Young, & Galea, 2017). In the context of air pollution, researchers found that decreased use of expressive suppression before the onset of pollution, was prospectively associated with heightened psychopathology symptoms, and reappraisal was adaptive in a subset of participants that relied heavily on suppression (Chen, Kong, Yu, & Peng, 2018).

The extremely aversive nature of natural disasters may also yield counterintuitive findings. For instance, self-enhancement, the use of overly unrealistic and self-serving biases (Taylor & Brown, 1994), has been linked to negative evaluations made by others (Paulhus, 1998), but its presence in the face of potential trauma appeared particularly adaptive (Bonanno, Field, Kovacevic, & Kaltman, 2002; Bonanno, Renicke, & Dekel, 2005). In addition to self-enhancement, studies have highlighted the importance of flexibly shaping and modifying one's cognition and behaviors (Bonanno & Burton, 2013; Bonanno, Papa,

Lalande, Westphal, & Coifman, 2004).

2.2.6. Social support

Social support has been found particularly important in the face of natural disasters. In a sample of partnered postpartum mothers exposed to the Iowa Flood, the perceived informational, physical, emotional, and tangible support from partners were found to buffer the effect of objective levels of stress on depression (Brock et al., 2014). Moreover, higher perceived partner support further predicted reduced depression. Indeed, studies have shown an interesting gap between received and perceived support; where received support tends to increase following natural disasters, perceived support often declines post-disasters (Kaniasty & Norris, 1995; Norris & Kaniasty, 1996). Multivariate studies have specifically linked perceived social support with resilient outcomes post-disaster while controlling for potentially confounding variables (Bonanno et al., 2007; Dai et al., 2017; Galea, Nandi, & Vlahov, 2005; Lai, Tiwari, Beaulieu, Self-Brown, & Kelley, 2015; Mandavia & Bonanno, 2019). In a semi-structured interview of Australian rural residents exposed to prolonged drought and extensive flooding, social connectedness was found to buffer the effects of flood and drought (Ng, Wilson, & Veitch, 2015). Findings for received support were less consistent. For example, one study showed that the amount of actual support received was unrelated to distress, but actual support evidenced a significant indirect path to reduced distress that led through perceived support (Norris & Kaniasty, 1996).

2.3. Family and community factors

Beyond impacting individual lives, natural disasters can strain family systems and disrupt the fabric of community life (Fritz, 1961). In the aftermath of disasters, survivors often rely on support from their families, relatives, and friends, making family and community resilience particularly relevant in this context. While community resilience has various definitions, some researchers refer to it as a process linking a set of adaptive capacities to long-term healthy functioning (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008). However, our understanding of post-disaster adaptation at a community or family level has been qualified by significantly methodological limitations. Researchers frequently rely on cross-sectional designs and fail to measure the process of resilience or identify robust predictors by controlling for confounds. Consequently, the temporal characteristics of resilience are often obscured and misrepresented (Bonanno, Romero, & Klein, 2015). What is clear, however, is that disasters have a complex and profound impact on relationships within and across broad social units, and furthering our understanding of post-disaster family and community resilience will provide important insights into successful adaptation.

Empirical studies examining post-disaster adaption at the family level frequently yield mixed results, suggesting the differential impact that disasters may exert across various domains. While community-wide disasters may enhance bonding and interaction within families, they can weaken interactions across the broader community (Bonanno et al., 2010). Following the 1966 Topeka tornado, Drabek and Key (1984) found that affected families had stronger connections to relatives and friends but their bonds with neighborhoods weakened, with one exception being church attendance, which increased amongst religious survivors. Likewise, Bolin (1982) found that victims with greater disaster losses reported more frequent visits with kin, but reduced their involvement with neighbors. Such decreases in communal activities can extend beyond primary survivors to include all residents living in an affected area (Kaniasty, Norris, & Murrell, 1990).

2.3.1. Changes in dynamics and structure of social relationships

Natural disasters frequently initiate changes in family dynamics and structure. In a prospective study following Hurricane Hugo in South Carolina, time-series analyses revealed that rates of marriages, births, and divorces all increased in the disaster-declared counties one year

later (Cohan & Cole, 2002). After controlling for pre-flood resources, mental health, and socio-demographic characteristics, adult flood survivors were more likely to report new conflict with extended family than were non-exposed survivors (Hutchins & Norris, 1989). Likewise, multivariate analyses of data following survivors of Hurricane Hugo highlighted various facets of disaster exposure predicted higher levels of marital stress and filial stress (Norris & Uhl, 1993).

