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World Trade Center disaster and sensitization to subsequent life stress: A longitudinal study of disaster responders

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ABSTRACT

Purpose. : The current study examined the role of World Trade Center (WTC) disaster exposure (hours spent working on the site, dust cloud exposure, and losing friend/loved one) in exacerbating the effects of post-disaster life stress on posttraumatic stress disorder (PTSD) symptoms and overall functioning among WTC responders.

Method. : Participants were 18,896 responders (8466 police officers and 10,430 non-traditional responders) participating in the WTC Health Program who completed an initial examination between July, 2002 and April, 2010 and were reassessed an average of two years later.

Results. : Among police responders, there was a significant interaction, such that the effect of post-disaster life stress on later PTSD symptoms and overall functioning was stronger among police responders who had greater WTC disaster exposure (β's = .029 and .054, respectively, for PTSD symptoms and overall functioning). This moderating effect was absent in non-traditional responders. Across both groups, post-disaster life stress also consistently was related to the dependent variables in a more robust manner than WTC exposure.

Discussion. : The present findings suggest that WTC exposure may compound post-disaster life stress, thereby resulting in a more chronic course of PTSD symptoms and reduced functioning among police responders.

Introduction

The World Trade Center (WTC) disaster, resulting from the terrorist attacks on September 11, 2001 (9/11), has been associated with numerous negative mental health problems for disaster response, rescue and recovery workers (Aldrich et al., 2010; Levin et al., 2002; Luft et al., 2012; Niles et al., 2011; Pietrzak et al., 2014). For example, responders have been found to have elevated rates of probable posttraumatic stress disorder (PTSD), (Berninger, Webber, Cohen, et al., 2010; Berninger, Webber, Niles, et al., 2010; Farfel et al., 2008; Stellman et al., 2008) depression (Chiu et al., 2011), anxiety disorders (Cukor, Wyka, Jayasinghe, et al., 2011; Cukor, Wyka, Mello, et al., 2011; Farach, Mennin, Smith, & Mandelbaum, 2008), and decreased overall functioning (Farfel et al., 2008). Interestingly, the mental health effects from the 9/11 attack and other disasters often vary by occupational type (e.g., Norris et al., 2002; Perrin et al., 2007; Wisnivesky et al., 2011). Specifically, police have reported fewer mental health problems and stressful life events in the face of more WTC exposure compared to non-traditional responders (e.g., construction workers), which may be attributable to such factors as financial resources (e.g., pensions, health insurance), professional training in disaster response among police officers, as well as occupational and social stigma for reporting psychiatric problems (Luft et al., 2012; Perrin et al., 2007).

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Irrespective of occupational status, empirical evidence suggests that the extent to which one was exposed to the WTC disaster, which includes such factors as spending long hours at the disaster site, being exposed to the dust cloud, or losing friend/loved one in the disaster, is associated with the onset, and to a lesser extent persistence, of mental health symptoms (Brackbill et al., 2009; Chiu et al., 2011; Luft et al., 2012; Perlman et al., 2011; Perrin et al., 2007; Pietrzak et al., 2014). Yet, it remains unclear what post-disaster factors may further compound the effects of WTC exposures in terms of the continuing PTSD symptoms and overall functioning. A wide variety of variables, including coping skills, personality traits, degree of social support, cognitive styles, and sociodemographic factors, have been linked to persistence of post-disaster mental health symptoms in general, as well as from the WTC disaster, more specifically (Berninger, Webber, Cohen, et al., 2010; Berninger, Webber, Niles, et al., 2010; Brewin, Andrews, & Valentine, 2000; Farfel et al., 2008; Norris, Murphy, Baker, & Perilla, 2004; Stellman et al., 2008). For example, stressful life events, such as job loss and relationship problems in the period following a disaster have consistently been found to be related to more severe and chronic course of psychological distress, including PTSD (Brewin et al., 2000; Kessler, Mclaughlin, Koenen, Petukhova, & Hill, 2012; Luszczynska, Benight, & Cieslak, 2009; Pietrzak, Van Ness, Fried, Galea, & Norris, 2013; Appleyard, Egeland, Dulmen, & Alan Sroufe, 2005; Galea et al., 2002; Green, Grace, Lindy, Gleser, & Leonard, 1990).

