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Predictors and Outcomes of Posttraumatic Stress Disorder in World War II Veterans Exposed to Mustard Gas

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Current posttraumatic stress disorder (PTSD) associated with participation in secret military tests of mustard gas during World War II was assessed in 363 male military veterans who were randomly sampled from a registry developed by the Department of Veterans Affairs. Current prevalence was 32% for full PTSD and 10% for partial PTSD. Prevalence of PTSD varied as a function of risk and protective factors, including volunteering, physical symptoms during the tests, and prohibited disclosure. Prediction of partial PTSD was weaker than prediction of full PTSD. Veterans with full PTSD reported poorer physical health, a higher likelihood of several chronic illnesses and health-related disability, greater functional impairment, and higher likelihood of health care use than those with no PTSD. Veterans with partial PTSD also had poorer outcomes than did veterans with no PTSD in a subset of these domains. There is discussion of the traumatic elements of experimental mustard gas exposure, vulnerability to PTSD, and the relevance of these findings to understanding the broad range of outcomes associated with PTSD.

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Studies have shown that posttraumatic stress disorder (PTSD) can result from accidental exposure to toxic substances (e.g., Palinkas, Russell, Downs, & Petterson, 1993; Schottenfeld & Cullen, 1985). This study assessed PTSD secondary to intentional exposure that was incurred by some veterans of World War II (WWII). During the war, the U.S. military conducted a secret research program aimed at determining how to best protect military personnel against the effects of mustard gas and a similar compound, lewisite (Pechura & Rall, 1993). These agents are chemical weapons known as *vesicants* because they cause blisters (vesicles) on exposed tissues. They can cause long-term damage, leading to chronic bronchitis, conjunctivitis, and skin ulceration. Both agents can be lethal or lead to several types of skin and respiratory cancers, as well as leukemia. (For brevity, we refer to them jointly as *mustard gas* below.)

Up to 4,000 men took part in the program, in either a field test or a chamber test (Pechura & Rall, 1993). Both types of tests required participants to wear gas masks and clothing that had been treated in an attempt to block the gas from reaching the skin. In a chamber test, men were placed in a sealed room into which the mustard gas was introduced and were required to remain for 1 to 4 hr. This procedure was repeated daily or every other day until the equipment failed, for example, there was reddened skin or blisters. In a field test, men stayed in a field that had been bombed with mustard gas anywhere from 1 hr to 3 days and were required to drop to the ground periodically so that they would have direct contact with contaminated surfaces.

The history of the testing was not made known to most military personnel or to Department of Veterans Affairs (VA) health care providers until 1991, when the story was presented on the "60 Minutes" television program (Thompson, 1991). In 1992, the VA began to allow compensation for seven conditions that can result from mustard gas exposure: laryngitis, chronic bronchitis, emphysema, asthma, chronic conjunctivitis, chronic keratitis, and corneal opacities. Following publication of a report by the National Academy of Sciences (Pechura & Rall, 1993), the VA extended the list to include respiratory cancers (nasopharyngeal, laryngeal, and lung except for mesothelioma), skin cancer, chronic obstructive pulmonary disease, and acute nonlymphocytic leukemia. This report concluded that PTSD could have resulted from mustard-gas exposure and recommended further investigation of the topic.

The life threat inherent in mustard-gas exposure (Pechura & Rall, 1993) suggests that experimental mustard-gas exposure is a traumatic event that meets the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM–IV*) A.1 criterion for a diagnosis of PTSD (American Psychiatric Association, 1994). Additional information provided by Pechura and Rall suggests how mustard-gas exposure could lead to the A.2 criterion that requires a subjective response of fear, helplessness, or horror. Participants sometimes were given faulty equipment or used their equipment incorrectly, which resulted in serious physical consequences. A number of men witnessed frightening events, for example, other men being unable to breathe or losing consciousness, and were given incomplete or no information about the outcomes of these events. Volunteers often lacked adequate knowledge and training and sometimes were given misleading information to induce them to volunteer.

Mustard-gas exposure also involved elements of *contamination stressors* (Green, Lindy, & Grace, 1994), in which the initial stressor may be only information about exposure rather than a tangible event. This was not strictly the case with mustard gas, although the full disclosure in 1990 about the dangerous nature of the tests served as an additional (information) stressor for many of the exposed men. The lack of complete information provided to many participants before, during, and after the tests also resembled contamination stressors, in which the threat is vague or diffuse and often has unknown or unclear consequences. Misinformation and incomplete disclosure about the tests by trusted sources may have led to suspicion about any new information from those sources, additionally complicating the psychological impact. Unlike other traumatic stressors, which may lead to a preoccupation with the past because they occurred and were completed in the past, contamination stressors lead to a future orientation: a worry about what problems will develop as a result of the contamination. Evidence from pilot study interviews (Schnurr, Friedman, & Green, 1996) and anecdotal evidence from other contacts with these veterans indicate that worry about the future health consequences of mustard gas has been and continues to be a significant concern for many. Thus, mustard-gas exposure may have been doubly stressful because it contained elements of both traditional traumatic stressors and contamination stressors.

Furthermore, some men were sworn to secrecy and threatened with criminal prosecution if they ever told anyone about the tests (Pechura & Rall, 1993). This secrecy could have impeded emotional processing of fear information, which is thought to be essential in recovering from trauma (Foa, Steketee, & Rothbaum, 1989). Secrecy also may have prevented participants from seeking professional assistance or social support, both of which are related to decreased risk of PTSD after a trauma (King, King, Fairbank, Keane, & Adams, 1998; Kramer & Green, 1991).

A pilot study of 24 mustard-gas participants, using the Structured Clinical Interview for *DSM–IV* (Spitzer, Williams, Gibbon, & First, 1990), found that 17% had current PTSD because of mustard gas, which also was the prevalence of lifetime mustard-gas–related PTSD (Schnurr et al., 1996). PTSD that was due to other events occurred in 8%, current and lifetime, and there was no overlap between cases of PTSD that was due to mustard gas and PTSD that was due to other events. Although this pilot study documented that experimental mustard-gas exposure can lead to PTSD, making inferences about PTSD in the larger population of mustard-gas–exposed men was hindered by the low power associated with the small sample size and the nonrepresentativeness of the sample.

