Journal of Psychiatric Research 61 (2015) 97–105

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/psychires

Post-disaster stressful life events and WTC-related posttraumatic stress, depressive symptoms, and overall functioning among responders to the World Trade Center disaster

Michael J. Zvolensky [a, b, *], Roman Kotov [c], Clyde B. Schechter [d], Adam Gonzalez [c], Anka Vujanovic [e], Robert H. Pietrzak [f, g], Michael Crane [h], Julia Kaplan [h], Jacqueline Moline [i], Steven M. Southwick [f, g], Adriana Feder [j], Iris Udasin [k], Dori B. Reissman [l], Benjamin J. Luft [m]

[a] University of Houston, Department of Psychology, Houston, TX, USA
[b] The University of Texas MD Anderson Cancer Center, Department of Behavioral Science, Houston, TX, USA
[c] Stony Brook University, Department of Psychiatry, Stony Brook, NY, USA
[d] Albert Einstein College of Medicine, Department of Family & Social Medicine, Bronx, NY, USA
[e] University of Texas Health Science Center at Houston, Department of Psychiatry and Behavioral Sciences, Houston, TX, USA
[f] United States Department of Veterans Affairs National Center for Posttraumatic Stress Disorder, VA Connecticut Healthcare System, West Haven, CT, USA
[g] Department of Psychiatry, Yale School of Medicine, New Haven, CT, USA
[h] Icahn School of Medicine at Mt. Sinai, Department of Preventive Medicine, New York, NY, USA
[i] North Shore-LIJ Health System, Department of Population Health, Great Neck, NY, USA
[j] Department of Psychiatry, Mount Sinai School of Medicine, New York, NY, USA
[k] University of Medicine & Dentistry of New Jersey, Environmental and Occupational Health Sciences Institute, Piscataway, NJ, USA
[l] WTC Health Program, NIOSH, USA
[m] Stony Brook University, Department of Medicine, Stony Brook, NY, USA

ARTICLE INFO

Article history:
Received 15 August 2014
Received in revised form
6 October 2014
Accepted 14 November 2014

Keywords:
Stress exposure
Stress generation
Depression
Disaster
Trauma

ABSTRACT

Background: The current study examined contributions of post-disaster stressful life events in relation to the maintenance of WTC-related posttraumatic stress, depressive symptoms, and overall functioning among rescue, recovery, and clean-up workers who responded to the September 11, 2001 World Trade Center (WTC) terrorist attacks.

Methods: Participants were 18,896 WTC responders, including 8466 police officers and 10,430 non-traditional responders (85.8% male; 86.4% Caucasian; $M_{age} = 39.5$, $SD = 8.8$) participating in the WTC Health Program who completed an initial examination between July, 2002 and April, 2010 and who were reassessed, on average, 2.5 years later.

Results: Path analyses were conducted to evaluate contributions of life events to the maintenance of WTC-related posttraumatic stress, depressive symptoms, and overall functioning. These analyses were stratified by police and non-traditional responder groups and adjusted for age, sex, time from 9/11 to initial visit, WTC exposures (three WTC contextual exposures: co-worker, friend, or a relative died in the disaster; co-worker, friend, or a relative injured in the disaster; and responder was exposed to the dust cloud on 9/11), and interval from initial to first follow-up visit. In both groups, WTC-related post-traumatic stress, depressive symptoms, and overall functioning were stable over the follow-up period. WTC exposures were related to these three outcomes at the initial assessment. WTC-related post-traumatic stress, depressive symptoms, and overall functioning, at the initial assessment each predicted the occurrence of post-disaster stressful life events, as measured by Disaster Supplement of the Diagnostic Interview Schedule. Post-disaster stressful life events, in turn, were associated with subsequent mental health, indicating partial mediation of the stability of observed mental health.

* Corresponding author. The University of Houston, 126 Heyne Building, Suite 104, Houston, Texas 77204-5502, United States. Tel.: +1 713 743 8056; fax: +1 713 743 8588.
E-mail address: mjzvolen@central.uh.edu (M.J. Zvolensky).

http://dx.doi.org/10.1016/j.jpsychires.2014.11.010
0022-3956/Published by Elsevier Ltd.

Conclusions: The present findings suggest a dynamic interplay between exposure, post-disaster stressful life events, and WTC-related posttraumatic stress, depressive symptoms, and overall functioning among WTC disaster responders.

Published by Elsevier Ltd.

The World Trade Center (WTC) disaster, resulting from the terrorist attacks on September 11, 2001 (9/11), was a devastating man-made event with widespread negative environmental, as well as acute and protracted physical and mental health consequences for rescue and recovery workers. (Aldrich et al., 2010; Levin et al., 2002; Luft et al., 2012; Niles et al., 2011; Pietrzak et al., 2014) Mental health-oriented work has found elevated rates of probable posttraumatic stress disorder (PTSD), (Farfel et al., 2008; Berninger et al., 2010a, 2010b; Stellman et al., 2008) depression, (Chiu et al., 2011) certain anxiety disorders, (Farach et al., 2008; Cukor et al., 2011a, 2011b) and functional impairment (Farfel et al., 2008) among rescue and recovery workers. Although the mental health effects among responders often vary by occupational type (e.g., police versus non-traditional responders such as construction workers), (Perrin et al., 2007; Wisnivesky et al., 2011) WTC-related exposure(s), which include, losing a colleague in the disaster, being exposed to the dust cloud, and working in close proximity to disaster site, have been routinely associated with the *onset* of a variety of mental health symptoms, most commonly posttraumatic stress. (Luft et al., 2012; Pietrzak et al., 2014; Chiu et al., 2011; Perrin et al., 2007; Brackbill et al., 2009; Perlman et al., 2011) These findings are generally consistent with the trauma exposure literature. (Pfefferbaum et al., 2012; van den Berg et al., 2012)..

