

Background

The 1993 Defense Authorization Act (PL 102-484, Section 3162) required the U.S. Department of Energy (DOE), formerly the Atomic Energy Commission (AEC), to evaluate the long-term health conditions of former employees who may be at risk for developing occupational diseases as a result of their employment at DOE facilities; thus, establishing the Former Worker Medical Screening Program (FWP).

In 2000, DOE contracted with The University of Iowa College of Public Health to coordinate and implement FWP screenings for those who formerly worked at the DOE-facility at the Iowa Army Ammunition Plant (IAAP).

Iowa Army Ammunition Plant (IAAP)

The IAAP is a 19,000 acre facility near Burlington, Iowa.

Since 1943, the IAAP has housed a large Department of Defense conventional weapons and explosives manufacturing facility (Division A) with over 30,000 employees. Today, the IAAP is still in operation manufacturing conventional weapons with about 600 employees.

From 1949-1975, the IAAP had a previously secret nuclear weapon assembly plant known as Line 1/Division B/Burlington AEC Plant (BAECP) with approximately 5,000 employees. From 1949-1951, BAECP was the only large scale manufacturer of nuclear weapons in the country. In 1975, the nuclear weapons production moved to the Pantex Plant in Amarillo, Texas.

Line 1 Work & Stressors

The Line 1/Division B workers assembled, disassembled, modified and tested nuclear weapons components during the Cold War period and conducted high explosives research to assist in the development of atomic weapons.

Workers were exposed to many toxic substances: ionizing radiation, high explosives, solvents, beryllium, uranium, plutonium, asbestos, isocyanates, epoxy adhesives and curing agents. These toxic exposures can lead to a variety of occupational lung diseases and cancers.

Learning about or revisiting exposures years later could elicit worry, uncertainty, anger, shock, betrayal & fear, which may increase the risk for developing non-clinical stress reactions such as generalized anxiety, depression & traumatic stress. Conversely, the process of learning about past exposures could be healing.

Psychological Stress Effects of Toxic Exposures

Since Love Canal in the 1970s, there has been extensive documentation of the psychological responses and stress reactions worldwide among those exposed to hazardous substances.

Characteristics of Toxic Exposures

- Result from human activities
- Invisible effects & damage (contamination & health effects)
- Occur over many years
- More likely to cause long-term psychological distress than natural disasters¹
- Long-term uncertainty
- Persistent stressors
- Lack of control due to human error
- Undefinable low point

Stressors Specific to Toxic Exposures that Contribute to Chronic Stress^{2, 3, 4, 5, 6}

- Chronic perception of possible threats to health & safety
- Persistent fear of threats
- Uncertainty: invisible nature of exposure, possible latent health effects
- Feelings of loss of control over the present & future
- Isolation and stigmatism
- Community conflict/faction: assigning blame, actions to take
- Economic losses; decline in property value
- Frustration over the lengthy clean-up process
- Confusion over highly technical information
- Dealing with government agencies
- Insufficient medical & psychological services, especially health care professionals trained in environmental health/toxic exposures

Symptoms of Chronic Stress: cognitive, emotional, behavioral, physiological reactions

Thinking	Feelings	Behavior
Poor concentration	Irritability	Impulsiveness
Short attention span	Anger	Inactivity
Memory problems	Anxiety	Dependency
Decision-making conflicts	Depression	Agitated movement
Slow thinking	Mood swings	Arguing
Can't see alternatives	Agitation	Fighting
Confusion	Insecurity	Reduced productivity
	Apprehension	

Psychological Conditions Resulting from Toxic Exposures^{2, 5, 6, 7, 8}

Physical symptoms of stress (HTN, elevated hormone levels, impaired immune functions)	Poor task performance	Increased substance abuse & alcohol consumption
Chronic worry <td>Sleep disturbances <td>Social isolation </td></td>	Sleep disturbances <td>Social isolation </td>	Social isolation
Anger <td>Increased sick days <td>Social conflict </td></td>	Increased sick days <td>Social conflict </td>	Social conflict
Anxiety/Clinical depression <td>Loss of control <td>Demoralization in community </td></td>	Loss of control <td>Demoralization in community </td>	Demoralization in community
PTSD <td>Marital stress <td></td> </td>	Marital stress <td></td>	

Methods

As of July 1, 2011, 1,249 Line 1 former workers completed the 'Distress In Relation to Work' Scale as a part of the self-administered Health & Occupational History Questionnaire in conjunction with their medical screening.

The 'Distress In Relation to Work' Scale consists of seven items tapping into bothersome feelings/difficulties during the past year regarding sleep, anger, irritability, trouble concentrating, feeling down, effects on social activities and reminders of work at IAAP. 93% answered all seven distress items.