According to stress sensitization theories of psychopathology, prior exposure to extreme stressors may lead to increased responsiveness to subsequent stressors (Hammen, Henry, & Daley, 2000; Post & Weiss, 1998). This perspective is thought to be driven by sensitization, a non-associative learning process, in which repeated administrations of an aversive stimulus produce progressive amplification of a response (Hammen et al., 2000; Post & Weiss, 1998). Drawing from such theory and empirical work, it is possible that people most exposed to disaster may become particularly vulnerable to effects of post-disaster life events on mental health. That is, post-disaster stressful life events may be more strongly related to posttraumatic stress symptoms and overall functioning among WTC responders most exposed to the disaster. To date, however, this type of interplay between WTC disaster exposure and post-disaster stressful life events has yet to be directly empirically explored among police and non-traditional WTC responders.

To address this gap in the literature, the current study examined the role of WTC disaster exposure (hours spent working on the site, dust cloud exposure, and losing friend/loved one) in exacerbating the effects of post-disaster life stress on mental health. Specifically, we examined changes in posttraumatic stress disorder (PTSD) symptoms and overall functioning among WTC responders over two years. We hypothesized that WTC disaster exposure would moderate the effect of post-disaster life stress, such that WTC responders with more post-disaster stressful life events and higher WTC exposure would experience greater decrements in mental health over time compared to WTC responders with many post-disaster stressful life events but lower WTC exposure. Moreover, consistent with stress sensitization theories (Hammen et al., 2000), we expected that this moderating effect would be evident most strongly for police responders because they had greater initial WTC disaster exposure (Zvolensky et al., 2015) and this prior exposure should theoretically be associated with increased responsiveness to subsequent stress.

Method

Participants

Participants ($n = 18{,}896$, 85.8% male; 86.4% Caucasian; M age = 39.5, $SD = 8.8$) were law enforcement (mostly police; $n = 8{,}466$; 44.8%) and non-professional (construction, maintenance, and transportation workers, electricians, clergy, etc.; $n = 10{,}430$; 55.2%) WTC disaster responders. Data were obtained from the WTC Health Program (WTC-HP), a consortium of five Centers for Disease Control (CDC) NIOSH-funded clinical programs in New York and New Jersey that provide annual monitoring and treatment service to WTC responders (Herbert et al., 2006; Luft et al., 2012). 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). Written informed consent is obtained. The study receives annual approval by the Institutional Review Boards at all participating sites. Although participation in research is optional as part of 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, and therefore, participants retrospectively reported on their experiences in relation to 9/11. 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 is the focus of the current study. The participants without V2 data were similar to the analysis cohort on posttraumatic stress, functioning, demographics, and WTC exposures. The only difference between the cohorts was that the excluded group enrolled about a year later; consequently, V2 was not completed.

Assessments

WTC exposure was assessed at the initial visit via clinical interview, including (a) hours spent working at the disaster site, (b) whether one worked in the dust cloud on 9/11, and (c) whether one lost a co-worker, friend, or a relative in the disaster. These three exposures were specifically examined as they previously were found to have the most reliable links to health problems in responders (Webber et al., 2011; Wheeler et al., 2007). A dichotomous variable was coded based on WTC hours worked into high exposure ($\geq$75th percentile = 1) and low exposure (<75th percentile = 0) as in previous papers (Luft et al., 2012). Similarly, a dichotomous variable was used to indicate whether a responder worked in the dust cloud on 9/11 and whether a responder lost friends/loved ones from the disaster — (coded 1 = yes or coded 0 = no). The three WTC exposure variables were summed to form a composite 'exposure' variable, wherein higher scores (possible range 0–3) indicate greater WTC disaster exposure.

A checklist of 12 stressful life events from the Disaster Supplement of the Diagnostic Interview Schedule (Robins & Smith, 1983) was used to assess life stress at V2. Illustrative examples of such stressful life events include job loss, layoff, or substantial loss of income, serious illness, and changing residences. 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 score (range: 0–12).

