A Twin Registry Study of Familial and Individual Risk Factors for Trauma Exposure and Posttraumatic Stress Disorder

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This study examines the association of individual and familial risk factors with exposure to trauma and posttraumatic stress disorder (PTSD) in male twins (N = 6744) from the Vietnam Era Twin Registry. Independent reports of familial psychopathology from co-twins were used to avoid the potential biases of the family history method. Risk for exposure to traumatic events was increased by service in Southeast Asia, preexisting conduct disorder, preexisting substance dependence, and a family history of mood disorders whose effects appear to be partly genetic. Preexisting mood disorders in the individual were associated with decreased odds of traumatic exposure. Risk of developing PTSD following exposure was increased by an earlier age at first trauma, exposure to multiple traumas, paternal depression, less than high school education at entry into the military service in Southeast Asia, and preexisting conduct disorder, panic disorder or generalized anxiety disorder, and major depression. Results suggest the association of familial psychopathology and PTSD may be mediated by increased risk of traumatic exposure and by preexisting psychopathology.

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Post-traumatic stress disorder (PTSD) occurs after exposure to a traumatic event and is defined by three symptom clusters: reexperiencing, avoidance and numbing, and arousal. With lifetime prevalence rates of approximately 7.8% in the general population, PTSD has been identified as a notable mental health problem by a number of epidemiological studies during the past decade (Kessler et al., 1995). As the prevalence and public health significance of PTSD has become clearer, interest has grown in understanding the disorder's cause. Toward this

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aim, several epidemiological studies focusing on risk factors of PTSD have been conducted (*e.g.*, Breslau et al., 1991; Bromet et al., 1998; Davidson et al., 1991; Helzer et al., 1987; Kulka et al., 1990; Norris, 1992; Resnick et al., 1993).

Lifetime prevalence rates of PTSD among men range from 5% in the general population (Kessler et al., 1995) to 30% in veterans who served in Southeast Asia (SEA) during the Vietnam War era (Kulka et al., 1990). The difference in rates may be attributed to a difference in the rates of exposure to life threatening events, particularly combat exposure. Events characterized by threat to life are much more likely to be associated with the development of PTSD than are non-life threatening events (*e.g.*, Dohrenwend, 1998). This highlights a way that PTSD is diagnostically unique among psychiatric disorders, in that exposure to a traumatic event is a prerequisite for the diagnosis. Thus, the risk of PTSD can be decomposed into the risk of exposure to a qualifying traumatic event and then, given exposure, the risk of developing PTSD. The identification of factors that contribute to risk at each point has public health implications for the prevention of PTSD.

Previous studies have indicated that different risk factors influence the likelihood of being exposed to a traumatic stressor and the risk of PTSD after exposure (Bromet et al., 1998). Preexisting mental disorders, specifically major depression and drug use, have been identified as risk factors for exposure (Breslau et al., 1991; Breslau and Davis, 1995; Breslau et al., 1998; Burnam et al., 1988; Kendler, 1998). The National Comorbidity Survey found that a preexposure history of anxiety disorder, parental substance abuse, and parental divorce predicted exposure to trauma in men (Bromet et al., 1998). However, once the type of trauma was controlled, only preexposure anxiety disorder and parental mental disorder increased the risk of developing PTSD (Bromet et al., 1998).

Studies have consistently reported that preexisting individual and familial psychopathology increases the risk of traumatic exposure and the risk of developing PTSD once exposed (for a review, see Brewin et al., 2000). Results from the National Vietnam Veterans Readjustment Study suggest that psychiatric morbidity before traumatic exposure increases vulnerability for developing PTSD when exposed to combat (Kulka et al., 1990). A history of familial psychopathology has also been associated with increased risk of developing PTSD among men in young adult (Breslau et al., 1991) and general population (Bromet et al., 1998) samples. Furthermore, family members of Vietnam veterans with PTSD are more likely to meet diagnostic criteria for

alcohol or drug abuse/dependence, anxiety disorders, or unspecified psychosis than are family members of depressed veterans (Davidson et al., 1985, Davidson et al., 1989). Research on members of the Vietnam Era Twin (VET) Registry has shown that at least part of the association between familial psychopathology and PTSD may be genetically mediated (True et al., 1993, Xian et al., 2000).