The frequency of each item is rated on a three point scale: never (0), little of the time (1) or most of the time (2). Each participants' non-missing response items were averaged and then multiplied by seven to obtain a standardized distress score, ranging from 0 to 14. Cronbach's alpha (based only on non-missing values) was 0.89, indicating that each item's contribution to the overall distress score is relatively equivalent.

Results

Table 1. Distress Scale Score by Demographics of Line 1 Former Workers

Parameter	Total, n(%)	Distress Scale Score mean (SD), range
Age when first screened , mean (SD), range	69.01 (9.3), 40 - 93	
40-49 years old	8 (0.7)	2.50 (2.93), 0 - 8
50-59 years old	224 (18.3)	3.78 (3.83), 0 - 14
60-69 years old	386 (31.5)	3.16 (3.60), 0 - 14
70-79 years old	434 (35.4)	2.97 (3.59), 0 - 14
80-89 years old	169 (13.8)	3.20 (3.66), 0 - 14
90-99 years old	5 (0.4)	6.80 (4.21), 0 - 14
Total	1,226	
Gender		
Male	1,008 (80.7)	3.19 (3.67), 0 - 14
Female	241 (19.3)	3.52 (3.74), 0 - 14
Total	1,249	
Ethnicity		
White	1,032 (95.0)	3.37 (3.71), 0 - 14
African-American	32 (2.9)	5.35 (4.46), 0 - 14
Hispanic	15 (1.4)	5.01 (4.03), 0 - 13
Native American	3 (0.3)	3.00 (3.00), 0 - 6
Mixed	3 (0.3)	2.67 (7.39), 0 - 7
Other	1 (0.1)	4.00 (0.00), 4 - 4
Total	1,086	
Smoking Status		
Current Smoker	126 (11.5)	3.54 (3.57), 0 - 14
Ex-Smoker	553 (50.5)	3.10 (3.63), 0 - 14
Never Smoker	417 (38.0)	3.30 (3.76), 0 - 14
Total	1,096	
Duration of Employment at IAAP , mean (SD), range	11.75 (12.0), <1 - 47	
<1-10 years	685 (60.7)	3.42 (3.75), 0 - 14
11-20 years	180 (15.9)	3.09 (3.68), 0 - 13
21-30 years	140 (12.4)	3.49 (3.69), 0 - 14
31-40 years	97 (8.6)	3.39 (3.59), 0 - 14
41-50 years	27 (2.4)	2.96 (3.77), 0 - 14
Total	1,129	
Decade of Employment at IAAP		
Pre-1950	35 (3.1)	3.71 (4.13), 0 - 14
1950-1959	439 (38.9)	3.11 (3.57), 0 - 14
1960-1969	598 (53.1)	3.58 (3.81), 0 - 14
1970-1979	54 (4.8)	2.48 (3.24), 0 - 13
Total	1,126	
Potential Occupational Exposure to High Explosives		
None/Background	395 (32.5)	2.73 (3.51), 0 - 14
Rare/Low	244 (36.1)	3.01 (3.71), 0 - 14
Occasional, Direct or Indirect	90 (7.4)	3.39 (3.76), 0 - 13
Frequent, Direct	487 (40.0)	3.76 (3.74), 0 - 14
Total	1,216	

Table 2. Frequency of Distress Items by Gender

Distress Items		Frequency of Distress, n(%)			
		Most of the Time	Little of the Time	Never	Total
1) Feeling downhearted and blue <i>Fisher's exact p=0.3281; C-A p=0.2389; JT p=0.1774</i>	Males	68 (6.9)	306 (31.1)	609 (61.9)	983
	Females	17 (7.2)	84 (35.9)	133 (56.84)	234
	Total	85 (7.0)	390 (32.0)	742 (61.0)	1,217
2) Physical or emotional health interfered with attending social activities <i>Fisher's exact p=0.1454; C-A p=0.2935; JT p=0.5179</i>	Males	76 (7.7)	171 (17.3)	739 (74.9)	986
	Females	27 (11.4)	35 (14.8)	174 (73.7)	236
	Total	103 (8.4)	206 (16.9)	913 (74.7)	1,222
3) Trouble falling asleep <i>Fisher's exact p=0.0776; C-A p=0.0419; JT p=0.0715</i>	Males	148 (14.9)	244 (24.5)	603 (60.6)	995
	Females	49 (20.9)	55 (23.5)	130 (55.6)	234
	Total	197 (16.0)	299 (24.3)	733 (59.6)	1,229
4) Trouble staying asleep <i>Fisher's exact p=0.7617; C-A p=0.5173; JT p=0.4955</i>	Males	192 (19.2)	256 (25.7)	550 (55.1)	998
	Females	48 (20.3)	64 (27.1)	124 (52.5)	236
	Total	240 (19.4)	320 (25.9)	674 (54.6)	1,234
5) Feel irritable and angry <i>Fisher's exact p=0.2999; C-A p=0.4390; JT p=0.6228</i>	Males	94 (9.5)	305 (30.7)	594 (59.8)	993
	Females	15 (6.4)	78 (33.2)	142 (60.4)	235
	Total	109 (8.9)	383 (31.2)	736 (59.9)	1,228
6) Trouble concentrating <i>Fisher's exact p=0.8001; C-A p=1.0000; JT p=0.8940</i>	Males	107 (10.8)	268 (27.0)	618 (62.2)	993
	Females	23 (9.8)	68 (28.9)	144 (61.3)	235
	Total	130 (10.6)	336 (27.4)	762 (62.1)	1,228
7) Reminders of work at IAAP caused physical reactions <i>Fisher's exact p=0.0305; C-A p=0.0110; JT p=0.0090</i>	Males	33 (3.3)	120 (12.1)	835 (84.5)	988
	Females	13 (5.6)	39 (16.9)	179 (77.5)	231
	Total	46 (3.8)	159 (13.0)	1014 (83.2)	1,219

