Psychological Effects of Hazardous Materials Exposures

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Objective: To study psychological outcomes after hazardous materials incidents. **Methods:** Individuals exposed to hazardous materials were contacted to complete a telephone questionnaire within 8 to 40 days of the incident. The Brief Symptoms Inventory was used for psychological assessment. General severity index, depression, anxiety, hostility, and somatization were analyzed. Positive findings were defined as two standard deviations above a normative mean. **Results:** A total of 202 (60%) of the 339 subjects in 87 incidents were surveyed. For 159 adults with valid Brief Symptoms Inventory scores, all dimensions were within normal ranges of elevation, with 1% to 5% of the subject pool having elevation, except for somatization. Twenty-four (14%) of 160 subjects had elevated somatization scores. Based on logistic regression analysis, prior medical therapy for a psychological condition and transport to a health care facility were predictors of elevated somatization scores. **Conclusions:** Somatization was the most frequently elevated score after exposure to hazardous materials incidents. Further research is needed to determine whether specific risk factors are useful in identifying individuals for intervention after hazardous materials incidents. **Key words:** hazardous materials, Brief Symptoms Inventory, psychological effects, chemical exposures.

ATSDR = Agency for Toxic Substances and Disease Registry; BSI = Brief Symptoms Inventory; GEE = generalized estimating equations; GSI = general severity index; PTSD = Post-Traumatic Stress Disorder; SCL-90-R = Symptoms Checklist 90 Revised; WPC = Washington Poison Center.

INTRODUCTION

A hazardous material can be defined as any potentially toxic chemical substance, material, or waste that is not a pharmaceutical product, plant, or cosmetic product and that may pose unreasonable risk to life, health, safety, property, or the environment. Common examples include gas and vapor releases, fires, spills, and explosions. Data collected by the ATSDR indicated that in 1997 alone, 5531 incidents occurred in 13 states, with 372 events exposing a total of 1896 people. Of these people, 1261 were transported to a health care facility, 119 were admitted, and 28 died (1).

Although physiological effects of hazardous materials exposures have been reported in various studies, psychological effects are unclear. However, related large-scale disasters, either natural (earthquakes, volcanoes, and fires) or human-made (war, nuclear explosions, and chemical disasters), commonly produce anxiety, depression, hostility, somatic complaints, and PTSD (2, 3). Glesser et al. (4) suggested that factors such as level of perceived control, cause of event (human vs. nature), and degree of treatment affect the psychological impact an event has on a victim.

The present study was conducted to determine individual, exposure, and treatment factors that are associated with self-reported BSI scores of GSI, depression, anxiety, hostility, and somatization after a real or perceived hazardous materials exposure. It was hypothesized that a combination of factors would contribute to the victim's level of stress in response to a chemical exposure. Recognition of factors that impact the level of psychological distress in hazardous materials exposure victims might help first responders and health care professionals to minimize psychological distress through appropriate intervention.

METHODS

Subjects

Individuals were eligible for inclusion in this study if they were potentially exposed to a hazardous materials incident in Washington State and a first responder (firefighter, police, hazardous materials team member, or paramedic) was present at the scene of the incident. The incident must have been reported to the WPC within 24 hours of the exposure start time. Incidents were identified when first responders, health care practitioners, or lay-persons called the WPC to request information. This WPC protocol has been described in previous studies (5, 6). The WPC acts as a mediator for first responders, health care personnel, and toxicologists to determine the best methods for treating exposure victims. The study was approved by the University of Washington Human Subjects Division.

During the initial call to the WPC, on-scene information was collected from the first responder or health care professional. If calls were received from a health care facility or lay-person, the WPC contacted the responding fire department to collect initial on-scene information. Telephone contact numbers for each subject were collected at the initial scene when available. If necessary, the WPC called health care facilities, fire departments, and places of employ-

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ment to obtain telephone contact numbers. Victims were contacted and surveyed on the telephone 8 to 40 days after the incident by specially trained WPC staff or the research study coordinator. After reading a verbatim paragraph describing the study goals, survey content, and confidentiality of information collected, verbal consent was obtained before asking survey questions. Subjects were called until contact with a person or recording device occurred. Up to three messages were left on telephone answering machines, voicemail, or with a person. Subjects not returning phone calls within 30 days after the incident were classified as unable to contact. Subjects that were reached by telephone and declined participation in the study were classified as refusals.