The mechanism by which family psychiatric history increases the risk of PTSD is not yet clear. Individuals with a family history of psychopathology may be more likely to have a preexisting psychiatric disorder that increases their risk of developing PTSD when exposed to trauma. Familial psychopathology may also increase the risk of PTSD by putting an individual at a greater risk of more severe traumatic exposure. Furthermore, the findings of previous risk factor studies (*e.g.*, Breslau et al., 1991; Breslau and Davis, 1992; Bromet et al., 1998; Kulka et al., 1990) are limited by their use of the family history method. Using PTSD-diagnosed individuals as primary informants regarding familial psychopathology is problematic because these reports may reflect potential biases. Research suggests that informant's reports of relative's psychopathology are influenced by their own psychiatric disorders (*e.g.*, Kendler et al., 1991). This may be especially problematic because previous risk factor studies have found that a family history of anxiety disorders and/or mood disorders increase the risk of PTSD; however, these disorders are also the most highly comorbid with PTSD. Authors of previous studies using the family history method have indicated that these studies may underestimate the contribution of familial psychopathology to traumatic exposure and PTSD (Breslau et al., 1991; Bromet et al., 1998).

The present study uses data from twins to examine individual and familial risk factors for traumatic exposure and the subsequent development of PTSD. Independent reports of psychopathology from co-twins are used to examine the role of familial psychopathology in the etiology of the disorder. Additionally, the unadjusted and adjusted associations between familial psychopathology and outcomes are presented. This allows for an investigation of whether familial psychopathology increases risk for PTSD after adjusting for trauma characteristics and preexisting psychopathology.

Methods

Design and Procedure

Participants were selected from the VET Registry. The VET Registry is a nationally distributed cohort

consisting of 7375 male-male twin pairs born between 1939 and 1957 in which both siblings served on active military duty during the Vietnam War era (Eisen et al., 1987). Zygosity was determined by using a questionnaire and blood-group typing methodology that achieved 95% accuracy (Eisen et al., 1989). Registry members are representative of all twins who served in the military during the Vietnam War on a variety of sociodemographic and other variables (Goldberg et al., 1987). A complete description of VET Registry construction has been published elsewhere (Eisen et al., 1987, Henderson et al., 1990).

The Harvard Twin Study of Drug Abuse and Dependence was undertaken in 1992 to determine the influence of genetic and environmental factors on substance abuse and dependence. There were 10,300 individuals determined to be eligible for the study, and an interview was attempted. Information about drug and alcohol use and lifetime prevalence of psychiatric disorders was successfully collected from 8169 individuals (response rate = 79.6%) via telephone interview.

Participants

The mean age of respondents at the time of the Harvard Twin Study of Drug Abuse and Dependence was 44.6 years (SD ± 2.8, range = 36 to 55 years); 90.4% were non-Hispanic white, 4.9% were African-American, 2.7% were Hispanic, 1.3% were Native American and .7% were categorized as other. Approximately one third reported high school as their highest degree attained and 38.6% were college graduates; 92.6% were employed full-time and 1.8% were employed part-time. Seventy-five percent had been married at the time of the study and 11% were never married. Registry members lived in all 50 of the United States.

Twin pairs who responded to the Harvard Twin Study of Drug Abuse and Dependence were included in the present study if complete data on the demographic, family psychopathology, and diagnostic factors under study were available from both twins in a pair (N = 6744).

Measures

Military history data were abstracted from military records. Diagnostic, co-twin, and parental psychopathology and demographic data were obtained by using the Mental Health Diagnostic Interview Schedule Version III - revised (DIS-III-R; Robins et al., 1988). The DIS-III-R is a structured psychiatric interview for epidemiological research that has been used in many studies of PTSD (Breslau et al., 1991;

TABLE 1
Prevalence (%) of Exposure to Traumatic Events by SEA Service History

Traumatic Event	SEA Service (N = 2411)	No SEA Service (N = 3590)	Odds Ratio (95% CI)[a]
Combat	34.67	0.00	—[b]*
Rape	0.08	0.11	0.74 (0.14–4.07)
Physical assault	3.61	4.43	0.81 (0.62–1.06)
Seeing a friend hurt or killed	11.90	11.75	1.01 (0.62–1.19)
Natural disaster	1.70	1.84	0.91 (0.62–1.34)
Threat	1.41	1.78	0.79 (0.52–1.20)
Narrow escape	1.24	1.39	0.89 (0.56–1.41)
Sudden injury or accident	7.26	8.86	0.80 (0.66–0.97)
News of sudden death/accident	7.13	7.21	0.99 (0.81–1.21)
Other personal shock	1.82	8.38	0.12 (0.07–0.18)*
More than one event	17.30	11.23	1.65 (1.42–1.91)*

[a] Odds Ratios compare prevalence of exposure to specific events with SEA service history. CI, confidence interval.