A wide variety of factors, including coping skills, personality traits, social support, cognitive styles, and sociodemographic factors, have been documented as being involved in the *maintenance* of post-disaster mental health symptoms in general and from the WTC disaster. (Farfel et al., 2008; Berninger et al., 2010a, 2010b; Stellman et al., 2008; Farach et al., 2008; Cukor et al., 2011a, 2011b; Bonanno et al., 2007) Exposure to stressful life events in the period following a disaster or trauma appears to be one of the most consistently reported risk factors, although the observed effect sizes are generally small to medium in magnitude. (Brewin et al., 2000; Luszczynska et al., 2009) Indeed, stressful life events post-trauma exposure are often related to poorer mental health, including PTSD. (Brewin et al., 2000; Bonanno, 2012; Solomon et al., 1989) For example, Pietrzak and colleagues (Pietrzak et al., 2013) found that greater number of traumatic and stressful life events after Hurricane Ike, particularly financial problems, were associated with a chronic PTSD trajectory. Thus, past work indicates that not all stressful life events necessarily exert a similar effect on mental health. Yet, in general, such findings are in line with research documenting that responders who have experienced more stressful life events in the aftermath of a disaster are more likely to develop PTSD. (Norris and Murrell, 1990; Fukuda et al., 1999) Similarly, post-disaster life stressors and traumatic events are related to the severity and chronicity of PTSD and related mental health problems. (Brewin et al., 2000; Cerdá et al., 2013; Kessler et al., 2012; Norris et al., 2002a, 2002b; Tracy et al., 2011; Norris and Uhl, 1993) Consistent with cumulative life stress models of psychopathology, these data suggest additional post-disaster life events and chronic distressing life conditions may contribute to poorer mental health. (Green et al., 1990; Appleyard et al., 2005).

Although stressful life events can increase risk for mental illness (i.e., stress exposure), mental health problems, in turn, can increase susceptibility to stressful events (i.e., stress generation). (Hankin and Abramson, 2001) Indeed, there can be reciprocal relations between life stress and mental health. (Hammen and Brennan, 2001; Harkness et al., 2008; Shih et al., 2009) Drawing from such work, it is possible that among WTC responders, stressful life events after the disaster may account for the experience of more chronic and severe posttraumatic stress, depressive symptoms, and overall functioning. Yet, to the best of our knowledge, the interplay between disaster exposure, initial mental health status, post-disaster stressful life events, and the maintenance of post-traumatic stress, depressive symptoms, and overall functioning has yet to be directly explored among those affected by the WTC disaster.

Together, the present investigation examined contributions of post-disaster stressful life events to the maintenance of WTC-related posttraumatic stress, depressive symptoms, and overall functioning among responders to the WTC disaster participating in the WTC Health Program (WTC-HP). It was hypothesized that (a) WTC exposures (e.g., losing a colleague, family member, or friend in the disaster, being exposed to the dust cloud on 9/11, and long duration of work) would be related to greater WTC-related post-traumatic stress, depressive symptoms, and decreased overall functioning at the initial assessment; (b) initial mental health would be associated with the occurrence of post-disaster stressful life events; and (c) post-disaster stressful life events would relate to the subsequent maintenance of WTC-related posttraumatic stress, depressive symptoms, and overall functioning.

1. Materials and methods

1.1. Participants

Data were obtained from the WTC-Health Program (WTC-HP), a consortium of 5 CDC-funded clinical programs in New York and New Jersey providing annual monitoring and treatment to WTC responders. (Luft et al., 2012; Herbert et al., 2006) The WTC-HP provides yearly health monitoring and treats WTC-related conditions of responders with documented involvement in the WTC clean-up and recovery efforts, except for New York City firefighters as they are enrolled in a parallel program. (Prezant, 2008) The Institutional Review Boards (IRB) of all participating organizations monitor the study and review it annually. Written informed consent is obtained. The study was approved annual by the IRB of Stony Brook University and all other sites. Although participation in research is optional as part of participation in the WTC-HP, more than 90% of responders consent for their de-identified monitoring data to be used for research purposes.

The WTC-HP began in July 2002 and enrollment remains open. The ascertainment period for the current study was 7/2002–7/2010. During that period, 26,965 responders enrolled in the program and completed monitoring visit 1 (V1), and 18,896 (70.1%) completed a second monitoring visit (V2); this group who completed both V1 and V2 assessments are the focus of the current study. The participants without V2 data were similar to the analysis cohort on posttraumatic stress and depressive symptom severity, functioning, demographics, and WTC exposures; the only substantial difference between the cohorts was that the excluded

group enrolled about a year later, and therefore, V2 was not completed.

Nearly half of the participants ($n = 8466$; 44.8%) worked in law enforcement (mostly police) and the others ($n = 10{,}430$; 55.2%) were non-traditional responders (construction, maintenance, and transportation workers, electricians, clergy, etc). These two groups differed in prior-disaster training and on study variables, as shown previously (Luft et al., 2012; Pietrzak et al., 2014); therefore, analyses were stratified by occupational group.

1.2. Measures

The **Posttraumatic Stress Disorder (PTSD) Checklist** (PCL-S) (Blanchard et al., 1996) was used to measure WTC-related posttraumatic stress symptom severity. The PCL-S is a 17-item self-report inventory assessing the severity of *Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition* (American Psychiatric Association APA, 2000) PTSD symptoms in the past month rated "in relation to 9/11" on a scale from 1 (not at all) to 5 (extremely); scores range from 17 to 85. The PCL-S has evidenced good convergent validity and internal consistency in previous work (Wilkins et al., 2011); in the present sample, the internal consistency of the total score was $\alpha = 0.95$.

The **Patient Health Questionnaire-9** (PHQ-9), (Kroenke et al., 2001) is a 9-item self-report measure that assesses current (past 2 weeks) *DSM-IV* depression symptoms. The PHQ-9 has been shown to be highly concordant with structured clinical interview measures of depression. (Cannon et al., 2007) Participants rated the frequency of each symptom on a 4-point Likert type scale (0 = *not at all*, 1 = *several days*, 2 = *more than half the days*, and 3 = *nearly every day*). Consistent with past work, the total score was utilized in the current study; (Cannon et al., 2007) the internal consistency of the scale in the present sample was $\alpha = 0.90$. At V2, 9680 participants completed the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977) rather than the PHQ-9. For them, we converted the CES-D score to PHQ-9 metric. The conversion formula was developed using censored regression in a subsample of 7973 responders who completed both the PHQ-9 and CES-D at V1. The reconstructed PHQ-9 was similar to the original with regard to mean (4.80 vs. 4.98) and SD (5.86 vs. 5.94) and the two versions correlated .86.

The **Sheehan Disability Scale** (SDS) (Sheehan, 1983) is a brief self-report tool that assesses functional impairment related to emotional problems. The measure has been used in many contexts and extensively validated. (Sheehan and Sheehan, 2008) Participants rated on an 11-point Likert-type scale (0 = *not at all* to 10 = *extremely*) how much their emotional symptoms have disrupted their lives in the past month on the domains of work/school, social life, and family/home life. Consistent with established practice, (Sheehan and Sheehan, 2008) the responses were averaged in a single composite (overall functioning); internal consistency of SDS items in the present sample was $\alpha = 0.92$.