The validity of the initial on-scene incident information was determined by recontacting the first responder agency at least 1 month after the initial call. The person verifying the information was either at the scene during the incident or reading an incident report. The chemical categories used in regression analyses were based on the verified information contained in the final report.

Survey Questionnaire

The telephone survey included information on exposure demographics, exposure severity, medical treatment since exposure, physiological and psychological symptoms since the exposure, past medical history, habits (smoking/drinking), employment, and educational history. Psychological questions came directly after physiological symptom questions on the survey. All survey information was entered into a database, and 110 (54%) of 202 of the surveys were manually verified with an error rate of less than 0.1%.

Psychological symptoms after chemical incidents were measured using the BSI 53-item index, which is a shortened version of the SCL-90-R (7). Administration of the test involved asking 53 questions that describe how much distress a particular problem had caused the subject since the incident, including the day of the survey. Each item received a score between zero and four, with zero being "not at all," one being "a little bit," two being "moderately," three being "quite a bit," and four being "extremely." Subjects had the option to refuse answering any question. When a minor answered the questions, permission was obtained from a parent or guardian. Surveys that were not answered by the person exposed were not used in the analyses, resulting in an exclusion of one (1%) of 169 adult surveys and 25 (76%) of 33 child surveys. Of the eight children who answered the psychological assessment questions, only four (12%) had valid BSI scores. Therefore, only 168 adults were analyzed in this paper.

BSI questions are organized into dimensions of somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, psychoticism, and additional items. All questions are added together then divided by 53 to form the general severity index. Depending on the dimension, if two or three questions were not answered by the subject, the score for that dimension was considered invalid. Valid adults per dimension ranged from 159 to 163. Analyses for somatization were restricted to 160 adult subjects with valid BSI scores. Raw scores were used for all analyses. This paper focuses on general severity index, depression, anxiety, hostility, and somatization.

Analyses

The raw scores of the study population were compared with the raw scores of a "normative" community nonpatient population (7). The normative sample included 494 male and 480 female subjects with a mean age of 46 ± 14.7 years, of whom 87% were white and 60% were married. A mean dimension score for each dimension was calculated using all subjects with valid scores for that dimension. Elevated scores were defined as any mean dimension score that was at least two standard deviations above the normative mean. Each mean dimension score was compared with the defined normative elevated score for that dimension.

Logistic regression models (8) were created for the outcome variable somatization. Each predictor variable was entered into regression models separately at first for bivariate comparison. Predictor variables included control factors (interviewer, time lapse between exposure and survey); individual factors including demographics (current smoker, race, gender, marital status, years of education, prior drinks per week, age), psychological factors (pre-incident counseling, prior use of psychoactive drugs), and health factors (bronchitis, asthma, heart problems, high blood pressure, and chemical sensitivity before the incident); and event factors including exposure factors (inhalation exposure, exposure on skin or clothes, location of exposure (inside/outside), exposure at work, acute symptoms, chemical category, exposure duration), and treatment factors (on-scene decontamination, transport to health care facility, significance of exposure described at the scene). Prior counseling was assessed by a question in the survey that asked, "Before the incident, had you ever seen a psychiatrist, psychologist, or counselor for an emotional problem." Prior use of medication was determined by the survey question, "Before the incident, had you ever been given medication for your nerves, your mood, or the way you were feeling, thinking, or acting?"

A multiple regression model was constructed for somatization by entering each variable that was a significant predictor of the outcome variable at the $p < .10$ level in the bivariate models. Chemical category was removed because the model was unstable with it included.

The method of GEE was used to check for correlation between victims from the same event (9). The correlation within event was quite small (<.10), and the coefficients were little affected, so no adjustment was made for correlation. Because the analyses were exploratory, no adjustments were made for multiple comparisons.

RESULTS

From December 1997 to October 1999, 87 hazardous materials incidents in Washington State meeting the study criteria were reported to the WPC. Of the estimated 575 total individuals potentially exposed, telephone contact information was available for 339 (59%). Surveys were completed for 202 (60%) of these 339 individuals. Of the remaining 137 (40%) victims, 93 (27%) refused participation and 44 (13%) were unable to be contacted. Female subjects represented 55% of participants, 48% of refusals, and 52% of those unable to be contacted. Minors (<18 years of age) represented 16% of participants, 4% of refusals, and 7% of those unable to be contacted. After 33 minors and one adult were excluded because they did not personally answer the survey, 168 adults remained for analysis. Of these 168 adults, a range of 159 to 163 had valid scores on the BSI subsections of the questionnaire. The mean (and median) number of days between exposure and survey was 19. The mean age for valid adults was 39.6 ± 12.1. Table 1 describes the study population.