We addressed these limitations by drawing a large random sample from a registry developed by the VA to assess mortality that was due to mustard-gas exposure (Bullman & Kang, 1997). The registry is based on a careful record review from multiple archival sources and represents the best estimate of the population of Army and Navy veterans who participated in the tests. Studying this population provides an opportunity to learn more about PTSD in a community sample of older military veterans, about whom relatively less is known compared with younger veterans (Spiro, Schnurr, & Aldwin, 1994). Also, similarities between the experiences of mustard-gas test participants and those of Gulf War veterans (e.g., fear of contamination, unclear information about exposure, and secrecy) can provide information that is relevant to the latter and to other contaminated populations.

In the present study, we assessed the prevalence of current PTSD and partial PTSD in mustard-gas–exposed veterans. Partial PTSD (e.g., Blanchard et al., 1996; Weiss et al., 1992), a subdiagnostic classification, was included in the event that a substantial number of men with mustard-gas–related PTSD symptoms would fail to meet full diagnostic criteria. Although it is not formally recognized in the *DSM–IV* (American Psychiatric Association, 1994), partial PTSD has been proposed as a useful way to distinguish individuals who have clinically significant symptoms but do not meet PTSD diagnostic criteria from asymptomatic individuals (Schützwohl & Maercker, 1999). Partial PTSD usually is intermediate between full and no PTSD in terms of associated psychiatric symptoms and functioning (e.g., Schützwohl & Maercker, 1999), although one study found that individuals with partial PTSD had as much social and interpersonal impairment as individuals with full PTSD (Stein, Walker, Hazen, & Forde, 1997).

One set of analyses examined risk factors for PTSD and partial PTSD. We focused on test characteristics, such as number of exposures and type of test, that would be expected on the basis of prior research to relate to the likelihood of developing PTSD (e.g., Green, Grace, Lindy, Gleser, & Leonard, 1990; Kulka et al., 1990). Variables related to preparation were included given previous findings on the protective effects associated with volunteering and prior experience and the increased risk associated with expectation of a traumatic experience (McCarroll, Ursano, Fullerton, & Lundy, 1993). Our selection of additional potential risk factors was constrained by a desire to minimize the potential for Type I error, so we selected only a few variables that previously had been shown

to be risk factors for PTSD: Hispanic ethnicity (Kulka et al., 1990), age at exposure (Green et al., 1990), and exposure to other traumatic events (King et al., 1998). Being sworn to secrecy and posttraumatic disclosure were included even though they have not been shown to be risk factors for PTSD because disclosure is thought to be an important part of the process of coming to terms with trauma (Pennebaker, 1997; Silver, Boon, & Stones, 1983). We did not make specific predictions about differences between risk factors for full and partial PTSD because almost nothing is known about what predicts whether a traumatized individual will develop partial PTSD. Prior studies have identified female gender (Stein et al., 1997) and personality (Schnurr, Friedman, & Rosenberg, 1993) as risk factors, but it was not possible to include these variables because of the all-male nature of the sample and practical constraints on the length of the assessment interview.

Another set of analyses examined whether there were poorer self-reported physical and mental health outcomes in PTSD and partial PTSD groups relative to no-PTSD controls. The association of psychiatric comorbidity and psychosocial impairment with PTSD is well documented (e.g., Kulka et al., 1990; Zatzick et al., 1997), and there is some evidence that partial PTSD also is associated with greater psychiatric symptoms and poorer psychosocial functioning (e.g., Schützwohl & Maercker, 1999; Stein et al., 1997). In addition, a growing number of studies have found that PTSD is associated with poor physical health outcomes (Friedman & Schnurr, 1995; Schnurr & Jankowski, 1999). Although most of the data linking PTSD with poor physical health are based on self-reported outcomes (e.g., Boscarino, 1997; Kulka et al., 1990; Schnurr & Spiro, 1999), several studies have found that PTSD is related to increased risk of medical problems as indicated by physician diagnosis or laboratory exam (Beckham et al., 1998; Boscarino & Chang, 1999; Schnurr, Spiro, & Paris, 2000). Specific physical health outcomes examined in the present study had all been previously shown to be related to PTSD: self-reported physician-diagnosed medical disorders (e.g., Boscarino, 1997), health status and functioning (e.g., Schnurr & Spiro, 1999; Zatzick et al., 1997), and medical service use (e.g., Friedman et al., 1997; Kulka et al., 1990).

Method

Participants

We randomly sampled 250 Army and 250 Navy male veterans from a registry developed for a mortality study of mustard-gas test participants conducted by the VA's Office of Public Health and Environmental Hazards. Those listed as alive as of October 1995 were considered to be our study population. (See Bullman & Kang, 1997, for information about the procedures used to develop the registry.) Of the 500 men selected, 363 (73%) participated, 15% could not be located, 8% were dead or ineligible (e.g., cognitive dysfunction), 1% could not be scheduled, and 3% refused. Of those located and eligible, 94% participated. The proportions of Army and Navy veterans in the final sample were virtually identical to the proportions in the registry who were alive at the time the sample was drawn.

Participants' average age was 71.9 years (SD = 4.1). Almost all were White (97%); 10% additionally reported Hispanic ethnicity. Most were married (83%), retired (78%), and had at least a high school education (64%).

Measures and Procedure

Participants were informed about the study by letter and were then contacted by trained staff at a survey research firm with extensive experience in studies of trauma and PTSD as well as experience with elderly veterans. Interviews were conducted by telephone after the interviewers obtained verbal informed consent and assured participants of confidentiality and anonymity. The approximately 40-min interviews, which were conducted in 1996, were designed to be administered by individuals without clinical training, and were conducted using a computer-assisted telephone interview procedure. Question topics included, in order, aspects of the mustard-gas testing, PTSD related to mustard gas, lifetime trauma exposure, current health and well-being, and demographics.

Mustard-gas exposure. Questions about mustard-gas exposure were derived from interviews conducted with pilot participants (Schnurr et al., 1996). Except for age at exposure, all items that assessed mustard-gas experiences were categorical. Having volunteered for the tests and having received protective training prior to the tests were coded yes or no. Several dichotomous items were created by pooling single items and coding the summary item as *yes* if a respondent said "yes" to any single item: physical symptoms during the tests (impaired breathing, burned skin or eyes, nausea or vomiting, or failure to maintain consciousness), seeing others in distress during the tests (emotional distress, physical distress, or failure to maintain consciousness), and prohibited disclosure (oath of secrecy or disclosure criminalized). Type of test was coded from answers to questions about how many times a respondent had participated in field and chamber tests and was coded as *field only, chamber only,* and *both chamber and field.* Number of exposures was coded by summing the number of exposures to both types of tests and then creating ordinal categories, roughly reflecting tertiles, because the resulting distribution was positively skewed: 1–2, 3–6, and 7+ exposures. Timing of disclosure was derived from the year the veteran first reported disclosing his participation to anyone. Because of positive skew, time of disclosure was coded as *never disclosed, up to 1990,* and *1991 to present,* with the latter distinction made to reflect before and after the story became known to the public.