The Posttraumatic Stress Disorder (PTSD) Checklist (PCL) is a 17-item self-report measure used to assess WTC-related posttraumatic stress symptom severity, per the diagnostic criteria defined by the *Diagnostic and Statistical Manual of Mental Disorders — Fourth Edition* (*DSM-IV*) (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). Symptoms are assessed in the past month "*in relation to 9/11*", and severity is rated on a scale from 1 (*not at all*) to 5 (*extremely*); possible scores range from 17–85. The PCL has good convergent validity and internal consistency in previous work (Wilkins, Lang, & Norman, 2011); in the present sample, the internal consistency of the total score was excellent (α = 0.95).

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

Data analysis

Comparisons of police and non-traditional responders were performed using chi-square tests. Police and non-traditional responders differ in pre-disaster training and on study variables (Kotov et al., 2015; Luft et al., 2012; Pietrzak et al., 2014); therefore, analyses were stratified by occupational group (police versus non-traditional responders). Four hierarchical multiple

regression analyses were conducted (for WTC-related posttraumatic stress symptom severity [PCL] and for overall functioning [SDS] by occupation status). In step 1, covariates included age, gender (male/female), race (Hispanic/non-Hispanic, black/non-black), the number of years from 9/11/2001 to V1, and the number of years from V1 and V2. The criterion variable at V1 was also included as a covariate to model the contributions of stress to the subsequent change in mental health and control for differences present before the stressor. In step 2, main effects were entered. In step 3, the interaction term of WTC exposures × post-disaster stressful life events was entered as a continuous variable. WTC exposures and the post-disaster stressful life event composite were centered prior to calculation of the interaction term.

Results

Regression analyses

Table 1 gives a descriptive overview of police and non-traditional responders by post-disaster life stress (predictor) and WTC disaster exposure (moderator). Characteristics of other variables have been reported elsewhere (Zvolensky et al., 2015). Tables 2 and 3 present results of hierarchical regression analyses by police and non-traditional responders for each of the two dependent variables. All models accounted for significant variance in the respective outcome variable (all p's < .001).

PTSD symptom severity

Total adjusted model R^2 for police responders (56.3%) and non-traditional responders (55.7%) indicate that a significant amount of variance in PTSD symptom severity was accounted for by the models (p's < .0001). Specifically, results indicated that greater WTC disaster exposure was related to more severe PTSD symptoms at V2 for police ($\beta = .048$, $p < .001$), but not for non-traditional responders ($\beta = .013$, $p = .077$). There was a significant association of post-disaster stressful life events with PTSD symptom severity at V2 for police ($\beta = .217$, $p < .001$) and non-traditional responders ($\beta = .247$, $p < .001$). The interaction between WTC disaster exposure and post-disaster life stressors was significant for police ($\beta = .029$, $p = .001$), but not for non-traditional responders ($\beta = -.006$, $p = .384$). The form of the interaction is displayed in Fig. 1. Specifically, it suggests that for police responders, number of post-disaster life events predicted PTSD symptom severity at V2 in responders with low WTC exposure, and this predictive effect was even stronger in responders with high WTC exposure.

Overall functioning

Total adjusted model R^2 for police responders (34.0%) and non-traditional responders (33.4%) indicated that significant variance in overall functioning was accounted for by the models (p's < .0001). There was a significant association between WTC disaster exposure and overall functioning at V2 for police responders ($\beta = .041$, $p < .0001$) and non-traditional responders ($\beta = .026$, $p = .006$). There was also a significant association between post-disaster life stress and overall functioning at V2 for police ($\beta = .259$, $p < .0001$) and non-traditional responders ($\beta = .267$, $p < .001$). For police only, there was a significant interaction between WTC disaster exposure and post-disaster life stress ($\beta = .054$, $p < .001$) on overall functioning at V2. The plot of the interaction (Fig. 1) indicated that for police responders, number of post-disaster life events predicted overall functioning at V2 in responders with low WTC exposure, and this predictive effect was even stronger in responders with high WTC exposure.

Table 1
Descriptive characteristics of WTC disaster exposure and life stress by occupation status.