[b] Chi-square = 1446.29, p < .0001 comparing combat exposure with SEA service history.

* Odds ratios with 95% CIs that do not include 1.00 are statistically significant.

Helzer et al., 1987). The structured questions from the DIS-III-R lead to clinical diagnoses according to *Diagnostic and Statistical Manual Third Edition Revised* (DSM-III-R; American Psychiatric Association, 1987). Diagnostic reliability was assessed by re-interviewing a subset of 146 participants using a different interviewer. The mean interval between interviews was 466 days (± 50.5). Retest reliability was calculated using the Kappa statistic. Using the Fleiss (1981) criteria, the retest reliabilities were in the fair to good range: alcohol dependence, .61; drug dependence, .63; major depression, .54; PTSD, .27; generalized anxiety disorder (GAD), .23; and panic, .32. The Kappa was not available for dysthymia.

Trauma Exposure and PTSD. The DIS-III-R inquires about the occurrence of a number of traumatic events. If a respondent endorses one of these events or another qualifying experience, the interviewer gathers information about age at exposure, age at onset of symptoms, symptom type, and duration. This information is collected on up to three traumatic events. From these data, the categorical variables "trauma exposure" and "PTSD after trauma exposure" were created to serve as dependent variables in this study. In the VET Registry, only a minority of individuals reported more than one trauma (Table 1), and of those, PTSD was almost always associated with the earliest trauma.

Preexisting Psychopathology. A series of categorical variables was then constructed to reflect the presence of preexisting psychopathology that pre-

dated the earliest reported trauma and may have served as a risk factor of exposure and/or subsequent development of PTSD. The variables were created from DIS-III-R diagnostic data on mood disorders, panic disorder and GAD, substance dependence (alcohol or drug), and conduct disorder.

Familial Psychopathology. Co-twin variables reflecting the presence or absence of lifetime DIS-III-R diagnoses were created for PTSD, panic disorder or GAD, mood disorders, conduct disorder and substance dependence. Interaction terms, calculated by multiplying the diagnosis in the co-twin by zygosity to test for whether the association between co-twin psychopathology and outcomes, differed between monozygotic and dizygotic twins. Significant interaction terms suggest the association between familial psychopathology and outcome are genetically influenced.

The categorical variables "maternal depression" and "paternal depression" were created based on the co-twin's response to a single item of whether his mother or father ever had problems with depression. The variables for maternal and paternal antisocial behavior were similarly created based on the co-twin's report of whether either parent had problems with drugs, alcohol, or the law. An affirmative answer in any of these problem areas was coded 1 for the parent, whereas the report of no problems in these areas was coded 0. Co-twin report of parental problems was used to construct the parental psychopathology variables to reduce the potential impact of index twin psychopathology on variables representing the functioning of his parents.

Combat Exposure. Combat exposure was measured by using the *Combat Exposure Index* (Janes et al., 1991), which asks each veteran whether he engaged in 18 specific combat activities, such as flying in an attack helicopter, being wounded, and receiving incoming fire. For each item, the veteran indicated whether he had that role or experience. A global index of combat exposure was constructed by summing over all positive responses from an individual. The combat index showed good internal consistency (coefficient a = .86) and test-retest reliability (κ = .84) (Janes et al., 1991). The validity of the index is supported by a strong association between the combat exposure index and being awarded a military combat medal (Janes et al., 1991).

Statistical Analyses

For all analyses, odds ratios (OR) and 95% confidence intervals (CI) were calculated from generalized estimating equations using the XTGEE command in STATA (Stata Corporation, College Station,