PTSD. Current mustard-gas–related PTSD was assessed by the PTSD Checklist (PCL; Weathers, Litz, Herman, Huska, & Keane, 1996). The PCL has high reliability (α = .97, test–retest reliability = .96) and validity (for a PTSD diagnosis: sensitivity = .82, specificity = .83). It consists of the 17 *DSM–IV* PTSD symptoms rated on a 1–5 scale. A symptom is scored as present if rated *3* or higher, indicating at least moderate severity in the past month. The PCL was introduced as "a list of problems and complaints that men sometimes have in response to mustard gas." Mustard-gas exposure served as the trauma referent for all trauma-specific items, for example, "In the past month how much have you been bothered by repeated disturbing dreams of your testing experiences?" PTSD that was due to other events was not assessed.

A diagnosis of PTSD was made if the participant met the *DSM–IV* criteria of at least one "B" (intrusive) symptom, three "C" (avoidance/numbing) symptoms, and two "D" (hyperarousal) symptoms. With respect to the "A" (event) criterion, the dangerous nature of the tests is arguably sufficient for meeting A.1 (life threat, injury, or threat to physical integrity). Because the PCL has good validity even though it does not formally assess the A criterion, we did not specifically require that participants meet A.2, which stipulates that the person who experienced a traumatic event responded with "fear, helplessness, or horror." However, we also report the percentage of men with PTSD who said that they experienced fear, helplessness, or horror either during the tests or when thinking about them in the past month. These were assessed separately as yes or no.

Partial PTSD was diagnosed if a participant met the B criterion and either the C or the D criterion from *DSM–IV* or if he met B and had at least one C symptom and one D symptom. These criteria, used by Friedman et al. (1997), are generally consistent with partial criteria used by other investigators. Schnurr et al. (1993) used these criteria but also allowed a partial diagnosis to be made if an individual had the number of B, C, and

D symptoms required for full PTSD, with some or all symptoms at a subthreshold level. For a diagnosis of partial PTSD, Stein et al. (1997) required the B criterion and at least one C and one D symptom. In contrast, Schützwohl and Maercker (1999) and Blanchard et al. (1996) required the B criterion and either the C or the D criterion.

Other traumatic events. We assessed exposure to seven additional types of trauma by using a modified version of the Trauma Assessment for Adults questionnaire (Resnick, 1996). If a participant experienced an event in a given category, we asked follow-up questions about whether any of the events in that category involved life threat or injury. The Trauma Assessment for Adults does not ask about subjective reactions to experienced stressors and, thus, does not permit determination of the *DSM–IV* A.2 criterion. The types of trauma assessed were war-zone exposure, serious accident, natural or human-made disaster, physical assault, childhood physical abuse, sexual assault, and other extraordinarily stressful events. For all categories except sexual assault, we counted presence of trauma only if life threat or injury was reported. Sexual assault ($n = 6$) was counted as a traumatic event regardless of whether the assault involved life threat or injury. We summarized the data on traumatic exposure as presence or absence of exposure to war-zone trauma, other trauma, and any trauma (either of the two categories).

Psychosocial functioning. The Medical Outcomes Study Short Form—36 (SF–36; Ware, Gandek, & the IQOLA Project Group, 1996) is a 36-item self-report questionnaire assessing perceived physical health and health-related psychosocial functioning. The SF–36 has excellent reliability and validity for measuring physical and mental health status (McHorney, Ware, & Raczek, 1993). It is scored for eight subscales and a single item that ranges from 0 (negative) to 100 (positive). Physical Function is a 10-item subscale referring to the ability to perform basic physical activities such as bathing oneself, walking up to a mile, climbing stairs, housecleaning, or participating in sports. Social Function is a 2-item subscale rating the extent to which physical health or emotional problems have interfered with social activities in the past month. Role Physical is a 4-item subscale asking about limitations in work involvement or accomplishment due to physical health problems in the past month. Role Mental is a 3-item subscale asking about limitations in work involvement or accomplishment due to emotional problems such as feeling depressed or anxious in the past month. Mental Health is a 5-item subscale for anxiety, dysphoria, and positive affect during the past 4 weeks. Fatigue is a 4-item subscale inquiring about energy level and fatigue in the past 4 weeks. Pain is a 2-item subscale asking about the severity of and limitations caused by bodily pain in the past 4 weeks. General Health is a 5-item subscale referring to global perceptions of current and expected health and illness proneness. Change in Physical Health is a single item referring to perceived improvement or worsening in health over the past year. SF–36 subscales have been extensively evaluated for test–retest reliability and internal consistency and validated as indexes of objectively corroborated health and psychosocial functioning (Ware et al., 1996). The SF–36 subscales with multiple items were internally consistent in this sample (αs = .76–.93).

Illnesses. Single items that were adapted from the *National Survey of Veterans* (National Center for Veteran Analysis and Statistics, 1995, p. 36) asked whether the veteran ever had had the following illnesses: cancer (or leukemia), a heart condition such as angina or a myocardial infarction (heart trouble), hypertension (high blood pressure), a stroke, chronic obstructive pulmonary disease (COPD), an ophthalmologic (eye or vision) condition, a gastrointestinal (stomach or digestive) condition, or diabetes ("sugar"). We added items for illnesses linked to mustard-gas exposure by the Institute of Medicine report (Pechura & Rall, 1993): dermatologic (skin) conditions and sexual problems. We also added urologic (urinary) conditions. Respondents could answer "don't know" or "not sure" if they were uncertain about a medical condition, but at most, 2% (for stroke) chose these response options.

Disability. Disability history was assessed by questions adapted from the Medical Outcomes Study (Katzelnick, Kobak, Greist, & Jefferson, 1997) and the VA *National Survey of Veterans* (National Center for Veteran Analysis and Statistics, 1995, pp. 44–45), asking if the veteran had ever received VA disability compensation for any medical condition, military discharge with disability, Social Security disability, workers' compensation disability, or any other type of disability. Veterans who reported VA disability benefits were asked if they had ever received veterans' compensation for "PTSD, 'nerves,' or any other psychiatric condition." Both variables—any lifetime disability and lifetime VA psychiatric disability—were coded yes or no.