A checklist of 12 stressful life events from the **Disaster Supplement of the Diagnostic Interview Schedule**, (Robins and Smith, 1983) was used to assess life stress at V2. A complete listing of specific stressful life events assessed is in Table 1; illustrative examples include job loss, layoff, or substantial loss of income, serious illness, and changed where you live. Participants indicated whether an event occurred since the first visit (i.e., between V1 and V2). The responses were summed to create a post-disaster life stress composite. Specifically, the life stress measure reflects the count of life stress items endorsed and ranges from 0 to 12, with one subtlety. For those with non-missing responses to at least 10 items, ipsative mean imputation was applied.

WTC exposures were assessed at initial visit via clinical interview. We focused on three exposures: losing a co-worker, friend, or a relative in the disaster; co-worker, friend, or a relative injured in the disaster; and being exposed to the dust cloud on 9/11. (Luft et al., 2012; Webber et al., 2011) We selected exposures that predicted health outcomes in previous literature, which includes our own work and Registry data. (Luft et al., 2012; Perrin et al., 2007) Moreover, on a theoretical basis, WTC exposures included in the model are associated with life threat and witnessing of horror, which are linked to increased risk of PTSD in past work. (Perrin et al., 2007).

1.3. Analytic plan

Comparisons of police and non-traditional responders were performed using chi-square tests. Bivariate associations were analyzed using Pearson correlations when both variables were continuous and polychoric/tetrachoric correlations when dichotomous variables were involved to produce equivalent estimates for continuous variables, dichotomous variables, and a mix of the two. Pearson, polychoric, and tetrachoric correlations have a consistent interpretation, with $r < .20$ conventionally considered a small effect, $r = .20–.50$ a medium effect, and $r > .50$ a large effect. (Cohen, 1988) Multivariate analyses were conducted using path analysis, a type of structural equation modeling. (Kline, 2011) A separate model was constructed for WTC-related posttraumatic stress, depressive symptoms, and overall functioning. Each model included the same path structure, exposure variables and covariates. The V1 outcome was regressed on WTC exposures. Interval life events were regressed on the V1 outcome and WTC exposures. The V2 outcome was regressed on the V1 outcome and interval life events. Sobel's test evaluated the indirect effect of V1 mental health

Table 1
Individual life events in the V1–V2 interval and their associations (Cohen's *d*) with V2 mental health.

Event	Non-traditional				Police			
	Prevalence	PTSD	Depression	Disability	Prevalence	PTSD	Depression	Disability
Job loss, layoff, or substantial loss of income	36.16%	0.75	0.77	0.71	11.30%	0.69	0.63	0.62
Problems with bad debts or had something repossessed	20.88%	0.74	0.77	0.69	8.15%	0.53	0.60	0.52
Changed where you live	23.83%	0.33	0.34	0.29	17.30%	0.19	0.19	0.21
Major car trouble	20.25%	0.29	0.34	0.27	14.62%	0.24	0.31	0.24
Injury	17.94%	0.28	0.37	0.24	19.01%	0.31	0.28	0.27
Serious illness	17.26%	0.65	0.66	0.55	10.80%	0.60	0.73	0.55
Break up with a spouse or partner	17.37%	0.49	0.55	0.48	11.47%	0.33	0.32	0.39
Break up with a best friend	16.12%	0.81	0.70	0.69	5.61%	0.52	0.44	0.48
Legal problems	8.17%	0.39	0.51	0.40	4.01%	0.43	0.46	0.39
Arrested	3.47%	0.25	0.28	0.22	0.64%	0.21	0.25	0.20
Robbery or house break in	4.93%	0.23	0.16	0.24	1.54%	0.13	0.15	0.11
Mugged or beaten up	1.88%	0.27	0.29	0.21	0.62%	0.14	0.16	0.15

on V2 dependent variables via interval life events (see Fig. 1A). Predictors were allowed to correlate. In evaluating fit of the models, we considered the four indices allowed by the estimator: the comparative fit index (CFI), the Tucker–Lewis Index (TLI), the root-mean-square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Although there are no strict (universal) criteria for evaluating indices, CFI and TLI ≥0.90, RMSEA <.10, and SRMR<.08 are widely considered evidence of acceptable fit, and CFI and TLI ≥0.95, RMSEA <.06, and SRMR<.05 evidence of excellent fit. (Lt and Bentler, 1999; Marsh et al., 2004) Given the number of paths in the model, a conservative p value of <0.01 was used to define statistical significance. These analyses also adjusted