C-A: Cochran-Armitage Trend Test
JT: Jonckheere-Terpstra Test

Results

Table 3. Frequency of Distress Items by Potential for Occupational Exposures*

Distress Items		Exposure Potential to High Explosives by Job Title, n(%)				Total
		No Exposure Administrative, Security, Medical, Power Plant, Cafeteria, Carpenter, Custodian, Auto/Equipment Mechanics	Rare/Low Exposure Production (assembly), Laundry, Millwright, Tool & Die, Machinist, Inspector, Storage	Occasional, Direct or Indirect Exposure Pipefitter, Plumber, Process Engineer, Firing Site	Frequent, Direct Exposure Production (fabrication), Explosive Operator Melt, Scientist	
1) Feeling downhearted and blue <i>Fisher's exact p=0.0042; JT p<0.0001</i>	Never	260 (36.0) (67.4)	151 (20.9) (63.5)	55 (7.6) (61.8)	257 (35.5) (61.8)	723 (61.0)
	Little of the time	107 (28.2) (27.7)	74 (19.5) (31.1)	25 (6.6) (36.7)	173 (45.6) (36.7)	379 (32.0)
	Most of the time	19 (22.9) (4.9)	13 (15.7) (5.5)	9 (10.8) (10.1)	42 (50.6) (8.9)	83 (7.0)
	Total	386 (32.6)	238 (20.1)	89 (7.5)	472 (39.8)	1,185
2) Physical or emotional health interfered with attending social activities <i>Fisher's exact p=0.0133; JT p=0.00026</i>	Never	311 (34.9) (80.1)	183 (20.5) (77.5)	64 (7.2) (70.2)	334 (37.4) (70.2)	892 (75.0)
	Little of the time	57 (28.8) (14.7)	33 (16.7) (13.9)	16 (8.1) (17.8)	92 (46.5) (19.3)	198 (16.6)
	Most of the time	20 (20.0) (5.2)	20 (20.0) (8.5)	10 (10.0) (11.1)	50 (50.0) (10.5)	100 (8.4)
	Total	388 (32.6)	236 (19.8)	90 (7.6)	476 (40.0)	1,190
3) Trouble falling asleep <i>Fisher's exact p=0.0022; JT p<0.00058</i>	Never	248 (34.6) (63.6)	158 (22.0) (66.4)	57 (8.0) (63.3)	254 (35.4) (53.1)	717 (60.0)
	Little of the time	94 (32.6) (24.1)	41 (14.2) (22.2)	20 (6.9) (22.2)	133 (46.2) (27.8)	288 (24.1)
	Most of the time	46 (25.1) (12.3)	39 (20.4) (16.4)	13 (6.8) (14.4)	91 (47.6) (19.0)	191 (15.9)
	Total	390 (32.6)	238 (19.9)	90 (7.5)	478 (40.0)	1,196
4) Trouble staying asleep <i>Fisher's exact p=0.0023; JT p=0.0000</i>	Never	243 (37.0) (62.0)	138 (21.0) (57.7)	45 (6.8) (57.7)	231 (35.2) (48.1)	657 (54.7)
	Little of the time	88 (28.5) (22.5)	53 (17.2) (22.1)	29 (9.4) (32.2)	139 (44.9) (32.2)	309 (25.7)
	Most of the time	61 (25.9) (15.6)	48 (20.4) (20.1)	16 (6.8) (17.8)	110 (46.8) (22.9)	235 (19.6)
	Total	392 (32.6)	239 (20.0)	90 (7.5)	480 (40.0)	1,201
5) Feel irritable and angry <i>Fisher's exact p=0.0802; JT p=0.0114</i>	Never	247 (34.4) (63.3)	155 (21.6) (64.6)	51 (7.1) (56.7)	264 (36.8) (55.6)	717 (60.0)
	Little of the time	116 (31.2) (29.7)	61 (16.4) (25.4)	29 (7.8) (32.2)	166 (44.6) (34.9)	372 (31.1)
	Most of the time	27 (25.5) (6.9)	24 (22.6) (10.0)	10 (9.4) (9.5)	45 (42.4) (9.5)	106 (8.9)
	Total	390 (32.6)	240 (20.1)	90 (7.5)	475 (39.8)	1,195
6) Trouble concentrating <i>Fisher's exact p=0.0345; JT p=0.0027</i>	Never	257 (34.7) (65.9)	154 (20.8) (64.7)	56 (7.6) (62.2)	274 (36.9) (57.2)	741 (62.0)
	Little of the time	103 (31.3) (26.4)	63 (19.1) (26.5)	20 (6.1) (22.2)	143 (43.5) (29.9)	329 (27.5)
	Most of the time	30 (23.6) (7.7)	21 (16.5) (8.8)	14 (11.0) (15.5)	62 (48.8) (12.9)	127 (10.6)
	Total	390 (32.6)	238 (19.9)	90 (7.5)	479 (40.0)	1,197
7) Reminders of work at IAAP caused physical reactions <i>Fisher's exact p=0.340; JT p=0.0367</i>	Never	332 (33.5) (85.8)	201 (20.3) (82.2)	74 (7.5) (82.2)	384 (38.8) (80.8)	991 (83.4)
	Little of the time	46 (30.1) (11.9)	26 (16.9) (11.02)	11 (7.2) (12.22)	70 (45.8) (14.7)	153 (12.9)
	Most of the time	9 (20.5) (2.3)	9 (20.5) (3.8)	5 (11.4) (5.6)	21 (47.7) (4.4)	44 (3.7)
	Total	387 (32.6)	236 (19.8)	90 (7.5)	475 (39.9)	1,188