Health care use. Measures adapted from the Normative Aging Study (1992) of male veterans and the *National Survey of Veterans* (National Center for Veteran Analysis and Statistics, 1995) were used to ensure appropriateness for this study group of aging men and to facilitate comparison of study results with normative data. Single items asked respondents if they had used inpatient or outpatient medical care, or telephone medical advice, from any source in the past 6 months. Additional single-item variables assessed lifetime use of VA outpatient health care and use in the past year and lifetime VA inpatient health care.

Unemployment. A single item from the *National Survey of Veterans* (National Center for Veteran Analysis and Statistics, 1995) asked if the veteran currently was *employed full* or *part-time, self-employed, retired, a student, a homemaker, out of work, or unable to work.* Responses were categorized as unemployed (out of work or unable to work) versus all other categories.

Health risk behaviors. A history of cigarette smoking for at least 10 years (coded yes or no) was assessed by a question from the Normative Aging Study (Garvey, Bliss, Hitchcock, & Heinold, 1992). Potentially problematic alcohol use was assessed using the CAGE, a 4-item scale that has been shown to detect heavy drinking (although not severe binge drinking, which our pilot study indicated was very rare in this sample) in older adults (Adams, Barry, & Fleming, 1996). A cutpoint of 2 (or more) items endorsed was used to classify problematic alcohol use.

Data Analysis

We used polytomous logistic regression to examine risk factors for partial and full PTSD. This technique is a generalization of ordinary logistic regression in which a categorical outcome can have more than two categories. The basic polytomous logistic regression model assumes proportional odds for the different PTSD categories, that is, the effect of a predictor is the same for all the cumulative logits. We used a partial proportional odds model (Peterson & Harrell, 1990), which is a flexible method of analyzing ordinal response variables without restricting them to the proportional odds assumption. Instead, the effects of the explanatory variables can be modeled so that a given risk factor can have different odds for predicting full PTSD than for predicting partial PTSD. Contrasts were parameterized so that the no-PTSD group served as the reference category for each outcome. The odds ratio (OR) for predicting each diagnostic category (e.g., partial) is the effect of a given predictor on the odds of that category (vs. no diagnosis), exclusive of the other diagnostic category (e.g., full).

There were small amounts of missing data for some risk factors. For several categorical variables, a number of men—sometimes more than 10%—replied "don't know." Rather than treat these men as having missing data, we included them as a separate category for any variable for which "don't know" constituted 5% or more of responses. We believe that this strategy is appropriate for our data because "don't know" is a plausible answer from someone who is asked about an event that happened long ago. A different strategy was used in handling missing data for age at exposure because it was continuous rather than categorical. Over 10% of these data were missing because some men responded "don't know" when asked about their year of mustard-gas exposure, thereby preventing calculation of age at exposure as a function of chronological age. The OR for age at exposure was estimated by including in logistic regression a dichotomous

variable indicating whether age at exposure was missing. The OR thus reflects the effect of age at exposure, given that the variable is not missing.

Analyses to examine outcomes associated with PTSD used PTSD group as an independent variable (rather than a dependent variable, as in the risk factor analyses). For SF–36 variables, we used a one-way analysis of covariance to compare the three PTSD groups. Logistic regression was used for categorical outcomes; PTSD group (partial, full) was indicator-coded, with the no-PTSD group as the reference category. Both types of analyses were adjusted for age at interview, 10-year smoking history, problematic alcohol use, and any physical symptoms during the tests; the last three covariates were coded dichotomously as indicator variables.

We attempted to balance Type I and Type II error probabilities by using a critical significance of .01 for contrasts involving full PTSD. We used a critical significance of .05 for contrasts involving partial PTSD because of the exploratory nature of these contrasts and because the smaller sample size of the partial PTSD group resulted in lower power relative to contrasts for full PTSD.

Results

Prevalence of current mustard-gas–related PTSD was 32% (95% confidence interval [CI] = 27%–36%). Prevalence of partial PTSD was 10% (95% CI = 7%–13%). The average PCL score was 57.8 in the full-PTSD group (SD = 11.2, range = 39–80), 37.6 in the partial PTSD group (SD = 6.6, range = 24–51), and 23.0 (SD = 7.5, range = 17–50) in the no-PTSD group, $F(2, 359) = 587.5$, $p < .001$. If prevalence is estimated by additionally requiring a report of fear, helplessness, or horror in response to the tests, either during the tests or in the past month, 26% of the sample had full PTSD (95% CI = 22%–30%) and 6% had partial PTSD (95% CI = 4%–9%).

Risk Factors for Mustard-Gas–Related PTSD

Table 1 presents the distribution of each risk factor as a function of PTSD diagnostic status. This information is provided to facilitate interpretation of Table 2, which summarizes the analyses of potential risk factors for mustard-gas–related PTSD and partial PTSD.

Several factors were not associated with the development of either full or partial PTSD: lifetime traumatic exposure, branch of service, age at exposure, and type of test. Both factors used to represent preparation were protective: Having volunteered and having received protective training independently predicted lower risk of full and of partial PTSD. All of the remaining factors predicted the increased likelihood of full PTSD, and some also predicted increased likelihood of partial PTSD. Factors that predicted the development of full PTSD included only Hispanic ethnicity, 3–6 exposures (relative to 1 or 2; the effect of 7 or more exposures failed to meet our restricted significance criterion), physical symptoms during the test, and timing of disclosure. Contrary to expectation, risk of full PTSD was increased only for those men who had disclosed after 1990, relative to those men who had never disclosed. Factors associated with increased risk of both full and partial PTSD were seeing others in distress and prohibited disclosure. Visual inspection of the data in Table 2 suggests that the significant associations between risk factors and both PTSD outcomes appeared to follow an ordinal relationship, such that a given factor was more strongly associated with full than with partial PTSD.