Familial stress was also found to mediate the impact of the hurricane on mental health outcomes, especially among youth disaster survivors (Bokszczanin, 2008; Green et al., 1991; Tuicomepee & Romano, 2008). Post-disaster family functioning is widely understood to be an important determinant of psychological distress. Studies using different samples, measurement strategies, and methodologies, have consistently demonstrated the link between post-disaster parental symptoms and children's distress (Gil-Rivas, Kilmer, Hypes, & Roof, 2010; Green et al., 1991; Kilmer & Gil-Rivas, 2010; McFarlane, 1987; McLaughlin et al., 2009; Spell et al., 2008; Swenson et al., 1996). Notably, studies using latent growth mixture modeling have found that trajectories of maternal PTSD symptoms (Self-Brown, Lai, Harbin, & Kelley, 2014), but not depression symptoms (Lai et al., 2015), were associated with children's distress two years after Hurricane Katrina.

Despite these detrimental outcomes, natural disasters can also have a salubrious impact on interpersonal relationships. Survivors of disasters frequently note that the events brought them closer together with their families (Henry, Tolan, Gorman-Smith, & Families and Communities Research Group, 2004; Kessler, Galea, Jones, & Parker, 2006). Drabek and Key (1984) found 3 years after the Topeka tornado, tornado victims who received help from friends or relatives reported being less alienated, happier in their marriages, and more involved in activities with friends, social organizations, or churches, suggesting that some social relationships may improve post-disaster.

2.3.2. Predicting family resilience

Climate related natural disasters and their subsequent challenges are faced by not only individuals but also family units. While research on family resilience has seen an increase in attention in the past decade (see Masten, 2018, Table 1, for a summary of family resilience factors), studies on family resilience factors specific to climate disasters are comparatively scarce, particularly in some high-risk regions and locations impacting indigenous persons and other marginalized populations (Rother et al., 2020; Billiot, Kwon, & Burnette, 2019). On the whole, however, perceived danger to the lives of family members during and after a climate disaster has consistently been identified as a risk factor for subsequent mental illness specifically anxiety (Mambrey, Wermuth, & Böse-O'Reilly, 2019; Moosavi et al., 2019).

Research on resilient outcomes among families, writ large, is based on systems theory, which views the family as a dynamic whole. However, global dimensions of family functioning addressing the family as a systematic unit are difficult to operationally define and measure (Jones & Tanner, 2017). Many studies on family adjustment rely on self-report questionnaires administered to individual respondents, thus contradicting the notion of a family unit and drawing into question whether or not these measures adequately capture outcomes of a family system. Further, research is often separated by family role categories into factors affecting children/adolescents and parents/caretakers. Despite these complexities and limitations, considering pathways of risk and resilience is essential in contextualizing the realities of climatic disasters.

Family risk and resilience is inextricably linked to developmental timing and status of the family members. Therefore, a successful systems-based assessment of family risk and resilience must consider specific familial roles as they relate to the life cycle (Harrist, Henry, Liu, & Morris, 2019; Masten, 2018). In several studies examining child and adolescent responses to hurricanes, flooding, and wildfires, findings implicate the role of social selection theory and point to the important protective roles of healthy family functioning, intact social support, and community involvement (Lai, Osborne, Piscitello, Self-Brown, & Kelley,

2018; Mambrey et al., 2019; Sprague et al., 2015). Interestingly, in the aftermath of Hurricane Katrina, researchers identified family support as particularly protective against depressive symptoms, as opposed to anxiety and posttraumatic stress symptoms (PTSS), which were more strongly influenced by peer support (Cobham, McDermott, Haslam, & Sanders, 2016).

Parents and caretakers directly impact the likelihood of family resilience in the wake of climate disasters. Several modifiable parental risk factors have been identified including existing or emerging psychopathology, hostile or anxious parenting styles, family conflict, low perceived family support and connectedness, and changes in family environment or functioning (Cobham et al., 2016; Zhou, 2018). After Hurricane Katrina, children who perceived their caregivers as unwilling or upset reported more PTSD symptoms (Gil-Rivas et al., 2010). The extent to which parents can maintain a sense of consistency in routines, home environment and surroundings, and the overall effectiveness and adequacy of time allocated toward communication as a family all impact the likelihood of resilience among family units and households.