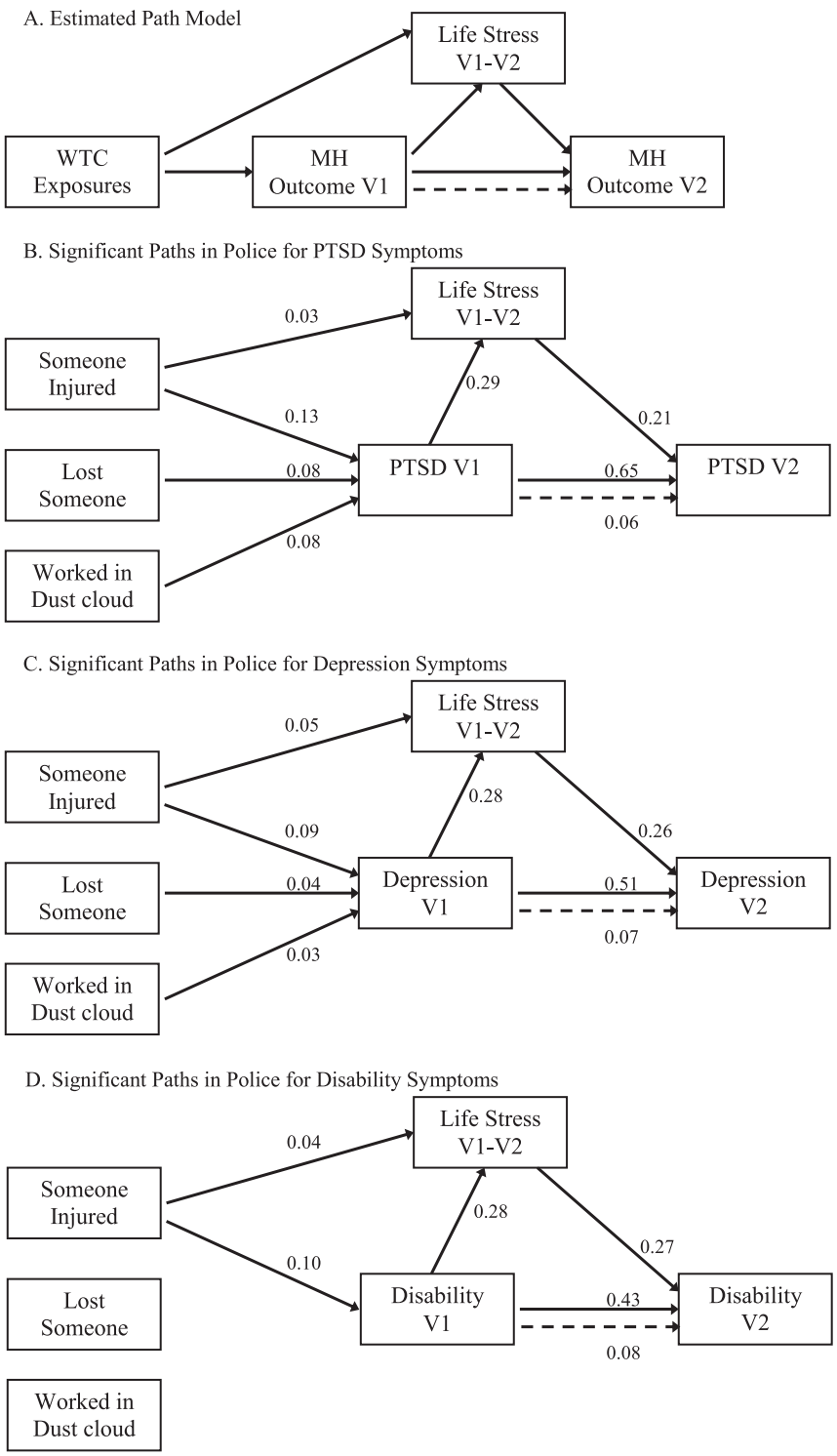

Fig. 1. Path model showing all effects being estimated (panel A) as well as effects significant at $p < .01$ in police (panel B–D). Values are standardized regression coefficients (β's). Analyses adjusted for age, gender, race/ethnicity, time to assessments, and WTC exposures (paths not shown). Directional arrows indicate regression paths; solid lines indicate direct effects and dashed lines indicate indirect effects on outcomes via life stress.

for age, sex, time from 9/11 to V1, and time from 9/11 to V2. The path analyses were performed using Mplus version 7.11. We used the robust maximum likelihood estimator, a recommended approach to handling non-normal distributions and missing data. (Schafer and Graham, 2002).

2. Results

2.1. Descriptive data

Table 2 presents the descriptive characteristics of study participants. The occupational groups differed on nearly all study variables. Police reported less posttraumatic stress and depressive symptom severity as well as better overall functioning at V1 and V2; they also reported fewer stressful life events between V1 and V2 than non-traditional responders. Police were more likely to have been exposed to dust cloud, losing someone on 9/11, or someone they knew being injured on 9/11 (all $p's < 0.001$).

Prevalence of specific life events in the two groups ranged from rare (e.g., having been assaulted) to common (e.g., job/income loss) (Table 1). All events were associated with increased severity of WTC-related posttraumatic stress, depressive symptoms, and overall functioning at V2, but four events showed the strongest effects: job/income loss, financial problems, serious illness, and break-up with a friend.

2.2. Bivariate associations

Table 3 presents correlations among study variables for each occupational group. Patterns of association were quite similar in these populations. In both groups, demographic factors and WTC exposures were modestly associated with WTC-related posttraumatic stress, depressive symptoms, and overall functioning at both visits and post-disaster life stress. Post-disaster life stress at V2 was moderately associated with WTC-related posttraumatic stress, depressive symptoms, and overall functioning at V1 ($r's = 0.29–0.38$) and had a stronger association with these mental health variables at V2 ($r's = 0.40–0.47$). As expected, WTC-related PTSD symptoms, depressive symptoms, and overall functioning were highly inter-correlated both within and across time points.

Table 2
Descriptive characteristics of the study groups.

Variable	Total $N = 18,896$	Police $N = 8466$	Non-traditional $N = 10,430$
	Mean (SD) or *n* (%)	Mean (SD) or *n* (%)	Mean (SD) or *n* (%)
Demographics and time			
Age at V1	39.5 (8.8)	37.1 (7.0)	41.4 (9.7)
Years from 9/11 to V1	3.7 (2.2)	4.3 (2.2)	3.3 (2.1)
Years from 9/11 to V2	6.3 (1.9)	6.8 (1.9)	5.9 (1.9)
Sex: female	N(14.2)	N(14.7)	N(13.9)
Hispanic	N(24.0)	N(20.7)	N(26.8)
Black Non-Hispanic	N(16.2)	N(20.6)	N(12.6)
WTC exposures			
Dust cloud	N(19.8)	N(28.6)	N(12.8)
Someone injured	N(45.7)	N(58.8)	N(34.5)
Lost someone	N(54.9)	N(70.6)	N(41.5)
Psychosocial variables			
V1 PTSD	31.8 (15.2)	26.5 (11.7)	36.1 (16.4)
V1 Depression	4.9 (5.8)	3.1 (4.3)	6.5 (6.4)
V1 Disability	5.5 (7.4)	3.1 (5.6)	7.4 (8.1)
V2 PTSD	32.6 (16.2)	27.3 (13.0)	37.0 (17.2)
V2 Depression	5.5 (6.2)	3.5 (4.8)	7.2 (6.8)
V2 Disability, mean (SD)	6.9 (8.0)	4.4 (6.6)	9.0 (8.5)
V2 Life Stress, mean (SD)	1.5 (1.7)	1.0 (1.4)	1.8 (1.9)

Table 3
Correlations among study variables among police (above diagonal) and non-traditional responders (below diagonal).