TX) to account for the clustered nature of the data. The first set of analyses focused on risk factors for traumatic exposure. The lifetime prevalence of specific types of traumatic exposure for participants who did and did not serve in SEA was compared. Next, ORs and 95% CIs were calculated individually for the association between each putative risk factor and traumatic exposure. Adjusted ORs and 95% CIs were then calculated for each risk factor in the presence of all other risk factors. The second set of analyses focused on risk factors affecting the development of PTSD after trauma exposure. Only veterans who had experienced a traumatic event were included in these analyses. Statistical methods paralleled those for trauma exposure, consisting of univariate analysis followed by simultaneous multivariate generalized estimating equations analyses. SEA service was included as a risk factor in both the traumatic exposure and the PTSD analyses. Analyses were repeated for SEA participants only, controlling for level of combat exposure. All analyses were performed on monozygotic and dizygotic twins separately. Because a similar pattern of results was found, only combined results are presented here. Finally, the continuation ratio was calculated to test the change in effect for each risk factor across the three stages of developing PTSD (*i.e.*, no trauma exposure, trauma exposure no PTSD, PTSD). The continuation ratio was calculated by the procedures presented by MacLean (1988). Significance of the continuation ratio is calculated by using the Student *t* test. In interpreting the continuation ratio, it is important to remember that it represents change in effect from one stage of disease to another and not total effect on risk of disease. Therefore, a given risk factor can have a significant association with the outcome but not a significant continuation ratio and vice versa. The adjusted continuation ratios for PTSD risk factors are calculated from models that include age of first trauma and multiple trauma exposure. Continuation ratios are not presented for these risk factors since they are completely confounded with exposure to trauma and, therefore, cannot be compared across stages.

Results

Types of Exposure

A total of 2411 (35.8%) participants served in SEA, whereas the other 3590 (64.2%) did not. Table 1 compares lifetime prevalence of exposure to different types of traumatic events for participants who did and did not serve in SEA. Results indicate that SEA veterans were more likely to report exposure to combat and being exposed to more than one trau-

TABLE 2
Univariate Odds for SEA Service

Risk Factor	Univariate Odds Ratios (95% CI)[a]
Minority	0.83 (0.66, 1.05)
Father did not graduate high school	1.1 (0.98, 1.23)
Mother did not graduate high school	1.09 (0.96, 1.23)
Age at first trauma (for 1-year difference)	0.95 (0.94, 0.96)*
Paternal depression	1.13 (0.99, 1.29)
Paternal antisocial behavior	1.22 (1.08, 1.38)*
Maternal depression	1.1 (0.97, 1.25)
Maternal antisocial behavior	1.29 (1.05, 1.60)*
Less than high school–level education at entry into the military	1.16 (0.98, 1.37)
Age of entry into the military (for 1-year difference)	0.94 (0.90, 0.97)*
Conduct disorder	1.04 (1.00, 1.09)

[a] Confidence intervals.
* Odds ratios with 95% CIs that do not include 1.00 are statistically significant.

matic event than non-SEA veterans. Era veterans were more likely to report exposure to other personal shock than did SEA veterans.

SEA Service

The association between premilitary risk factors and SEA service were examined to determine whether some risk factors increased risk of traumatic exposure or PTSD through their association with SEA service. Table 2 presents these results. A younger age at first traumatic exposure, paternal antisocial behavior, maternal antisocial behavior, and a younger age of entry into the military were associated with SEA service.

Risk Factors of Trauma Exposure

A total of 2708 participants, comprising 45.42% of the sample, reported exposure to one or more traumatic events. Table 3 presents the prevalence of exposure associated with each risk factor. Univariate analyses indicate that paternal depression, paternal antisocial behavior, maternal depression, maternal antisocial behavior, less than high school–level education, age of entry into the military, SEA service, co-twin psychopathology, a preexisting conduct disorder, history of major depression, and substance dependence are significant predictors of traumatic exposure. In adjusted analyses only paternal and maternal depression, SEA service, the interaction of co-twin mood disorder with zygosity, preexisting conduct disorder, and substance dependence increased the risk of traumatic exposure. Preexisting major depression was associated with a decreased risk of traumatic exposure.

Risk Factors of PTSD after Exposure

To investigate influences on the development of PTSD after trauma exposure, the risk factor variables were reexamined among the subset of participants who reported exposure to one or more traumatic events. Of these 2708 participants, 568 (20.8%) received lifetime diagnoses of PTSD. Table 4 presents the prevalence of PTSD associated with each risk factor. Univariate analyses indicate that an earlier age at first exposure, multiple trauma exposure, maternal antisocial behavior, less than a high school–level education at entry into the military, younger age of entry into the military, SEA service, co-twin conduct disorder, mood disorder and major depression, the interaction term for these co-twin disorders with zygosity, and a preexisting conduct disorder, panic disorder or GAD, and mood disorder are significant predictors of PTSD after traumatic exposure. In adjusted analyses, only earlier age at first exposure, multiple trauma exposure, paternal depression, less than a high school–level education at entry into the military, and preexisting conduct disorder, panic disorder or GAD, and mood disorder are significant predictors of PTSD.