Table 1
Risk Factors as a Function of Current Mustard-Gas–Related PTSD

Variable	No PTSD (n = 210)	Partial PTSD (n = 38)	Full PTSD (n = 115)
Hispanic ethnicity (% yes)	6	11	17
Lifetime traumatic exposure (% yes)	61	76	64
Branch of service (% Navy)	49	61	63
Mean age at exposure (SD)	20.5 (4.1)	21.1 (4.6)	19.6 (3.1)
Volunteered for test (% yes)	89	76	65
Protective training (% yes)	49	16	33
Type of test (%)			
Field only	19	16	15
Chamber only	61	63	60
Both chamber and field	21	21	25
Number of exposures (%)			
1–2	39	37	26
3–6	20	21	32
7+	28	29	32
Don't know	14	13	13
Physical symptoms during test (% yes)	80	89	97
Saw others in distress during test (% yes)	50	74	78
Prohibited disclosure (%)			
Yes	28	50	62
Don't know	15	8	10
Timing of disclosure (%)			
Never disclosed	11	18	7
Up to 1990	62	50	56
1991–present	12	21	26
Don't know	15	12	11

Note. N = 363, with small amounts of missing data for some variables. PTSD = posttraumatic stress disorder.

Table 2
Risk Factors for Current Mustard-Gas–Related Full PTSD and Partial PTSD

	PTSD vs. no PTSD		Partial PTSD vs. no PTSD	
Variable	Odds ratio	95% CI	Odds ratio	95% CI
Hispanic ethnicity				
No	1.00		1.00	
Yes	3.00**	1.42–6.35	1.78	0.55–5.82
Lifetime traumatic exposure				
No	1.00		1.00	
Yes	1.13	0.71–1.82	2.02	0.91–4.51
Branch of service				
Army	1.00			
Navy	1.77*	1.11–2.83	1.62	0.80–3.29
Age at exposure (per year)	0.94	0.87–1.00	1.04	0.96–1.13
Volunteered for test				
No	1.00		1.00	
Yes	0.23***	0.13–0.41	0.40*	0.17–0.96
Protective training				
No	1.00		1.00	
Yes	0.52**	0.32–0.85	0.21***	0.08–0.52
Type of test				
Field only	1.00		1.00	
Chamber only	1.41	0.74–2.66	1.39	0.53–3.64
Both chamber and field	1.71	0.82–3.56	1.33	0.42–4.19
Number of exposures				
1–2	1.00		1.00	
3–6	2.85**	1.52–5.34	1.14	0.44–2.96
7+	2.01*	1.10–3.69	1.11	0.47–2.63
Don't know	1.63	0.76–3.51	1.01	0.33–3.06
Physical symptoms during test				
No	1.00		1.00	
Yes	9.17***	2.76–30.48	2.03	0.68–6.07
Saw others in distress during test				
No	1.00		1.00	
Yes	3.47***	2.02–5.94	2.48*	1.14–5.40
Prohibited disclosure				
No	1.00		1.00	
Yes	4.38***	2.60–7.36	2.42*	1.16–5.05
Don't know	1.29	0.58–2.85	0.73	0.20–2.66
Timing of disclosure				
Never disclosed	1.00		1.00	
Up to 1990	1.43	0.60–3.38	0.48	0.18–1.29
1991–present	3.32*	1.26–8.71	1.01	0.32–3.24
Don't know	1.17	0.41–3.29	0.41	0.11–1.58

Note. $N = 363$, with small amounts of missing data for some variables. Odds ratios are crude estimates, unadjusted for covariates. CI = confidence interval; PTSD = posttraumatic stress disorder.
* $p < .05$. ** $p < .01$. *** $p < .001$.

We performed two additional sets of analyses in an attempt to understand the lack of expected effects for disclosure and for lifetime trauma. Timing of disclosure was related to the prohibition of disclosure, $\chi^2(6, N = 362) = 50.4, p < .001$; in particular, only 45% of the men for whom disclosure was prohibited actually disclosed up to 1990, compared with 71% of men for whom disclosure was not prohibited. We wondered if our failure to find a protective effect of disclosure was due to an increased risk of PTSD among individuals who had disclosed while believing that disclosure was prohibited. This hypothesis was tested by selecting individuals for whom disclosure was prohibited and examining current full-PTSD prevalence in those who had disclosed up to 1990 ($n = 60$) versus those who had disclosed from 1991 to the present ($n = 44$). However, prevalence did not differ between the two groups (57% vs. 59%; OR = 1.10; 95% CI = 0.50–2.43).

Because of the unusual nature of experimental exposure to mustard gas as a stressor, we performed several comparisons aimed at determining the specificity of participants' PTSD symptoms to mustard gas relative to other traumatic experiences. As indicated above, any lifetime exposure to trauma other than mustard gas was unrelated to the likelihood of full or partial PTSD. We also examined differences between lifetime trauma-exposed and -nonexposed groups in total PCL scores, total number of PTSD symptoms, number of trauma-specific symptoms (B.1–5, C.1–2), and number of trauma nonspecific symptoms (C.3–7, D.1–5). The groups did not differ on any of these measures (lowest $p = .18$, with trauma exposed having trivially lower scores). To assess whether we failed to find effects associated with lifetime trauma because our "any lifetime trauma" measure was perhaps too inclusive, we computed ORs separately for full PTSD (vs. no PTSD)

for war-zone and other exposure. (Participants with partial PTSD were excluded to maximize sensitivity.) As we had found for the overall trauma measure, full-PTSD prevalence in exposed and nonexposed groups did not differ for war-zone trauma (OR = 1.35; 95% CI = 0.86–2.13) or other trauma (OR = 1.25; 95% CI = 0.79–1.98). We thus feel confident that our attempts to confine PTSD symptom reports to those associated with mustard-gas experiences only were reasonably successful.

Outcomes Associated With PTSD

Mustard-gas test veterans with full PTSD were younger than those with partial PTSD; no PTSD participants were intermediate in age, although the absolute differences in age across groups were small: $M = 72$, $SD = 4.3$; $M = 73$, $SD = 4.6$; and $M = 71$, $SD = 3.5$, for no, partial, and full PTSD, respectively, $F(2, 361) = 3.1, p < .05$. Ten-year history of cigarette smoking did not differ for the no-PTSD (11%) versus partial PTSD (10%) or full-PTSD (11%) group. Alcohol problems did not differ for the no-PTSD (9%), partial PTSD (15%), or full-PTSD (16%) groups. The groups differed in the proportion of who reported physical symptoms during the tests: no-PTSD (80%), partial PTSD (89%), and full-PTSD (98%) groups, $\chi^2(2, N = 360) = 18.97, p < .001$.

Table 3 presents the association of full and partial PTSD with self-reported medical illnesses. Veterans with full PTSD were significantly more likely than veterans without PTSD to report experiencing several illnesses: coronary, urologic, dermatologic, ophthalmologic, and gastrointestinal disorders, COPD, and sexual dysfunction. Veterans with partial PTSD were significantly more likely to report experiencing COPD compared with veterans without PTSD.