*Job codes, job titles and work tasks were reviewed by industrial hygienists & a group of former workers to develop a qualitative exposure matrix for exposure to high explosives. The estimates for each job category were based on task frequency & proximity to the potential sources of airborne exposures and reflected the group's consensus.

Table 4. Significant Differences Between Independent Variables & Distress Items

Increase in Age by Decade Associated with Increase in:	
<i>Fisher's exact test; JT</i>	
•Downhearted and blue	Fisher's p=0.0100; JT p=0.1307 males Fisher's p=0.0277
•Trouble falling asleep	Fisher's p=0.1118; JT p=0.0709 males JT p=0.0378
•Trouble staying asleep	Fisher's p=0.0449; JT p=0.7317 males Fisher's p=0.0331
•Feel irritable and angry	Fisher's p=0.0108; JT p=0.0018 males Fisher's p=0.0044; males JT p=0.0013
•Trouble concentrating	Fisher's p=0.0786; JT p=0.0582 males Fisher's p=0.0392
Increase in Employment Duration by Decade Associated with Increase in:	
<i>Fisher's exact test; JT</i>	
•Trouble staying asleep	females Fisher's p=0.0703; females JT p=0.0360
Ethnic Minorities Associated with Increase in:	
<i>Fisher's exact test</i>	
•Downhearted and blue	Fisher's p=0.0055; males Fisher's p=0.0070
•Trouble falling asleep	Fisher's p=0.0082; males Fisher's p=0.0104
•Feel irritable and angry	Fisher's p=0.0363; males Fisher's p=0.0579
•Trouble concentrating	Fisher's p=0.0494
•Reminders of work cause physical reactions	Fisher's p=0.0217; males Fisher's p=0.0694; females Fisher's p=0.0171

Findings

Over one-third of Line 1 former workers experienced five distress items (45% had trouble staying asleep; 40% had trouble falling asleep and felt irritable/angry; 39% felt downhearted and blue; 38% had trouble concentrating). The average distress scale score was 3.13 (SD=3.53) and the mode was 0 (38%); thus, 62% had a distress scale score ranging from 1 to 14.

Females had a greater mean distress score (3.52) compared to males (3.19). A greater proportion of females experienced four distress symptoms compared to males (Downhearted and blue: 43% females, 38% males; Trouble falling asleep: 44% females, 39% males; Trouble staying asleep: 47% females, 44% males; Reminders of work: 23% females, 16% males). Whereas a similar proportion of males and females experienced three distress symptoms (~26% health interfered with social activities; ~40% felt irritable/angry; ~38% had trouble concentrating).

Furthermore, females may experience trouble falling asleep and reminders of work that cause physical reactions at a higher rate than males (Fisher's