While families have their own internal and intrapersonal factors influencing resilience in the wake of climate disasters (Bonanno et al., 2015), family units are inherently nested within and interdependent on a larger socioecological system (Masten & Monn, 2015). Considering the interplay in the wake of climate disasters, the most impactful protective factors for families include access to and integrity of social, emotional, and concrete supports (Sprague et al., 2015), as well as strong community cohesion (Cianconi, Betrò, & Janiri, 2020). Further, there is broad agreement that community and social systems supporting the reunion and connectedness of families, restoration of family routines, resumption of school, and maintenance of cultural practices all serve to increase resilient outcomes among families after natural disasters (Masten & Monn, 2015). Chronic climate related disasters can also have considerable impacts unique to family units. A recent review on drought events identified causal pathways by which drought impacted families through socioecological systems, such as employment sectors, the economy, social/community structures, and forced migration patterns (see Berry, Waite, Dear, Capon, & Murray, 2018, Figure 1 for a summary). While difficult to adequately study and analyze, chronic disasters may pose particular risks for families through indirect, socioecological channels.

2.3.3. Predicting community resilience

Some research suggests that climate change directly affects components of community well-being, namely social cohesion and relationships. A rigorous meta-analysis found that deviations from normal precipitation and temperatures systematically increase the risk of human conflict (Hsiang, Burke, & Miguel, 2013). Examining community factors associated with climate disaster outcomes could provide insights into how to intervene at the community level.

Social capital, a frequently identified predictor of resilience, and has unique implications for community level resilience after climate related natural disasters (Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997; Kawachi, 1999; Sherrieb, Norris, & Galea, 2010). Broadly speaking, social capital refers to positive resources, for both individuals and communities, generated by involvement and participation in groups (Portes, 1998). In post-disaster situations, community social capital networks provide access to a myriad of resources such as direct aid, information, child care, financial resources, and emotional and psychological support (Elliott, Haney, & Sams-Abiodun, 2010; Hurlbert, Haines, & Beggs, 2000; Norris et al., 2002). Likewise, greater community-level social cohesion before the 2011 earthquake and tsunami in Tohoku, Japan, predicted a lower risk of PTSD symptoms when controlling for depression and experiences during the disaster (Hikichi, Aida, Tsuboya, Kondo, & Kawachi, 2016). It is important to note that, however, varying definitions of social capital may yield divergent outcomes. For example, despite the aforementioned positive associations between social capital and post-disaster resilience, higher

social capital at the community level, operationalized by a lower percentage of residents living alone, can counterintuitively result in higher posttraumatic stress (Lowe et al., 2015). The same study also found that stronger economic development within a community was a protective factor against depression, but for those who were less affected by disaster-related stressors. These findings highlight the need of studying the interaction of community and individual factors, and the collective effect of various predictors.

Several recent studies have begun to advance our understanding of the relationship between community-level resources and post-disaster risk and resilience. A prospective study examining depression trajectories among older adults who experienced both the 2008 recession and Hurricane Sandy found that a class of individuals who were depressed initially but improved over time resided in areas with higher rates of crime, highlighting the potential influence of neighborhood characteristics (Mandavia & Bonanno, 2019). In addition to crime, the severity of impact experienced at the community level also tends to yield greater needs and a higher risk of negative psychological outcomes. Gruebner et al. (2016) found that after Hurricane Ike, residents in heavily affected communities exhibited higher risk for chronic or delayed mental health problems, controlling for individual factors. Likewise, after Hurricane Sandy, those who experienced individual stressors and lived in the most damaged communities were most likely to report perceived need (Lowe et al., 2016). Taken together, severity of impact and concurrent neighborhood level risk factors appear to increase risk of negative post-disaster adjustment among communities.

When community identities and economic livelihoods rely directly on the natural environment and land-based resources, they are more easily impacted by climate change. In Australia, the negative impacts of prolonged drought periods were associated with increased risk of suicide among rural male farmers (Hanigan, Butlera, Kokicc, & Hutchinson, 2012). Similarly, indigenous communities are often not only dependent on natural resources for their livelihood and cultural identities, but are also located in geographically vulnerable regions (Cunsolo Willox et al., 2012). Further exploration is needed to identify characteristics of communities and high-risk regions in order to improve psychological outcomes and better define pathways of resilience following climate disasters.

3. Limitations and future directions

Our discussion of anxiety and resilience in the face of natural disaster suggests a number of compelling research questions. These range from broad questions about risk and resilience, such as the extent that anxiety and resilience might vary according to the nature of a disaster and how the mental health impact of natural disasters might be best studied, to more specific questions about the function of resilience factors, such as the relative importance of different resilience factors or how these factors might interact, to more applied questions, such as identifying the best strategies and actions that individuals, families, and communities might use to alleviate psychological distress post-disaster, or whether focused prevention might be developed for residents in high-risk areas to mitigate the impacts when natural disasters occur. Although the sheer number of questions is somewhat daunting, by the same token they suggest that the study of resilience in the face of natural disasters has an exciting future.