Table 4 presents data from the SF–36 as a function of PTSD status. Compared with veterans with no PTSD, veterans with full PTSD reported poorer outcomes on all subscales. Veterans with partial PTSD also reported significantly worse outcomes than did veterans with no PTSD on all subscales. A nonstatistical comparison with normative scores for a representative sample of American men of comparable age (i.e., 70–74 years old) from the Medical Outcomes Study indicated that mustard-gas veterans with full PTSD were extremely impaired in all domains of health-related physical and psychosocial functioning, with scores consistently 30–50 points lower than those for a similarly aged normative cohort of men (Wetzler & Radosevich, 1992, p. 5). Mustard-gas veterans with partial PTSD, although reporting less impairment than those with full PTSD, were substantially impaired in all domains of health-related physical and psychosocial functioning, consistently reporting scores 20–30 points lower than normative scores.

Health care use varied as a function of PTSD status as well (see Table 5), although group differences were confined to VA use and not to overall use during the past 6 months. Veterans with full or partial PTSD were more likely than veterans without PTSD to have used VA outpatient services, both within the past year and during their lifetime. Veterans with full PTSD also were more likely to have used VA inpatient services during their lifetime.

Table 5 shows that veterans with full or partial PTSD had increased likelihood of ever having received any disability award, relative to veterans without PTSD. The likelihood of a specific VA psychiatric disability was greater only in the full-PTSD group, however. The table shows a similar pattern for employment status, with the full-PTSD group, but not the partial-PTSD group, more likely than the no-PTSD group to be unemployed.

Discussion

This study contributes to information about the very long-term consequences of traumatic exposure. Almost one third of men who were exposed to mustard gas or lewisite in secret tests during WWII had PTSD associated with the tests when assessed 50 years after their exposure. In addition, 10% had partial PTSD at the time of assessment. Compared with prevalence in non–treatment-seeking WWII veterans, the prevalence of current full mustard-gas–related PTSD is higher than in combat veterans (Spiro et al., 1994) but similar to prevalence in former prisoners of war (Engdahl, Dikel, Eberly, & Blank, 1997). One possible reason for the relatively high current prevalence is that PTSD symptoms were

Table 3
Self-Reported Illnesses of Mustard-Gas Veterans According to PTSD Status

Illness	No PTSD (%; n = 206–210)	Partial PTSD (%; n = 37–38)	Full PTSD (%; n = 109–115)	Full PTSD vs. no PTSD		Partial PTSD vs. no PTSD	
				OR	95% CI	OR	95% CI
Leukemia/cancer	23	18	36	1.81*	1.06–3.07	0.83	0.34–2.03
Coronary disease	41	45	63	2.70**	1.64–4.44	1.23	0.59–2.54
Hypertension	51	60	63	1.50	0.91–2.46	1.29	0.62–2.72
Stroke	12	5	20	1.58	0.82–3.03	0.19	0.02–1.44
Diabetes	19	27	20	1.09	0.60–1.98	1.57	0.67–3.66
Pulmonary disease	27	55	67	5.36***	3.12–9.20	3.40**	1.56–7.38
Dermatologic	58	65	79	2.46**	1.42–4.28	1.46	0.67–3.16
Ophthalmalogic	65	82	88	4.07***	2.05–8.07	2.00	0.82–4.85
Gastrointestinal	39	45	59	2.19**	1.34–3.57	1.40	0.68–2.90
Sexual dysfunction	23	30	45	2.43**	1.46–4.05	1.31	0.58–2.97
Urologic	40	39	63	2.80**	1.70–4.61	1.15	0.55–2.39

Note. Odds ratios adjusted for age, smoking, problematic alcohol use, and physical symptoms at test. OR = odds ratio; CR = confidence interval; PTSD = posttraumatic stress disorder.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4
Physical and Psychosocial Functioning and Impairment of Mustard-Gas Veterans According to PTSD Status

	No PTSD (n = 198–210)		Partial PTSD (n = 31–38)		Full PTSD (n = 107–115)		Full PTSD vs. no PTSD		Partial PTSD vs. no PTSD	
SF–36 Scale	*M*	*SE*	*M*	*SE*	*M*	*SE*	*F*	*df*	*F*	*df*
General Health	49.8	1.5	28.7	3.6	19.9	2.1	132.50***	1, 344	29.08***	1, 344
Change in Health	43.2	1.5	29.5	3.7	28.9	2.1	29.16***	1, 344	11.90***	1, 344
Fatigue	49.7	1.5	31.7	3.6	23.1	2.0	107.94***	1, 345	21.69***	1, 345
Pain	63.5	1.8	48.3	4.5	33.6	2.5	90.01***	1, 338	9.96**	1, 338
Physical Function	59.2	1.9	31.0	4.8	27.0	2.6	94.03***	1, 332	29.23***	1, 332
Social Function	76.5	1.8	57.1	4.4	38.1	2.5	147.81***	1, 345	16.70***	1, 345
Role Impairment—Physical	50.9	2.5	18.3	6.2	7.9	3.4	100.88***	1, 326	24.20***	1, 326
Role Impairment—Emotional	71.5	2.6	39.6	6.7	23.8	3.6	112.08***	1, 323	19.52***	1, 323
Mental Health	72.0	1.4	56.9	3.4	42.1	2.0	147.96***	1, 345	16.82***	1, 345

Note. Means adjusted for age, smoking, problematic alcohol use, and physical symptoms at test. PTSD = posttraumatic stress disorder.
** $p < .01$. *** $p < .001$.

exacerbated or reactivated recently, in 1991, when the truth about the tests was made public. A sense of having been betrayed by the government also may have contributed to exacerbation or reactivation. Betrayal has been suggested as an important element of some traumatic events (Freyd, 1994). In addition, the medical problems experienced by a number of these men may have been an ongoing traumatic reminder; indeed, medical illness has been implicated as a trigger of PTSD reactivation in older combat veterans (Macleod, 1994).