Adjusted analyses were repeated for SEA veterans only, controlling for combat exposure. Table 5 lists these results. The significant risk factors in the adjusted analyses are identical to those for the whole sample.

Change in Risk Factor Effect

Table 6 presents adjusted continuation ratios calculated to examine the significance of changes in risk factor effect for exposure to trauma and for developing PTSD once exposed. Paternal depression, maternal depression, SEA service, preexisting conduct disorder, and preexisting substance dependence showed a significant increase in effect for trauma exposure, whereas preexisting major depression showed a significant decrease in effect. Paternal depression, less than a high school–level education at entry into the military, SEA service, preexisting panic disorder or GAD, and preexisting mood disorder showed a significant increase in effect for PTSD.

Discussion

The major goal of this study was to identify individual and familial risk factors that increased vulnerability for trauma exposure and subsequent development of PTSD in members of the VET Registry. Our study provides further evidence that exposure

TABLE 3
Risk Factors and Adjusted Odds for Trauma Exposure (N = 6744)

Risk Factor	% Exposed		Univariate Odds Ratios (95% CI[a])	Adjusted Odds Ratios (95% CI)
	People with Risk Factor	People without Risk Factor		
Demographic				
Monozygotic	54.51	55.29	0.97 (0.87, 1.08)	0.97 (0.87, 1.08)
Minority	5.72	6.55	0.86 (0.69, 1.08)	1.05 (0.83, 1.32)
Father did not graduate high school	38.59	40.60	0.93 (0.83, 1.03)	0.93 (0.83, 1.05)
Mother did not graduate high school	26.11	28.37	0.90 (0.80, 1.01)	0.87 (0.76, 1.00)
Family				
Paternal depression	21.64	17.15	1.27 (1.11, 1.44)*	1.34 (1.16, 1.54)*
Paternal antisocial behavior	27.18	23.29	1.19 (1.06, 1.34)*	0.99 (0.87, 1.13)
Maternal depression	23.23	17.89	1.27 (1.15, 1.50)*	1.43 (1.24, 1.64)*
Maternal antisocial behavior	7.46	5.65	1.32 (1.07, 1.63)*	0.99 (0.80, 1.25)
Military service				
Less than high school–level education at entry into the military	13.59	10.11	1.40 (1.19, 1.64)*	1.09 (0.91, 1.29)
Age of entry into the military (for 1-year difference)			0.92 (0.88, 0.95)*	0.97 (0.93, 1.00)
Served in SEA	49.96	31.87	2.12 (1.91, 2.36)*	2.16 (1.94, 2.41)*
Co-twin psychopathology				
Conduct disorder	47.87	40.30	1.11 (1.05, 1.16)*	1.02 (0.95, 1.11)
Panic disorder or GAD	4.14	2.74	1.34 (1.01, 1.78)*	0.85 (0.53, 1.35)
Mood disorder	11.34	7.81	1.35 (1.14, 1.61)*	0.90 (0.68, 1.19)
Substance dependence	41.77	33.68	1.33 (0.19, 1.47)*	1.10 (0.93, 1.31)
Co-twin psychopathology by zygosity				
Conduct disorder			1.09 (1.02, 1.15)*	0.96 (0.87, 1.06)
Panic disorder or GAD			1.79 (1.21, 2.65)*	1.63 (0.85, 3.13)
Mood disorder			1.81 (1.43, 2.30)*	1.65 (1.11, 2.46)*
Substance dependence			1.28 (1.13, 1.46)*	0.99 (0.79, 1.26)
Preexposure psychopathology				
Conduct disorder	52.51	37.46	1.37 (1.31, 1.45)*	1.30 (1.23, 1.37)*
Panic disorder or GAD	1.14	1.20	0.93 (0.57, 1.51)	0.80 (0.45, 1.41)
Mood disorder	2.44	4.92	0.47 (0.35, 0.63)*	0.3 (0.25, 0.46)*
Substance dependence	38.63	29.81	1.46 (1.31, 1.62)*	1.30 (1.15, 1.47)*

[a] Confidence intervals.
* Odds ratios with 95% CIs that do not include 1.00 are statistically significant.

to traumatic events is not random, but is influenced by a number of individual and familial risk factors. Some of these factors increase vulnerability for exposure to traumatic events, whereas others increase risk of developing PTSD after exposure. Moreover, the association between familial psychopathology and PTSD appears to be mediated, at least in part, by exposure to trauma and the presence of preexisting psychopathology in the exposed individual.