Variable	Age	Gender	Hispanic	Black	Years to V1	Years to V2	Dust cloud	Someone injured	Lost someone	V1 PTSD	V1 depression	V1 Disability	V2 PTSD	V2 depression	V2 Disability	V2 life stress
Age		−0.01	−0.16	0.04	−0.07	−0.11	0.05	0.03	0.05	0.12	0.10	0.07	0.11	0.09	0.10	−0.03
Gender	−.02		**0.21**	−0.10	0.05	0.06	−0.05	−0.07	−0.14	0.08	0.09	0.08	0.07	0.09	0.08	0.10
Hispanic	−.23	**.38**		**−.86**	0.01	0.03	0.02	−0.07	−0.12	0.05	0.04	0.05	0.06	0.04	0.09	0.09
Black	.07	−.20	**−.84**		**0.35**	**0.29**	−0.03	−0.03	−0.02	−0.02	0.01	−0.02	−0.02	0.01	−0.04	−0.07
Years to V1[a]	−.04	.03	.02	**.30**		**0.83**	−0.17	−0.03	−0.08	−0.02	0.01	0.02	−0.04	−0.02	−0.03	−0.06
Years to V2[b]	−.08	.02	.03	**.28**	**.80**		−0.14	−0.03	−0.07	−0.02	0.00	0.02	−0.02	0.00	−0.02	0.03
Dust Cloud	.03	−.12	−.16	.06	.05	.03		0.18	0.16	0.14	0.06	0.04	0.12	0.05	0.05	0.00
Someone injured	.02	−.02	−.11	.05	.02	.02	**.29**		**0.52**	**0.22**	0.14	0.14	0.19	0.12	0.11	0.09
Lost someone	.05	−.13	**−.20**	.10	.01	−.01	**.25**	**.58**		0.17	0.09	0.06	0.16	0.09	0.08	0.04
V1 PTSD[c]	−.02	.16	**.22**	−.11	.07	.06	.09	**.20**	.13		**0.78**	**0.70**	**0.72**	**0.58**	**0.53**	**0.29**
V1 Depression[d]	−.03	.20	**.22**	−.11	.06	.06	.01	.13	.06	**.80**		**0.72**	**0.60**	**0.59**	**0.51**	**0.29**
V1 Disability[e]	−.06	.17	**.24**	−.11	.06	.06	.02	.14	.05	**.73**	**.74**		**0.55**	**0.51**	**0.52**	**0.29**
V2 PTSD	.00	.16	**.26**	−.14	.03	.05	.04	.14	.07	**.71**	**.62**	**.57**		**0.79**	**0.72**	**0.41**
V2 Depression	−.01	.20	**.25**	−.12	.05	.05	−.01	.08	.02	**.60**	**.62**	**.56**	**.81**		**0.70**	**0.41**
V2 Disability	−.02	.17	**.24**	−.13	.02	.03	.00	.07	.02	**.51**	**.50**	**.51**	**.70**	**.70**		**0.40**
V2 Life Stress[f]	−.15	.08	.16	−.13	.03	.12	.03	.13	.04	**.36**	**.37**	**.38**	**.47**	**.47**	**.43**	

Note.
[a] Visit 1.
[b] Visit 2.
[c] Posttraumatic Stress Disorder Checklist (Blanchard et al., 1996).
[d] Patient Health Questionnaire-Depression Module (Kroenke et al., 2001).
[e] Sheehan Disability Scale (Sheehan, 1983).
[f] Disaster Supplement of the Diagnostic Interview Schedule (Robins and Smith, 1983). Three exposures: losing a co-worker, friend, or a relative in the disaster; co-worker, friend, or a relative injured in the disaster; and being exposed to the dust cloud on 9/11.Correlations involving continuous variables are polychoric; all others are tetrachoric. Correlations >0.04 are significant at $p < 0.01$ level. Moderate associations ($r \geq 0.20$) are shown in bold. Stability correlations are underlined.

Stability of functional impairment (r's = 0.51–0.52) and depression symptoms (r's = 0.59–0.62) over the assessment interval was substantial, and stability of WTC-related posttraumatic stress symptoms was even higher (r's = 0.71–0.72).

2.3. Path analyses

To test the mediating effect of post-disaster life stress on WTC-related posttraumatic stress, depressive symptoms, and overall functioning, we conducted path analyses. These models adjusted for age, sex, time from 9/11 to V1, and time from 9/11 to V2. Significant paths within the models tested are presented in Fig. 1 for police and Fig. 2 for non-traditional responders. All models showed excellent fit to the data (see Table 4). In both groups, WTC exposures were associated with V1 WTC-related posttraumatic stress, depressive symptoms, and overall functioning The strongest and

Table 4
Model fit indices for police and non-traditional responders.

Outcome	χ^2	*df*	CFI[a]	TLI[b]	RMSEA[c]	SRMS[d]
Police						
PTSD	25.418	3	0.996	0.963	0.031 (0.021, 0.043)	0.005
Depression	9.662	3	0.998	0.984	0.017 (0.006, 0.029)	0.003
Disability	13.076	3	0.997	0.971	0.021 (0.010, 0.033)	0.004
Non-Traditional						
PTSD	8.495	3	0.999	0.993	0.014 (0.003, 0.026)	0.003
Depression	12.058	3	0.999	0.985	0.018 (0.008, 0.030)	0.004
Disability	4.337	3	1.000	0.997	0.007 (0.000, 0.020)	0.002

Note.
[a] Comparative Fit Index.
[b] Tucker-Lewis Index.
[c] Root-mean-square error of approximation and 90% Confidence Interval.
[d] Standardized Root Mean Square Residual.