Increased likelihood of full PTSD was associated with numerous risk factors, which may be characterized in terms of personal characteristics (Hispanic ethnicity), context and preparation (being ordered to participate or lack of protective training), severity of exposure (a moderate—but not high—number of exposures, physical symptoms, and seeing others in distress), and the recovery environment (prohibited disclosure or recent disclosure). Our results are generally consistent with theory and other data on risk factors for PTSD that show risk to be influenced by variables that occur before, during, and after a trauma (e.g., Green et al., 1990; King et al., 1998; Kulka et al., 1990), but there were three exceptions. The risk of full PTSD that was due to mustard gas was not increased as a function of exposure to other traumatic events (King et al., 1998), and additional analyses failed to explain this finding. Although it is possible that our method of assessing lifetime trauma was not sufficiently sensitive or specific, measurement per se seems an unlikely explanation because our method was based on a validated trauma-assessment measure (Resnick, 1996). Another exception was that risk of full PTSD among men with the greatest number of exposures did not meet our significance criterion, even though risk was increased among men with an intermediate number of exposures. Post hoc analyses (not reported) failed to explain this result, but it may simply reflect error because the confidence intervals for the two ORs overlap substantially. A third exception was that age at exposure was not related to the risk of full PTSD (e.g., Green et al., 1990; Kulka et al., 1990). A possible reason explaining these exceptions is the age of the sample: Differential mortality may have resulted in the survival of the healthiest men, which may have attenuated some risk-factor relationships.

Table 5
Health Care Use, Disability, and Employment Outcomes in Mustard-Gas Veterans According to PTSD Status

				Full PTSD vs. no PTSD		Partial PTSD vs. no PTSD	
Outcome	No PTSD (%; n = 206–210)	Partial PTSD (%; n = 37–38)	Full PTSD (%; n = 109–115)	OR	95% CI	OR	95% CI
Health care use							
Past 6 months inpatient	15	26	27	2.05*	1.14–3.67	2.24	0.97–5.16
Past 6 months outpatient	83	87	90	2.22*	1.02–4.84	1.44	0.51–4.09
Past 6 months phone	23	24	35	1.63	0.96–2.76	1.16	0.51–2.68
Past year VA outpatient	16	42	45	4.24***	2.44–7.39	3.29**	1.49–7.29
Lifetime VA outpatient	45	71	76	3.57***	2.98–6.13	3.07**	1.37–6.84
Lifetime VA inpatient	18	29	44	3.80***	2.20–6.57	1.51	0.64–3.55
Any lifetime disability	43	74	78	5.14***	2.85–2.98	3.73*	1.54–9.04
Lifetime VA psychiatric disability	2	3	13	6.15***	3.47–10.81	2.53	0.24–26.41
Current unemployment	4	3	21	5.57***	2.37–13.08	0.68	0.08–5.57

Note. Odds ratios adjusted for age, smoking, problematic alcohol use, and physical symptoms at test. PTSD = posttraumatic stress disorder; OR = odds ratio; CI = confidence interval; VA = Veterans Affairs.
* $p < .05$. ** $p < .01$. ** $p < .001$.

A unique aspect of this study was the exploration of how preparation for a traumatic event relates to the subsequent development of PTSD. Protective training and volunteering (vs. being ordered to participate) were associated with substantial decreases in the likelihood of PTSD. These results are similar to findings of McCarroll et al. (1993), who reported that distress among military mortuary workers was greatest for individuals who had not volunteered and who had no prior experience handling human remains. Our findings, along with McCarroll et al.'s, have implications for prevention strategies with individuals who are not formally assigned to hazardous duty but who may be exposed to traumatic stimuli in the course of military or other occupational assignments.

The prohibition of disclosure was associated with increased risk of PTSD. Secrecy has been invoked as an element contributing to the negative effects of childhood sexual abuse (e.g., Leonard, 1996), but there is little empirical evidence on the topic. Our data suggest a complex role for secrecy and disclosure in the development of posttraumatic reactions. We failed to find that disclosure was associated with lower PTSD prevalence, contrary to data linking experimentally induced disclosure with a range of favorable outcomes (Pennebaker, 1997). Concerns about the criminal consequences of disclosure may have been a source of error in reports of the timing of disclosure, but such distortion is unlikely to have produced the observed association between recent disclosure and full PTSD. Instead, differences between prior studies and our own may have been responsible. Our participants controlled the timing and nature of their disclosure, which allowed disclosure to be a reflection of PTSD as well as an influence on PTSD. Also, experimentally induced disclosure is carefully prescribed and usually involves repeatedly writing about a trauma. This may lead to more successful processing of traumatic material than is typical in unstructured discussions, which may result in mixed or negative feedback (Roesler, 1994; Silver et al., 1983) that exacerbates PTSD symptoms.

Our analytic approach allowed us to simultaneously model the effect of each studied risk factor on full- and partial PTSD outcomes. The effect of the risk factor on the likelihood of partial PTSD is thus what is left over provided that full PTSD did not occur. In general, the pattern of results suggested an ordinal relationship between a given risk factor and the two PTSD categories, but fewer risk factors were significant for predicting partial, rather than full, PTSD. The failure of some risk factors (e.g., physical symptoms during testing) to predict partial PTSD may have been due to the relatively small number of men with partial PTSD and the fact that the observed effect sizes usually were smaller than those for full PTSD. We attempted to address this issue by using a higher significance level for comparisons involving partial PTSD but still may have made Type II errors. Several analyses indicated that the smaller number of significant risk factors for partial PTSD than for full PTSD was not due merely to low power, however. Number of exposures and timing of disclosure showed no ordinal relationship to partial and full PTSD. Another exception is protective training, for which the effect was nonsignificantly greater for partial PTSD than for full PTSD.

Both full and partial mustard-gas–related PTSD were associated with physical and psychosocial problems. Relative to veterans without PTSD, those with full PTSD showed the most impairment, reporting substantially greater likelihood of several physical illnesses, severely compromised physical and mental health status, marked functional impairment due to their problems, and greater likelihood of medical disability, psychiatric disability, and unemployment. Veterans with partial PTSD reported increased likelihood of only one illness (COPD), but generally had poorer physical and mental health status and greater functional impairment and medical disability than did veterans without PTSD.

The PTSD groups did not differ with respect to the likelihood of recent health care use aggregated across sources. Because trauma (e.g., Koss, Koss, & Woodruff, 1991) and PTSD (e.g., Kulka et al., 1990) are associated with more health care use, our failure to find effects may have been due to the use of a dichotomous outcome. Amount of use may be a more sensitive measure, especially among older individuals with substantial medical problems. Veterans with full PTSD, and, to a lesser extent, veterans with partial PTSD, reported a higher likelihood of lifetime and recent VA use, however. That effects of PTSD were observed only for VA use may be due to the relatively greater amount of disability awards among the full and partial PTSD groups.