Of the 168 adult subjects analyzed, six (3.6%) had elevated general severity index scores, three (1.8%)

TABLE 1. Description of Study Population

Variable	Dimensions	N[a]
Demographics		
Marital status	Divorced, widowed, or separated	25
	Never married	44
	Married	90
Education level (yr)	<12	13
	12	44
	>12	102
Age	>40	79
	18–40	81
Psychological factors		
Prior counseling[b]	>1 yr	13
	1 mo–1 yr	25
	None	118
Prior medication[c]	Yes	28
	No	131
Health factors		
Asthma	Yes	22
	No	138
Exposure factors		
Exposure at work	Yes	136
	No	18
Chemical category	Carbon monoxide	7
	Hydrocarbons	16
	Irritants	63
	Mixture	26
	Pesticides	9
	Other/unknown	39
Exposure duration	>60 min	38
	11–60	53
	≥10 min	57
Treatment factors		
Significance explained[d]	Yes	46
	No	113
Transport to health care facility	Yes	103
	No	57

[a] Number out of 160 adults with valid somatization scores.
[b] Prior visit to psychologist, psychiatrist, or counselor for an emotional problem.
[c] Prior use of medications for nerves, moods, thoughts, feelings, or actions.
[d] Significance of exposure explained at the incident scene.

had elevated depression scores, three (1.8%) had elevated anxiety scores, four (2.4%) had elevated hostility scores, and 24 (14.3%) had elevated somatization scores. Mean dimension scores are compared with normative dimension scores in Figure 1. In all dimensions, except somatization, our study population had scores lower (more psychologically well) than the normative scores. The mean somatization score for our population was markedly higher than the normative score. Therefore, somatization was chosen as the focus of analysis.

Table 2 shows our study population compared with the defined elevated scores for the normative population.

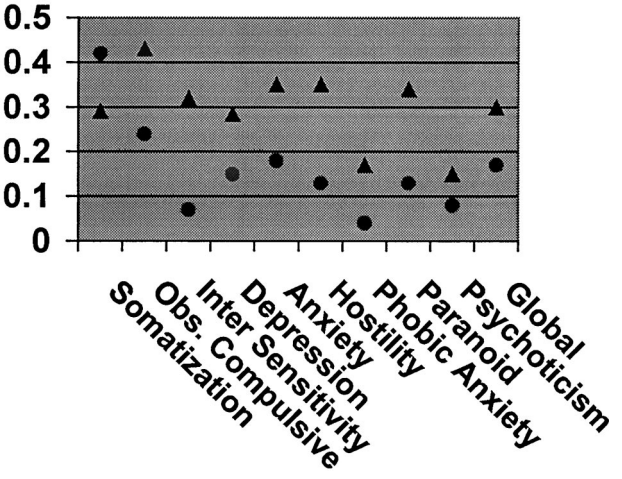

Fig. 1. Mean BSI scores of study population compared with mean normative (Norm) scores. All study (●) mean scores were significantly different than normative (▲) scores ($p < .01$). Obs = obsessive.

The somatization dimension had the highest number of elevated scores, whereas the interpersonal sensitivity dimension had the least number of elevated scores.

Table 3 shows bivariate logistic regression and multiple logistic regression model results for somatization. Bivariate analysis of somatization showed that marital status, educational level, prior medical therapy for a psychological condition, and transport to a health care facility were statistically significant predictors ($p < .05$). With multiple regression analysis, only prior medical therapy for a psychological condition and transport to a health care facility were statistically significant predictors of elevated somatization scores. When transport to a health care facility was removed from the multiple regression model, prior medical therapy for a psychological condition was the only statistically significant predictor of elevated somatization score.