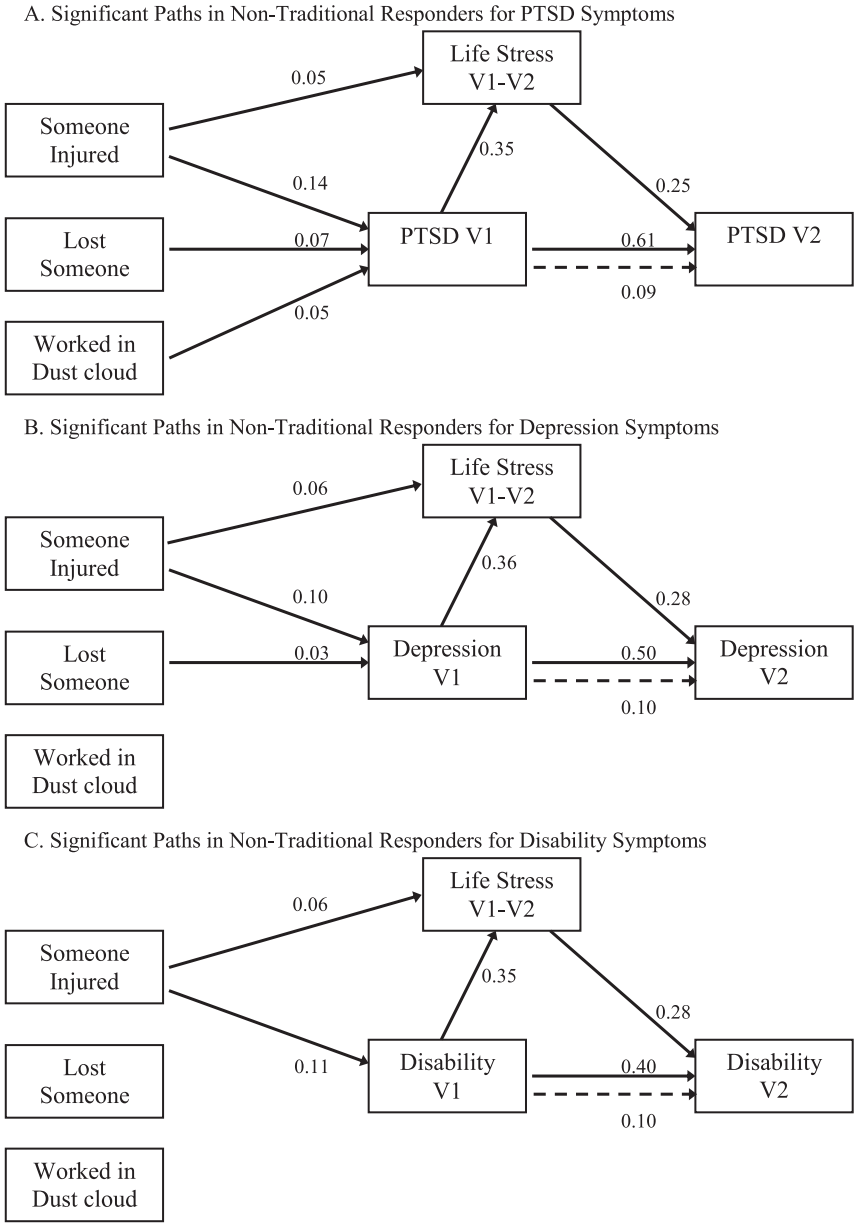

Fig. 2. Path model showing effects significant at $p < .01$ in non-traditional responders (panel A–C). Values are standardized regression coefficients (β's). Analyses adjusted for age, gender, race/ethnicity, time to assessments, and WTC exposures (paths not shown). Directional arrows indicate regression paths; solid lines indicate direct effects and dashed lines indicate indirect effects on outcomes via life stress.

most consistent predictor was a close person having been injured on 9/11 (β's = 0.10–0.14). WTC exposures were not significantly related to post-disaster life stress, other than if a close person was injured on 9/11. In contrast, V1 WTC-related posttraumatic stress, depressive symptoms, and overall functioning predicted the subsequent occurrence of stressful life events (β's = 0.28–0.36). In turn, these interval stressful life events predicted V2 mental health above and beyond V1 mental health (β's = 0.21–0.28). In fact, the chronicity of WTC-related posttraumatic stress, depressive symptoms, and overall functioning from V1 to V2 was partially mediated by the interval life stress (indirect β's = 0.07–0.10). The patterns of results were similar across occupational groups and outcomes.

3. Discussion

For both police and non-traditional responders, WTC exposures (worked in dust cloud, lost someone, and long duration of work on site) were significantly, but modestly, associated with WTC-related posttraumatic stress, depressive symptoms, and overall functioning at both visits. These findings are in line with past work documenting significant associations between exposure to potentially traumatic events and deleterious mental health in general (van den Berg et al., 2012; Friedman et al., 2007) and among WTC responders, in particular. (Luft et al., 2012; Chiu et al., 2011; Brackbill et al., 2009; Perrin et al., 2007; Perlman et al., 2011) Although the size of the observed effects was small, these data indicate, similar to previous studies, [e.g., 3] that WTC exposures play a role in increasing risk for WTC-related posttraumatic stress, depressive symptoms, and overall functioning. Moreover, because measures of WTC exposure were collected on average four years post-disaster, only the most basic characteristics of WTC exposure could be obtained. Accordingly, it is possible that the 'true clinical impact' of such exposures is greater than what was observed.

Broadly in line with both stress generation and exposure models of psychopathology (van den Berg et al., 2012; Hammen and Brennan, 2001) WTC-related posttraumatic stress, depressive symptoms, and overall functioning at the initial assessment was associated with the occurrence of post-disaster stressful life events. Post-disaster stressful life events, in turn, was related to subsequent mental health above and beyond initial levels. These effects were not attributable to confounding by age, sex, time from 9/11 to initial visit, WTC exposure, and interval from initial to follow-up visit, documenting a distinct, and therefore, potentially clinically and theoretically significant effect. Additionally, the general pattern and strength of the observed mediational effects were similar among both police and non-traditional responders despite the fact that police reported fewer mental health problems and stressful life events in the face of more WTC exposure. (Perrin et al., 2007) The latter finding that may be due to selection, resources (e.g., pensions), training of police officers, as well as stigma leading to underreporting of psychiatric symptoms and problems. (Luft et al., 2012).

The partial mediational effect of post-disaster stressful life events on the relation between initial and follow-up WTC-related posttraumatic stress, depressive symptoms, and overall functioning has clinical and theoretical significance because it was (a) evident above and beyond the variance accounted for by numerous 'third variables,' including WTC exposures and time from such exposures; (b) robust across occupations; and (c) evident over the span of years (events could have occurred at any point in the interval). Future work is needed to explore the mechanisms underlying these associations, including such processes as emotion regulation capacity. Based upon such findings, it may further be advisable to complete a randomized clinical trial comparing a standard care versus post-disaster stress management program for responders. This type of program may be especially useful clinically when the exposure is more recent than the WTC evaluated in the current report. Notably, given a similar effect was observed across occupational groups, interventions that serve to mitigate post-disaster stress may apply to both professional and non-professional responders. It also may be useful to explore whether other processes (e.g., adaptive coping, social support) may serve a protective function in the observed mental health–stress relation, and whether the observed pattern of findings generalizes to the presence and chronicity of other factors known to co-occur with mental health problems, such as physical illnesses, sedentary behavior, and substance use problems.

Although not a primary focus of the present investigation, at least two additional observations warrant comment. First, a broad array of life events were endorsed by responders (see Table 1). Of the types of life events endorsed, financial problems (e.g., job loss, debt) demonstrated some of the largest effects in relation to the mental health dependent variables across occupations. These findings are consistent with other disaster research that has reported financial problems after a disaster were associated with a chronic PTSD trajectory. (Pietrzak et al., 2013) Indeed, these data suggest that not all stressful life events exert a similar effect on mental health. Therefore, a stress management program may offer greater impact if oriented on those stressful life events that have the largest effect on mental health. For instance, financial problems appear to be especially potent and financial management classes may need to be part of treatment. Second, WTC-related posttraumatic stress symptoms, depressive symptoms, and functioning were substantially inter-correlated both within and across time points. This pattern is well-established in the literature and is thought to reflect the 'common core' of general distress present in anxiety and depressive disorders. (Watson, 2009).