A younger age at entry into the military and parental antisocial behavior predicted service in SEA that was then associated with increased risk of being exposed to trauma and of developing PTSD. Trauma exposure was also positively associated with parental depression, preexisting conduct disorder, and preexisting substance dependence, and was negatively associated with preexisting major depression. Co-twin psychopathology, in general, was significantly associated with trauma exposure in the univariate analyses, but only the interaction term for co-twin mood disorder with zygosity was associated

in analyses adjusted for SEA service and preexisting psychopathology. These findings suggest that, whereas familial mood disorders may impart a genetically mediated risk for exposure to trauma, much of the vulnerability imparted by familial psychopathology functions through increasing exposure opportunity (*e.g.*, SEA service) and through preexisting psychopathology.

Familial depression was found to significantly increase the risk of trauma exposure in this sample. This result is consistent with recent research that supports the notion that individuals may put themselves in environments where the risk of stressful life events is high (Kendler et al., 1999). The genetic risk factor for exposure to stressful events correlates positively with the genetic risk factor for major depression (Kendler and Karkowski-Shuman, 1997), suggesting that a shared, genetically influenced factor—a personality trait or set of traits, for example—increases liability for both trauma exposure and depression (Kendler et al., 1999). A growing

TABLE 4
Risk Factors and Adjusted Odds for PTSD after Trauma Exposure (N = 2708)

Risk Factor	% with PTSD		Univariate Odds Ratios (95% CI)	Adjusted Odds Ratios (95% CI)
	People with Risk Factor	People without Risk Factor		
Demographic				
Monozygotic	52.58	55.01	0.91 (0.75, 1.10)	0.83 (0.62, 1.12)
Minority	5.15	5.87	0.87 (0.57, 1.34)	0.92 (0.52, 1.46)
Father did not graduate high school	36.41	39.16	0.89 (0.74, 1.09)	0.81 (0.65, 1.01)
Mother did not graduate high school	27.18	25.83	1.09 (0.88, 1.34)	1.13 (0.88, 1.46)
Age at first trauma (for 1-year difference)			0.96 (0.95, 0.98)*	0.98 (0.97, 0.99)*
Multiple trauma exposure	44.58	26.25	2.25 (1.86, 2.72)*	1.87 (1.55, 2.36)*
Family				
Paternal depression	22.56	21.40	1.02 (0.81, 12.8)	1.44 (1.14, 1.81)*
Paternal antisocial behavior	30.37	26.34	1.19 (0.97, 1.47)	0.91 (0.72, 1.15)
Maternal depression	26.82	22.28	1.25 (1.00, 1.55)	1.13 (0.89, 1.44)
Maternal antisocial behavior	11.01	6.53	1.75 (1.27, 2.44)*	1.27 (0.87, 1.85)
Military service				
Less than high school–level education at entry into the military	20.96	11.66	1.97 (1.55, 2.53)*	1.55 (1.19, 2.04)*
Age of entry into the military			0.87 (0.81, 0.94)*	0.96 (0.89, 1.02)
Served in SEA	64.48	46.15	2.12 (1.75, 2.57)*	2.24 (1.82, 2.75)*
Co-twin psychopathology				
Conduct disorder	54.17	46.22	1.16 (1.08, 1.24)*	1.10 (0.97, 1.24)
Panic disorder or GAD	6.04	3.64	1.49 (0.96, 2.32)	1.23 (0.57, 2.62)
Mood disorder	16.34	10.02	1.61 (1.21, 2.15)*	1.02 (0.63, 1.65)
Substance dependence	50.62	39.44	1.51 (1.31, 1.83)*	1.00 (0.73, 1.36)
Co-twin psychopathology by zygosity				
Conduct disorder			1.11 (1.01, 1.21)*	0.89 (0.75, 1.04)
Panic disorder or GAD			1.64 (0.96, 2.83)	0.92 (0.35, 2.48)
Mood disorder			1.84 (1.29, 2.63)*	1.44 (0.77, 2.73)
Substance dependence			1.44 (1.15, 1.80)*	1.45 (0.95, 2.23)
Index twin preexposure psychopathology				
Conduct disorder	63.59	49.60	1.29 (1.21, 1.38)*	1.18 (1.04, 1.27)*
Panic disorder or GAD	3.02	0.65	4.64 (2.26, 9.19)*	2.67 (1.20, 5.92)*
Mood disorder	5.51	1.63	3.53 (2.14, 5.83)*	2.90 (1.58, 5.82)*
Substance dependence	41.56	37.86	1.14 (0.95, 1.38)	1.01 (0.84, 1.26)

a Confidence interval.