3.1. Examination of resilience factors at different levels

As previously mentioned, resilience factors can be characteristics of disasters, individuals, as well as families and communities. Thus far, however, most studies focus on a select few predictors, making it difficult to understand how multiple resilience factors work together. Furthermore, each predictor appears to have relatively small effects. Is it the case that each resilience factor contributes independently, or do these resilience factors overlap and even interact to inform outcomes?

Analyses incorporating multiple risk and resilience factors, ideally across different levels, are especially encouraged as they have the potential to depict a more holistic picture of how various dimensions of resilience function together. A more person-centered, individualized approach, such as establishing profiles of resilience factors and linking these profiles to outcomes may help identify those who are at high risk for developing psychopathology and enable earlier intervention. One way of integrating existing findings is to conduct meta-analyses of methodologically congruent studies, particularly those that identify patterns of outcomes such as trajectories, rather than simple prevalence rates (Galatzer-Levy, Huang, & Bonanno, 2018). Similarly, reliance on more advanced machine learning approaches that involve variable selection and regularization (e.g., shrinking the contribution of small effects) may enhance the prediction accuracy and interpretability of statistical models and thus reveal only the strongest predictors for outcomes (McNeish, 2015).

3.2. Stress-buffering effects of resilience factors

Although many studies have used resilience factors to predict prospective outcomes, relatively few studies thus far have examined whether these factors buffer stress. A recent review by Kalisch et al. (2017) highlighted the importance of examining the stress-buffering effect of resilience factors (i.e., the interaction between resilience factors and stress exposure) rather than simply capturing the longitudinal correlation between resilience factors and outcomes. According to these authors, whether a given resilience factor interacts with stress exposure in affecting outcomes is crucial since it would show the buffering effect that a factor has against stress and yields insights into potential interventions. Predictors of resilient outcomes identified thus far are mostly weak, explaining only a small proportion of the variance in long-term mental health. In addition, it is still unclear whether integrating multiple independent resilience factors will necessarily improve prediction, and whether resilience factors across different populations and disasters are replicable. In other words, it is currently uncertain whether a group of individuals with similar resilience factors will show no or only minor and temporary impairments in mental health in response to natural disasters. Taken together, there is a pressing need for prospective longitudinal resilience studies in this field.

3.3. Prevention and intervention

Finally, potential prevention and intervention still remains to be developed, tested, and adapted. Shultz, Kossin, and Galea (2018), for example, highlighted the need to integrate knowledge from climate science (e.g., disaster forecasting) into public health preparedness for hurricanes, tropical cyclones, and related disasters. Attempts to aid individuals residing in areas of severe exposure to natural disasters by developing and building necessary coping skills have thus far produced only relatively small effects. Questions that remain to be answered include better understanding which individuals would most benefit from interventions, how to increase the efficacy of available interventions, and the optimal dissemination and delivery of interventions. Previous techniques that are meant to answer such questions, such as screenings, unfortunately lack clear evidence to support their effectiveness (Rona, Burdett, Greenberg, Fear, & Wessely, 2017). This may partly result from a failure in successfully elucidating risk and resilience factors and the inability to identify high-risk individuals. To date, it seems that evidence points to what not to do more so than what to do (Greenberg & Wessely, 2017). For instance, debriefing, a popularized technique in the last century has, unfortunately, been found to be ineffective and even harmful (van Emmerik, Kamphuis, Hulsbosch, & Emmelkamp, 2002). Interventions that have been found to be useful thus far are consistent with the individual-level resilience factors reviewed earlier. One study, for example, examined the effect of low-cost intervention to facilitate teachers' recovery from traumatic events by improving their coping

skills (Seyle, Widyatmoko, & Silver, 2013). These authors considered intervention for teachers in impacted areas as one potential way to influence students by capitalizing on social support networks, although they did not directly test this effect. In addition, trauma risk management techniques such as mobilizing social support and improving post-traumatic help seeking have been found to be effective (e.g., Whybrow, Jones, & Greenberg, 2015). Although promising, more research seems warranted before meaningful conclusions in this field can be reached.

4. Conclusions

Studies on the impact of climate disasters on mental health have been conducted in various samples and across the globe, emphasizing the universal threat that climate disasters pose to individuals, families, and communities. Despite these adverse impacts, individuals exposed to these disasters remain mostly resilient. Anxiety and resilience are informed by a number of factors across domains including event, individual, as well as family and community. To better understand the impact of climate disasters, we outlined a number of methodological limitations that need to be considered. As such, even given the large volume of studies, research is still needed to better understand the pathways of resilience and anxiety to identify the robust predictors and provide appropriate interventions to the most vulnerable individuals and communities.

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