There are a number of interpretive caveats and directions for future study that warrant consideration. First, despite the prospective design, causal inferences cannot be drawn from the existing observational data. Second, the study employed self-report measures to assess the examined variables. Accordingly, method variance may have played a role in the observed effects. Third, recall bias may be involved in the reporting of exposures and post-disaster stressful life events. For example, post-disaster stressful life events were assessed retrospectively and their report may have been affected by visit two psychopathology. We tried to minimize the impact of reporting biases by focusing on discrete major events, but several more closely spaced follow-up assessments would be preferable. Fourth, the post-disaster life stress checklist employed naturally did not index all possible relevant types or forms of stress. Therefore, future work is needed to explore whether other types of stress (e.g., daily hassles, social strain) play a similar mediational role in the maintenance of mental health problems. Fifth, future research could usefully replicate this model with the most recently defined posttraumatic stress symptoms. (American Psychiatric Association APA, 2013) Sixth, because the study was carried out exclusively among WTC responders, generalizability to other disaster-exposed populations is not certain. It will, therefore, be important for future studies to evaluate the present model in relation to other disasters. Finally, we opted *a priori* to examine initial WTC exposure as the earliest primary predictor variable. Of course, many other pre-disaster predictors could similarly be explored, including, but not limited to, pre-disaster life events, demographic factors, prior disaster exposure, substance use history, personality characteristics, among others. Future study might benefit from exploring such factors in the maintenance of mental health symptoms among responders to disasters.

4. Conclusions

Overall, the present findings suggest that there is dynamic interplay among exposure, post-disaster stressful life events, and WTC-related posttraumatic stress, depressive symptoms, and overall functioning among WTC responders. Accordingly, there may be clinical benefit to assessing post-disaster stressful life events and utilizing evidenced-based stress management interventions to facilitate better mental health adjustment among responder populations, including but not necessarily limited to, WTC responders.

Role of funding sources

This project was supported by National Institute of Occupational Safety and Health awards (200-2011-42057 and 200-201139410). NIOSH had no direct role in the study design, collection, analysis, or interpretation of the data, writing of the manuscript, or the decision to submit the paper for publication.

Contributor roles

Dr. Zvolensky and Dr. Kotov developed the project idea and wrote the paper. Dr. Schechter ran the analyses. All others contributed equally to the collection of the data, as well as commenting on the paper, and providing feedback throughout.

Conflict of interest disclosure

None.

Acknowledgments

This work was supported by National Institute of Occupational Safety and Health awards (200-2011-42057 and 200-2011-39410). The author(s) report no financial or other relationship relevant to the subject of this article. Please note that the content presented does not necessarily represent the official views of the National Institutes of Occupational Safety and Health, and that the funding sources had no other role other than financial support.

References

Aldrich TK, Gustave J, Hall CB, Cohen HW, Webber MP, Zeig-Owens R, et al. Lung function in rescue workers at the World Trade Center after 7 years. N Engl J Med 2010;362(14):1263–72.
American Psychiatric Association APA. Diagnostic and statistical manual of mental disorders: DSM-IV-TR®. American Psychiatric Pub; 2000.
American Psychiatric Association APA. Diagnostic and statistical manual of mental disorders: DSM-V®. American Psychiatric Pub; 2013.
Appleyard K, Egeland B, Dulmen MHM, Alan Sroufe L. When more is not better: the role of cumulative risk in child behavior outcomes. J Child Psychol Psychiatry 2005;46(3):235–45.
Berninger A, Webber MP, Niles JK, Gustave J, Lee R, Cohen HW, et al. Longitudinal study of probable post-traumatic stress disorder in firefighters exposed to the World Trade Center disaster. Am J Ind Med 2010;53(12):1177–85.
Berninger A, Webber MP, Cohen HW, Gustave J, Lee R, Niles JK, et al. Trends of elevated PTSD risk in firefighters exposed to the World Trade Center disaster: 2001–2005. Public Health Rep 2010;125(4).
Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD Checklist (PCL). Behav Res Ther 1996;34(8):669–73.
Bonanno GA. Resilience and variability following oil spill disasters. Psychiatry 2012;75(3):236–42.
Bonanno GA, Galea S, Bucciarelli A, Vlahov D. What predicts psychological resilience after disaster? The role of demographics, resources, and life stress. J Consult Clin Psychol 2007;75(5):671.
Brackbill RM, Hadler JL, DiGrande L, Ekenga CC, Farfel MR, Friedman S, et al. Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. JAMA 2009;302(5):502–16.
Brewin CR, Andrews B, Valentine JD. Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. J Consult Clin Psychol 2000;68(5):748.
Cannon DS, Tiffany ST, Coon H, Scholand MB, McMahon WM, Leppert MF. The PHQ-9 as a brief assessment of lifetime major depression. Psychol Assess 2007;19(2):247.
Cerdá M, Bordelois P, Galea S, Norris F, Tracy M, Koenen K. The course of post-traumatic stress symptoms and functional impairment following a disaster: what is the lasting influence of acute versus ongoing traumatic events and stressors? Soc Psychiatry Psychiatr Epidemiol 2013;48(3):385–95.
Chiu S, Webber MP, Zeig-Owens R, Gustave J, Lee R, Kelly KJ, et al. Performance characteristics of the PTSD Checklist in retired firefighters exposed to the World Trade Center disaster. Ann Clin Psychiatry 2011;23(2):95–104.
Cohen J. Statistical power analysis for the behavioral sciences. Psychology Press; 1988.
Cukor J, Wyka K, Jayasinghe N, Weathers F, Giosan C, Leck P, et al. Prevalence and predictors of posttraumatic stress symptoms in utility workers deployed to the World Trade Center following the attacks of September 11, 2001. Depress Anxiety 2011;28(3):210–7.
Cukor J, Wyka K, Mello B, Olden M, Jayasinghe N, Roberts J, et al. The longitudinal course of PTSD among disaster workers deployed to the World Trade Center following the attacks of September 11th. J Trauma Stress 2011;24(5):506–14.
Farach FJ, Mennin DS, Smith RL, Mandelbaum M. The impact of pretrauma analogue GAD and posttraumatic emotional reactivity following exposure to the September 11 terrorist attacks: a longitudinal study. Behav Ther 2008;39(3):262–76.
Farfel M, DiGrande L, Brackbill R, Prann A, Cone J, Friedman S, et al. An overview of 9/11 experiences and respiratory and mental health conditions among World Trade Center Health Registry enrollees. J Urban Health 2008;85(6):880–909.
Friedman MJ, Keane TM, Resick PA. Handbook of PTSD: science and practice. Guilford Press; 2007.
Fukuda S, Morimoto K, Mure K, Maruyama S. Posttraumatic stress and change in lifestyle among the Hanshin-Awaji earthquake victims. Prev Med 1999;29(3):147–51.
Green BL, Grace MC, Lindy JD, Gleser GC, Leonard A. Risk factors for PTSD and other diagnoses in a general sample of Vietnam veterans. Am J Psychiatry 1990;147(6):729–33.
Hammen C, Brennan PA. Depressed adolescents of depressed and nondepressed mothers: tests of an interpersonal impairment hypothesis. J Consult Clin Psychol 2001;69(2):284.
Hankin BL, Abramson LY. Development of gender differences in depression: an elaborated cognitive vulnerability–transactional stress theory. Psychol Bull 2001;127(6):773.
Harkness KL, Lumley MN, Truss AE. Stress generation in adolescent depression: the moderating role of child abuse and neglect. J Abnorm Child Psychol 2008;36(3):421–32.
Herbert R, Moline J, Skloot G, Metzger K, Baron S, Luft B, et al. The World Trade Center disaster and the health of workers: five-year assessment of a unique medical screening program. Environ Health Perspect 2006;114(12):1853.
Kessler R, McLaughlin K, Koenen K, Petukhova M, Hill E. The importance of secondary trauma exposure for post-disaster mental disorder. Epidemiol Psychiatr Sci 2012;21(01):35–45.
Kline RB. Principles and practice of structural equation modeling. Guilford press; 2011.
Kroenke K, Spitzer RL, Williams JBW. The Phq-9. J Gen Intern Med 2001;16(9):606–13.
Levin S, Herbert R, Skloot G, Szeinuk J, Teirstein A, Fischler D, et al. Health effects of World Trade Center site workers. Am J Ind Med 2002;42(6):545–7.
Lt Hu, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model A Multidiscip J 1999;6(1):1–55.
Luft BJ, Schechter C, Kotov R, Broihier J, Reissman D, Guerrera K, et al. Exposure, probable PTSD and lower respiratory illness among World Trade Center rescue, recovery and clean-up workers. Psychol Med 2012;42(5):1069–79.
Luszczynska A, Benight CC, Cieslak R. Self-efficacy and health-related outcomes of collective trauma: a systematic review. Eur Psychol 2009;14(1):51.
Marsh HW, Hau K-T, Wen Z. In search of golden rules: comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. Struct Equ Model 2004;11(3):320–41.
Niles JK, Webber MP, Gustave J, Zeig-Owens R, Lee R, Glass L, et al. The impact of the world trade center attack on FDNY firefighter retirement, disabilities, and pension benefits. Am J Ind Med 2011;54(9):672–80.
Norris FH, Murrell SA. Social support, life events, and stress as modifiers of adjustment to bereavement by older adults. Psychol Aging 1990;5(3):429.
Norris F, Uhl G. Chronic stress as a mediator of acute stress: the case of hurricane hugo. J Appl Soc Psychol 1993;23(16):1263–84.
Norris F, Friedman M, Watson P. 60,000 disaster victims speak: Part II. Summary and implications of the disaster mental health research. Psychiatry 2002;65(3):240–60.
Norris F, Friedman M, Watson P, Byrne C, Diaz E, Kaniasty K. 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. Psychiatry 2002;65(3):207–39.
Perlman SE, Friedman S, Galea S, Nair HP, Eros-Sarnyai M, Stellman SD, et al. Short-term and medium-term health effects of 9/11. Lancet 2011;378(9794):925–34.