WTC disaster exposure	Police N (%)	Non-traditional N (%)
0	1820 (21.5%)	4331 (41.5%)
1	3929 (46.4%)	4361 (41.8%)
2	2181 (25.8%)	1530 (14.7%)
3	536 (6.3%)	208 (2.0%)
	Mean (SD)	Mean (SD)
Number of stressful life events	1.0 (1.4)	1.8 (1.9)

Table 2
Predictors of visit 2 WTC-related PTSD symptom severity: WTC disaster exposure and post-disaster stressful life events.

DV: V2 PTSD symptoms[1]	Police responders	Non-traditional responders
	β	β
Step 1		
Age at 9/11/2001	.024**	.025**
Female (vs male)	.022	.012
Hispanic (vs non-Hispanic)	.019*	.068***
Black (vs other)	.010	−.019*
Time to V1[2]	−.083***	−.051***
Time V1–V2[3]	.064***	.047***
V1 PTSD symptoms	.715***	.694***
Step 2		
WTC disaster exposure[4]	.048***	.013
Stressful life events V1–V2[5]	.217***	.247***
Step 3	.563	.557
WTC exposure × life events	.029**	−.006

* $p < .05$.
** $p < .01$.
*** $p < .001$.
[1] Posttraumatic stress disorder check list (Blanchard et al., 1996; Weathers et al., 1993).
[2] Number of years from 9/11/2001 to V1.
[3] Number of years between V1 and V2.
[4] WTC disaster exposure coded as 0–3 (sum of events experienced).
[5] Number of stressful life events between V1 and V2.

Discussion

Police responders who had greater initial WTC disaster exposure experienced more severe WTC-related PTSD symptoms and decreased overall functioning over time, especially when exposed to post-disaster life stressors. There was no moderational effect for non-traditional WTC responders. These data suggest that the association of post-disaster life stress with PTSD and overall functioning may vary by occupation type (segments of the WTC responder population).

Table 3
Predictors of visit 2 overall functioning: WTC disaster exposure and post-disaster stressful life events.

DV: V2 overall functioning[1]	Police responders	Non-traditional responders
	β	β
Step 1		
Age at 9/11/2001	.053***	.015
Female (vs male)	.036**	.044***
Hispanic (vs non-Hispanic)	.054***	.081***
Black (vs other)	.001	−.034**
Time to V1[2]	−.040**	−.001
Time V1–V2[3]	−.020	−.015
V1 overall functioning	.480***	.497***
Step 2		
WTC disaster exposure[4]	.041***	.026*
Stressful life events V1–V2[5]	.259***	.267***
Step 3		
WTC exposure × life events	.054***	−.005

* $p < .05$.
** $p < .01$.
*** $p < .001$.
[1] Sheehan Disability Scale (Sheehan, 1983).
[2] Number of years from 9/11/2001 to V1.
[3] Number of years between V1 and V2.
[4] WTC disaster exposure coded as 0–3 (sum of events experienced).
[5] Number of stressful life events between V1 and V2.