Several of the self-reported physical illness categories associated with full PTSD (pulmonary, dermatologic, ophthalmologic, and sexual) have been causally linked to mustard-gas exposure (Pechura & Rall, 1993), and it is likely that exposure severity directly increased the likelihood of both physical problems and PTSD. However, there are several reasons why it is unlikely that exposure severity is the only explanation for the observed association between PTSD and poor health outcomes. First, we controlled for the physical consequences of exposure by using physical symptoms at the time of the test as a covariate in all analyses. Second, we observed effects of PTSD on gastrointestinal, urologic, and coronary illnesses, which are not causally linked to mustard-gas exposure (Pechura & Rall, 1993). Third, a growing literature shows that PTSD is associated with poor physical health, including morbidity (Beckham et al., 1998; Boscarino & Chang, 1999; Schnurr et al., 2000). PTSD has been proposed as a mediator of the relationship between trauma exposure and poor health (Friedman & Schnurr, 1995; Schnurr & Jankowski, 1999), and path-analytic findings support this possibility (e.g., Schnurr & Spiro, 1999; Taft, Stern, King, & King, 1999). The extent to which PTSD mediates this relationship may depend on the amount of physical harm incurred during a trauma: The greater the amount of harm, the less its effects may be mediated through PTSD and the more its effects may be directly related to poor health.

The role played by health risk factors in the PTSD–health relationship warrants attention. Cigarette smoking did not alter PTSD's effect as a risk factor for illness and was uncorrelated with PTSD, in contrast to other studies (e.g., Boscarino, 1997; Schnurr & Spiro, 1999). Yet smoking remains a likely pathway to coronary and pulmonary morbidity. Alcohol use problems also did not alter PTSD's effect as a risk factor for illness and were not associated with PTSD in this sample of older mustard-gas veterans—in contrast to findings with Vietnam War–era veterans (Kulka et al., 1990). Schnurr and Spiro likewise found that PTSD operated independently of the effects of alcohol use in increasing the risk of physical illness in a sample of older military veterans, so it may be that alcohol use problems and PTSD are separate pathways to illness.

A potential limitation of this study is that our estimates of PTSD are based on self-reported symptoms. It would have been prefer-

able to additionally have clinician ratings, but we chose a verbally administered questionnaire method so that we could maximize sample size. We suggest that the benefit of the large sample size outweighs the potential disadvantage of having self-reported data only, especially in light of the fact that our PTSD measure and other self-report measures of PTSD have very good convergence with clinical diagnosis (Kulka et al., 1990; Weathers et al., 1996). The health and functional outcome measures used in this study also were based on self-reports, and it would have been preferable to have had more objective measures, such as physician diagnosis, laboratory exams, and archival records. However, the illness data came from questions about specific disease states (Boscarino, 1997), many of which had been clearly linked to mustard-gas exposure (Pechura & Rall, 1993). We omitted less serious health conditions, for which the risk of overreporting is greatest—a method that shows good concordance with clinician diagnosis for illnesses that are chronic and involve functional impairment (Edwards et al., 1994). In addition, the SF–36, our other primary source of health information, has good correspondence with objective disease indicators (McHorney et al., 1993).

Another potential limitation is that our data are correlational, which makes it impossible to conclusively establish temporal order for most of the risk factors with respect to the PTSD outcome, or between PTSD and physical health problems. A further issue is that we asked participants to recall events that happened 50 years ago. This is a problem for anyone who is studying older trauma survivors, and we acknowledge that memory errors had to have occurred. We attempted to counter this problem by allowing respondents to answer "don't know" rather than forcing them to answer every question. We also structured the order of questions about mustard-gas exposure to facilitate recall by following a chronological sequence and placed these questions at the beginning of the interview to minimize the effects of participants' fatigue on their answers. Retrospective bias may have played a role as well, artificially inflating the relationship between PTSD and risk factors, for example, by causing individuals with PTSD to overreport exposure or underreport protective factors. Despite these potential limitations, the large size and representativeness of our study sample, along with the good location and excellent participation rates, are strengths that permit reasonable generalization of our findings to the population of surviving mustard-gas veterans.

Our data suggest that even when full PTSD is absent, posttraumatic symptomatology is associated with substantial risk of health-related impairment and disability and excess health care use. These results extend Stein et al.'s (1997) finding of psychosocial impairment in partial PTSD to the domain of physical health. However, neither the physical and mental health outcomes observed in our partial PTSD group nor the risk factor data conclusively indicate whether a categorical or a continuous approach to conceptualizing subsyndromal reactions is preferable. One advantage of using a categorical diagnostic variable in data analysis, rather than a continuous severity score, is enhanced specificity. Some of the men in our no-PTSD group had PTSD scores as high as 50 without reporting mustard-gas–specific intrusions or avoidance. We think it is desirable to distinguish such cases from those who have scores of 50 along with a symptom profile that is more consistent with a *DSM–IV* (American Psychiatric Association, 1994) diagnosis of PTSD.

This study contributes to evidence that PTSD and partial PTSD can result from exposure to toxic substances (e.g., Palinkas et al., 1993; Schottenfeld & Cullen, 1985). Experimental (intentional) exposure to mustard gas is an unusual stressor, in that it occurred in the context of a military exercise that should not have been as dangerous or frightening as combat. Nevertheless, the life threat inherent in mustard-gas exposure (Pechura & Rall, 1993), along with participants' experiences of physical injury and witnessed distress and injury in others and reactions of fear, helplessness, or horror, indicate that experimental exposure to mustard gas was traumatic. As noted above, mustard-gas exposure may have been additionally stressful because it also contained elements of contamination stressors (Green et al., 1994). Our results may be relevant to understanding PTSD in military and civilian populations exposed to events that contain elements of both traditional and contamination stressors. Further research is needed to examine how elements of these stressors interact to promote PTSD and other symptoms.

This study also contributes to evidence about the adverse physical health consequences associated with PTSD. Toxic contamination has been shown to be associated with illness, biological alterations such as increased stress hormone levels, and sociovocational impairment (e.g., Baum & Fleming, 1993; Palinkas et al., 1993), but this is the first study of toxic exposure that examined PTSD as an independent risk factor by controlling for physical reactions to exposure. Our findings suggest that PTSD is a risk factor for persistent physical morbidity and illness independent of the immediate physical effects of toxic exposure.

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