Perrin M, DiGrande L, Wheeler K, Thorpe L, Farfel M, Brackbill R. Differences in PTSD prevalence and associated risk factors among World Trade Center disaster rescue and recovery workers. Am J Psychiatry 2007;164(9):1385–94.
Pfefferbaum B, Noffsinger MA, Sherrieb K, Norris FH. Framework for research on children's reactions to disasters and terrorist events. Prehosp Disaster Med 2012;27(6):567.
Pietrzak RH, Van Ness PH, Fried TR, Galea S, Norris FH. Trajectories of posttraumatic stress symptomatology in older persons affected by a large-magnitude disaster. J Psychiatr Res 2013;47(4):520–6.
Pietrzak RH, Feder A, Singh R, Schechter CB, Bromet EJ, Katz CL, et al. Trajectories of PTSD risk and resilience in World Trade Center responders: an 8-year prospective cohort study. Psychol Med 2014;44(01):205–19.
Prezant D. World Trade Center cough syndrome and its treatment. Lung 2008;186(1):94–102. 2008/02/01.
Radloff L. The CES-D scale a self-report depression scale for research in the general population. Appl Psychol Meas 1977;1(3):385–401.
Robins LN, Smith EM. The diagnostic interview schedule/disaster supplement. St. Louis, MO: Washington: University School of Medicine.; 1983.
Schafer JL, Graham JW. Missing data: our view of the state of the art. Psychol Methods 2002;7(2):147.
Sheehan DV. The anxiety disease. New York: Scribner; 1983.
Sheehan KH, Sheehan DV. Assessing treatment effects in clinical trials with the discan metric of the Sheehan Disability Scale. Int Clin Psychopharmacol 2008;23(2):70–83.
Shih JH, Abela JRZ, Starrs C. Cognitive and interpersonal predictors of stress generation in children of affectively ill parents. J Abnorm Child Psychol 2009;37(2):195–208.
Solomon Z, Mikulincer M, Flum H. The implications of life events and social integration in the course of combat-related post-traumatic stress disorder. Soc Psychiatry Psychiatr Epidemiol 1989;24(1):41–8.
Stellman JM, Smith RP, Katz CL, Sharma V, Charney DS, Herbert R, et al. Enduring mental health morbidity and social function impairment in world trade center rescue, recovery, and cleanup workers: the psychological dimension of an environmental health disaster. National Emergency Training Center; 2008.
Tracy M, Norris F, Galea S. Differences in the determinants of posttraumatic stress disorder and depression after a mass traumatic event. Depress Anxiety 2011;28(8):666–75.
van den Berg B, Wong A, van der Velden PG, Boshuizen HC, Grievink L. Disaster exposure as a risk factor for mental health problems, eighteen months, four and ten years post-disaster–a longitudinal study. BMC Psychiatry 2012;12(1):147.
Watson D. Differentiating the mood and anxiety disorders: a quadripartite model. Annu Rev Clin Psychol 2009;5:221–47.
Webber MP, Glaser MS, Weakley J, Soo J, Ye F, Zeig-Owens R, et al. Physician-diagnosed respiratory conditions and mental health symptoms 7–9 years following the World Trade Center disaster. Am J Ind Med 2011;54(9):661–71.
Wilkins KC, Lang AJ, Norman SB. Synthesis of the psychometric properties of the PTSD checklist (PCL) military, civilian, and specific versions. Depress Anxiety 2011;28(7):596–606.
Wisnivesky JP, Teitelbaum SL, Todd AC, Boffetta P, Crane M, Crowley L, et al. Persistence of multiple illnesses in World Trade Center rescue and recovery workers: a cohort study. Lancet 2011;378(9794):888–97.