DISCUSSION

Our findings indicate that hazardous materials incidents have an impact on psychological well-being. However, the only mean psychological score that was statistically elevated above the normative population for the BSI (7) was somatization. Thirty-three (20%) of the 168 subjects in this study had psychological scores elevated above average in one dimension, and 11 (7%) had elevated scores in more than one dimension. Although few subjects had elevation in the dimensions of general severity index, depression, anxiety, and hostility, ranging from 1.8% to 3.8% of the subject pool, somatization scores were elevated in 14.3% of the population. Other studies have also suggested an in-

TABLE 2. Dimension Scores in the Normative and Study Populations

Dimension	Normative Population			Study Population	
	Mean	SD	Mean + 2SD	Mean	No. (%) Elevated[a]
Somatization	.29	.40	1.09	.42	24 (14.3)
Obsessive-compulsive	.43	.48	1.39	.24	8 (4.8)
Interpersonal sensitivity	.32	.48	1.28	.07	2 (1.2)
Depression	.28	.46	1.20	.10	3 (1.8)
Anxiety	.35	.45	1.25	.18	3 (1.8)
Hostility	.35	.42	1.19	.13	4 (2.4)
Phobic anxiety	.17	.36	0.89	.04	3 (1.8)
Paranoid ideation	.34	.45	1.24	.13	6 (3.6)
Psychoticism	.15	.30	0.75	.08	7 (4.4)
General Severity Index	.30	.31	0.92	.17	6 (3.8)

[a] Number of scores ≥mean + 2SD of the normative population.

creased level of somatization after a chemical or natural disaster (10–17).

Our study identified significant bivariate risk factors for psychological distress measured by elevated BSI somatization scores, including marital status, education less than or equal to a high school level, prior medical therapy for a psychological condition, and transport to a health care facility. Even though the difference between chemically related physiologic symptoms and psychosomatic symptoms could not be determined by the telephone assessment used in our study, the evaluation of individual and event factors can give an idea of variables that are associated with symptomatic distress after a chemical exposure.

Although no other studies focused specifically on identification for risk factors for somatization after hazardous materials exposure, a review of the relevant literature helps place our findings in context. Common psychological complaints after natural disasters (volcanic eruptions, earthquakes, fires) and human-made disasters (nuclear explosions, wars, chemical spills) include anxiety, depression, hostility, PTSD, alienation, hysteria, fatigue, sleep disturbances, and intrusive thoughts (3, 10, 11, 18–21). Only three published studies on psychological effects of chemical exposures were available for review (12, 19, 21), and similar to our findings, disaster victims had increased stress and psychological complaints. In the literature review of

TABLE 3. Bivariate Logistic Regression and Multiple Logistic Regression Analysis of Subject and Event Risk Factors for Elevated Somatization Score (Value > 1.09)

Variable	Total	Elevated Score	Bivariate OR (95% CI)	Multiple Regression OR (95% CI)
Marital status				
Previously	25	7	4.0 (1.3–12.4)	2.2 (0.5–9.0)
Single	44	9	2.6 (0.9–7.4)	2.0 (0.6–7.1)
Married	90	8	1.0	1.0
Education				
> 12 yr	102	10	0.34 (0.14–0.83)	0.65 (0.22–1.9)
≤ 12 yr	58	14	1.0	1.0
Prior medication[a]				
Yes	42	9	5.0 (1.9–13.2)	5.5 (1.7–17.8)
No	118	15	1.0	1.0
Asthma				
Yes	22	6	2.5 (0.9–7.2)	1.9 (0.5–7.3)
No	138	18	1.0	1.0
Exposure at work				
Yes	136	16	0.4 (0.1–1.1)	0.6 (0.1–2.2)
No	18	5	1.0	1.0
Transport to health care facility				
Yes	103	21	4.6 (1.3–16.2)	6.7 (1.3–33.8)
No	57	3	1.0	1.0

[a] Prior use of medications for nerves, moods, thoughts, feelings, or actions. OR, odds ratio; 95% CI, 95% confidence interval.

all disaster types, compared with control subjects, subjects involved in disasters had significantly higher SCL-90 scores in depression, hostility, anxiety, and general severity index (13, 21), significantly elevated Beck Depression scores (13), higher stress, more intrusive thoughts, and lower perceived control (3, 12, 13). In some studies, up to 80% of disaster victims reported elevated psychological distress (10, 21). Even some physical effects of exposures were explained by elevated distress (19).

Post-disaster psychological effects can vary depending on duration and cause (natural vs. human-made). Some studies show a decreasing level of depression, anxiety, and PTSD over time (2, 3, 12), whereas others show that certain symptoms continue after many years (2, 14). Natural disasters have been associated with an intense but short-term impact because they are usually unexpected, are of brief duration, and have a clearer end point than human-made disasters (12). Shore et al. (2) used the SCL-90 to measure distress in survivors of the Mt. St. Helens eruption and found that depression and anxiety symptoms decreased over time. However, 1 year after flash floods in Puerto Rico, subjects were still reporting elevations in pseudo-neurological symptoms and gastrointestinal measures compared with tests before the floods (22).