* Odds ratios with 95% CIs that do not include 1.00 are statistically significant.

body of research points to neuroticism as a key trait in the relationship among personality, depression, and stressful life events (Breslau and Davis, 1992; Horwood and Fergusson, 1986; Roberts and Kendler, 1999). However, our finding that preexposure depression in the index twin was associated with a reduced risk of exposure to traumatic events contrasts with that of previous studies. The relatively low prevalence of trauma exposure in individuals with and without preexisting depression limits interpretation of this finding. One possibility is that whereas parental depression increases exposure risk, some unique aspect of having the disorder itself may simultaneously reduce risk. For example, the anhedonia and loss of energy that accompany depression might limit an individual's contact with potentially traumatic situations by limiting the individual's level of activity and engagement with the environment, particularly in a military sample.

Vulnerability to PTSD was increased by a younger age at first trauma exposure, multiple trauma exposure, less than a high school–level education at entry into the military, SEA service and preexisting conduct disorder, panic disorder or GAD, and mood disorder in both univariate and adjusted analyses. The importance of a younger age at first trauma and multiple trauma exposure in vulnerability for PTSD is consistent with a number of studies to date (Breslau et al., 1999; Bremner et al., 1993; Davidson et al., 1991; Kulka et al., 1990). These results support the hypothesis that exposure to trauma at a younger age and multiple exposures to trauma increases sensitization to the effects of later traumatic events. Similar to the findings for trauma exposure, maternal antisocial behavior and co-twin psychopathology predicted PTSD in univariate analyses only. This suggests that the association between familial psychopathology and PTSD appears to be partially me-

TABLE 5
Adjusted Odds for PTSD after Trauma Exposure in SEA Veterans (N = 1353)

Risk Factor	Adjusted Odds Ratio (95% CI[a])
Demographic	
Monozygotic	0.98 (0.67, 1.43)
Minority	1.14 (0.62, 2.09)
Father did not graduate high school	0.96 (0.72, 1.29)
Mother did not graduate high school	1.08 (0.78, 1.51)
Age at first trauma (for 1-year difference)	0.97 (0.94, 0.99)*
Multiple trauma exposure	1.61 (1.23, 2.01)*
Family	
Paternal depression	1.40 (1.03, 1.91)*
Paternal antisocial behavior	0.95 (0.70, 1.29)
Maternal depression	1.31 (0.96, 1.80)
Maternal antisocial behavior	1.21 (0.77, 1.90)
Military service	
Less than high school level education at entry into the military	1.81 (1.28, 2.56)*
Age of entry into the military (for 1-year difference)	0.95 (0.87, 1.04)
Combat exposure	1.14 (1.09, 1.19)*
Co-twin psychopathology	
Conduct disorder	1.08 (0.91, 1.28)
Panic disorder or GAD	1.57 (0.61, 4.05)
Mood disorder	0.84 (0.41, 1.70)
Substance dependence	0.99 (0.66, 1.51)
Co-twin psychopathology by zygosity	
Conduct disorder	0.87 (0.70, 1.09)
Panic disorder or GAD	0.79 (0.22, 2.88)
Mood disorder	1.81 (0.74, 4.46)
Substance dependence	1.45 (0.83, 2.53)
Index twin preexposure psychopathology	
Conduct disorder	1.20 (1.09, 1.33)*
Panic disorder or GAD	3.33 (1.01, 11.00)*
Mood disorder	3.01 (1.18, 7.69)*
Substance dependence	0.99 (0.74, 1.32)

[a] Confidence intervals.
* Odds ratios with 95% CIs that do not include 1.00 are statistically significant.