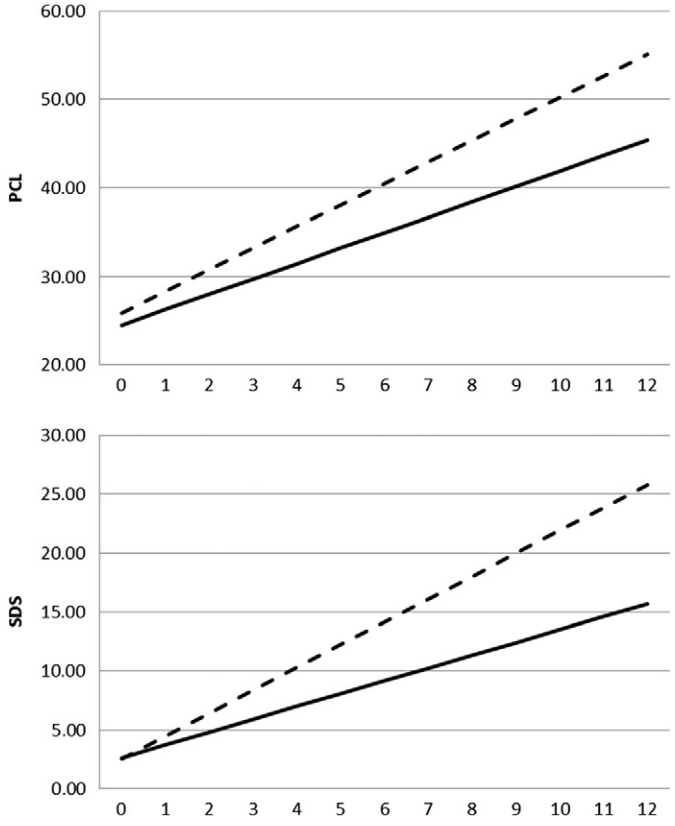

Fig. 1. Number of post-disaster life stressors stratified by WTC disaster exposure predict symptoms and functioning at V2. Solid line is police responders with low WTC exposure (exposure score = 0). Dashed line is police responders with high WTC exposure (exposure score = 3). X-axis is the number of stressful life events between V1 and V2. Y-axis is V2 WTC-related PTSD symptoms (PTSD Checklist [PCL] score) in the top panel and V2 overall functioning (Sheehan Disability Scale [SDS] score) in the bottom panel.

Consistent with stress sensitization theories of psychopathology (Post & Weiss, 1998), it is possible that post-disaster life stressors may be related to PTSD and functioning levels among police responders as a consequence of their greater initial exposure to the WTC disaster. The observed conditional effect in terms of the designated mental health outcomes, although modest in overall effect size, was evident above and beyond the variance accounted for by numerous other variables, thereby suggesting a high degree of clinical and theoretical significance.

In line with prior work (Galea et al., 2002), there was a consistent association between post-disaster life stress and PTSD and overall functioning for police and non-traditional responders. These data add to the empirical literature that make clear the importance of considering post-disaster life stress for WTC responders in efforts to understand and manage mental health outcomes among this and other disaster response populations (e.g., Farfel et al., 2008). There also was a consistent relation, albeit less robust than that observed for post-disaster life stress when comparing the size of the betas, for WTC exposure in police across the mental health outcome measures; a finding, again, in accord with past studies (e.g., APA, 2013; Blanchard et al.,1996) . Among non-traditional WTC responders, significant association with WTC exposure was evident only for overall functioning. In all cases, the effect size of WTC disaster exposure was modest, as in past work (e.g., APA, 2013), perhaps owing to the fact that the measures of WTC disaster exposure were collected on average four years post-disaster.

There are a number of interpretive caveats to the present study and directions for future research. First, causal inferences cannot be drawn from these longitudinal, observational data. Second, the study employed self-report measures and therefore method variance or reporting biases may have played a role in the observed effects. Third, recall bias may have been involved in the reporting of WTC disaster exposures as well as post-disaster stressful life events, although we tried to minimize the impact of reporting biases for at least WTC disaster exposure by focusing on exposure to discrete major events. Fourth, the post-disaster life stress checklist employed did not measure all possible types of stress, prompting future work to explore whether other types of stress (e.g., daily hassles, social strain, job-specific stressors beyond job loss) play a similar role in the maintenance of mental health problems. Fifth, future research could replicate and extend the model with the most recently defined clusters of PTSD symptoms (APA, 2013). Sixth, WTC-related posttraumatic stress symptoms and functioning were substantially inter-correlated (e.g., $r = .70$ at V2); perhaps, reflecting a 'common core' of general distress present in emotional disorders (Watson, 2009). Seventh, time to V1 had a significant effect on PTSD symptoms for both groups and overall functioning for police. Future work may benefit from exploring on an a priori basis the relevance of time to V1 in the context of mental health among responders and how it interplays with other factors such as post-disaster life stress. Finally, the present findings may not be generalizable to other disaster-exposed populations.

Overall, the present findings suggest that WTC exposure may compound post-disaster life stress, thereby resulting in a more chronic course of PTSD symptoms and reduced functioning for police responders. Therefore, there may be clinical benefit to assess post-disaster stressful life events and employ stress management interventions among police, especially those who report extensive exposure to WTC disaster, to better manage mental health adjustment.

Disclosures and Conflicts of Interest

This work has not been presented previously in any form. No authors have any conflicts of interests or financial disclosures to report.

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