Conversely, human-made disasters often have an unclear end point, violate expectations of control, and result in distrust of authorities (11, 12, 23). The perception of threat does not always end with the termination of a human-made accident, so in events that occur at work or near a person's home, chronic stress and fear of ongoing disease is possible (11, 12, 14). Anxiety was found to be associated with diarrhea, trouble concentrating, headaches, and shortness of breath in victims of a hydrofluoric acid spill (19). Our study of small-scale human-made disasters (chemical exposures) focused on the time period of 8 to 40 days after the incident. Because psychological symptoms manifest differently over time, it is difficult to ascertain a person's mental status before or after the testing period (24).

In our study, prior medical therapy for a psychological condition was associated with an increased risk of somatization. Although few other studies looked at psychological disorders before incidents, a study of the Mt. St. Helens disaster revealed that prior depression and anxiety were associated with psychological elevations after the eruption (2, 25). The stress-diathesis model suggests that a combination of individual vulnerability (disposition) and environmental stressors (events) leads to increased symptoms or impaired functioning (26). People with mental illness might lack coping skills that are necessary to deal with community changes after an incident (27).

Although not significantly associated with subjects that had elevated raw somatization scores in our study, age has been found to be associated with adverse outcomes in other studies. In a study of tornado survivors, PTSD was associated with victims aged ≥65 years (18). In a study of exposure to traumatic death, unmarried body handlers reported more avoidance and somatization than married workers (3). Similarly, disruption of social structure has been associated with PTSD in tornado survivors (18) and post disaster distress in evacuated and/or relocated earthquake victims (28), and social support has been associated with reduced stress after a disaster (20, 27).

This study has several limitations. An initial psychological assessment of subjects was not conducted, so it was impossible to assess quantitatively the psychological changes after the exposure. Because contact information was available for only 59% of the total potentially exposed individuals, beyond gender and adult/child status, it was not possible to determine how the unavailable population compared with the study population. This limits our ability to generalize the results to any individual exposed to a hazardous material. Due to concerns about the validity of information provided by proxy, only adults were used for this study. The impact of hazardous materials exposures may be different in children than in adults. As with any self-reported evaluation conducted after an incident, recall bias is an issue (19). However, self-reported psychological measures are described in literature as being an effective way to analyze incident outcome (3, 18, 19). Although the normative data from the BSI manual was used for comparison, the absence of a carefully selected control group for comparison is also a weakness of the study. Some analyses depend on very small numbers for significant odds ratios, so results should be analyzed with caution.

Other than evaluating the effect of general communication with hazardous materials victims regarding the significance of the event, this study was not able to measure the effects of psychological intervention. Reports show that unclear, confusing, or inaccurate information early in an event leads to increased fear, distrust, anxiety, depression, and anger (12, 15, 21). Previous studies suggest that certain coping strategies were successful in decreasing the level of psychological distress after a disaster. First responders and emergency personnel dealing with disaster aftermath reported that pre-incident training exercises and clean-up rituals were helpful during an actual event (25). Emergency personnel and large companies can easily create emergency protocols and training exer-

cises to prepare for disasters. Other coping mechanisms reported to be beneficial after a disaster included social support (12, 18, 20, 21), teamwork/camaraderie (25), and exercises in stress management and mastery over the situation (11, 20). Simple coping mechanisms can be suggested to victims of hazardous materials exposures through handouts or advertised community contact numbers.

In addition to potential interventions at the site of the incident or during transport, it may be reasonable to have social workers or other behavioral health staff available to evaluate hazardous materials exposure victims during the initial evaluation in a health care facility. Based on the risk factors identified in this study, certain victims may be more likely to develop persistent psychological morbidity after exposure, and limiting intervention to this group may be the most cost-effective.

In conclusion, real or perceived exposure to hazardous materials was associated with increased somatization scores 8 to 40 days after the incident. However, hazardous materials exposures did not seem to affect the remaining eight BSI dimensions or the general severity index. Both individual characteristics such as prior medical therapy for a psychological condition as well as incident characteristics such as transport to a medical facility were associated with elevated somatization scores. Additional research is required to support the results of this study and to create guidelines for assessing an individual's risk of psychological distress after a hazardous materials exposure.

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