TABLE 6
Adjusted Continuation Ratios for Trauma Exposure and PTSD

Risk Factor	Overall Model	Trauma Exposure	PTSD
Demographic			
Zygosity	−.05	−.01	−.18
Minority	.03	.03	−.09
Father did not graduate high school	−.11	−.02	−.20
Mother did not graduate high school	−.08	−.10	.13
Family			
Paternal depression	.32*	.16*	.34*
Paternal antisocial behavior	−.02	−.004	−.09
Maternal depression	.30*	.24*	.10
Maternal antisocial behavior	.04	−.02	.23
Military service			
Less than high school level education at entry into the military	.17*	.02	.43*
Age of entry into the military (for 1-year difference)	−.03*	−.02	−.04
Served in SEA	.77*	.46*	.74*
Co-twin psychopathology			
Conduct disorder	.04	.01	.09
Panic disorder or GAD	−.01	−.16	.20
Mood disorder	−.02	−.09	−.02
Substance dependence	.11	.05	−.01
Co-twin psychopathology by zygosity			
Conduct disorder	−.06	−.02	−.12
Panic disorder or GAD	.32	.36	−.10
Mood disorder	.50*	.30	.33
Substance dependence	.06	−.02	.37
Preexposure psychopathology			
Conduct disorder	.24*	.17*	.14
Panic disorder or GAD[a]	.04	−.24	.98*
Mood disorder	−.65*	−.83*	1.12*
Substance dependence	.19*	.19*	−.007

[a] Generalized anxiety disorder.
* p < .05.

diated through trauma characteristics such as a younger age at first trauma and multiple trauma exposure and by the individual's preexisting psychopathology.

Our results highlight the important role of preexposure conduct disorder as both a risk factor of traumatic exposure and of PTSD. Co-twin and preexposure index-twin conduct disorder, when considered individually, increased the risk of exposure and of subsequent PTSD. However, when the two were included together in a multivariate model, only preexposure index-twin conduct disorder remained significant. Conduct disorder might increase the risk of traumatic exposure and of PTSD through risky behaviors that place an individual in situations in which traumatic exposure is likely and/or a lack of internal resources necessary to successfully cope

with a traumatic experience. These results are consistent with those in the National Vietnam Veterans Readjustment Study, in which problem behaviors in childhood were found to be significant risk factors of developing PTSD (Kulka et al., 1990) and which suggested that youths with conduct disorder may be at high risk of traumatic exposure and PTSD. Treatments of conduct disorder might need to include components focused on preventing traumatic exposure.

The role of preexisting mood disorder and anxiety disorders in vulnerability for trauma exposure and PTSD also merits comment. Both mood and anxiety disorders showed a decrease in effect for trauma exposure and an increase in effect for developing PTSD once exposed. In a military sample, characteristics associated with these disorders might be related to inhibition in risk taking and, therefore, reduced risk of traumatic exposure. At the same time, the negatively biased cognitions about the self, environment, and future characteristic of these disorders could impair an individual's ability to respond

effectively to a traumatic event. For example, individuals with depression might blame themselves for the event's occurrence, rather than examining the many factors that contribute to adverse life events. Such internal causal attributions might then increase the risk of post-traumatic stress. Evidence of a role for internal causal attributions in the development of PTSD symptomatology has been found among traumatized adolescents (Joseph et al., 1993).

This study has several limitations that should be noted. Our conclusions, like those in previous studies, are based on cross-sectional data and may be subject to recall biases. This study has attempted to identify associations of risk factors with traumatic events and PTSD; statements about causal relationships are not definitive. The VET Registry sample is comprised exclusively of men who have served in the military and the findings may not apply to women or civilian men. Although our results are consistent with those found in community samples, it is not clear whether the differences between our findings and those of others are caused by differences between samples or methodology. Other limitations of this study relate to the methods used to determine traumatic exposure and PTSD diagnosis. Twins were asked about a maximum of three traumatic events and participants were not asked about certain forms of traumatic experienced (i.e., childhood sexual or physical abuse). As a result, we may underestimate the prevalence of traumatic exposure and PTSD in this sample. Furthermore, the risk factors identified in this study may not be unique to PTSD. Stressful life events are risk factors of other psychiatric disorders (Dohrenwend, 1998), and PTSD is also highly comorbid in both community (Kessler et al., 1995) and veteran (Kulka et al., 1990) samples. Our study cannot disentangle risk factors of PTSD alone versus risk factors of comorbid PTSD. Finally, although our study improves on previous work by using co-twin rather than self-reports of familial psychopathology, we did not use any formal diagnostic criteria to measure parental psychopathology or validate co-twin reports with personal interview data.

This study's use of twin data to separate familial from individual risk factors and to avoid the possible reporting biases related to exclusive reliance on self-reports are strengths not shared by other PTSD risk factors research to date. The results highlight the complexity of risk factor research by suggesting that conditions such as major depression may confer differential risk in the sequence of events leading to the development of PTSD. Future studies of risk factors of PTSD would benefit from the use of longitudinal twin and family designs to better specify the temporal and familial vulnerability factors for this complex disorder.

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