TABLE 11-9.

Adjusted Analyses for Selected Variables of Peripheral Nerve Function by Group

Variable	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Group: Comparison Number	Comparison Percent	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks
Pin Prick	n	1,003		1,273		****	****	GRP*DIAB(p=0.003)
	Abnormal	59	5.9	79	6.2			AGE(p<0.001)
	Normal	944	94.1	1,194	93.8			
Light Touch	n	964		1,236		1.02 (0.65,1.60)	0.921	OCC*RACE(p=0.013)
	Abnormal	37	3.8	46	3.7			AGE(p=0.043)
	Normal	927	96.2	1,190	96.3			DRKYR(p=0.031)
Muscle Status	n	977		1,248		1.00 (0.57,1.75)	0.999	DRKYR*AGE(p=0.009)
	Abnormal	25	2.6	31	2.5			DIAB*INS(p=0.039)
	Normal	952	97.4	1,217	97.5			
Achilles Reflex	n	971		1,240		1.00 (0.69,1.45)	0.999	DRKYR*OCC(p=0.016)
	Abnormal	56	5.8	71	5.7			AGE(p<0.001)
	Normal	915	94.2	1,169	94.3			DIAB(p<0.001)

****Group-by-covariate interaction--adjusted relative risk, confidence interval, and p-value are not presented.

TABLE 11-10.

Unadjusted Analyses for CNS Coordination Variables by Group

Variable	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Comparison Number	Comparison Percent	Est. Relative Risk (95% C.I.)	p-Value
Tremor	n	1,016		1,292			
	Abnormal	26	2.6	19	1.5	1.76 (0.97,3.20)	0.069
	Normal	990	97.4	1,273	98.5		
Coordination	n	1,015		1,292			
	Abnormal	9	0.9	7	0.5	1.64 (0.61,4.43)	0.327
	Normal	1,006	99.1	1,285	99.5		
Romberg Sign	n	1,015		1,292			
	Abnormal	2	0.2	1	0.1	2.55 (0.23,28.15)	0.586
	Normal	1,013	99.8	1,291	99.9		
Gait	n	1,016		1,290			
	Abnormal	20	2.0	16	1.2	1.60 (0.82,3.10)	0.178
	Normal	996	98.0	1,274	98.8		
CNS Summary Index	n	1,015		1,290			
	Abnormal	48	4.7	39	3.0	1.59 (1.04,2.45)	0.036
	Normal	967	95.3	1,251	97.0		

TABLE 11-11.

Adjusted Analyses for Selected Variables of CNS Coordination by Group

Variable	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Comparison Number	Comparison Percent	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
Tremor	n	1,016		1,288				GRP*INS (marginal:p=0.055) DIAB(p=0.001)
	Abnormal	26	2.6	19	1.5	1.70 (0.93,3.09)	0.080	
	Normal	990	97.4	1,269	98.5			
Gait	n	977		1,246				DIAB(p=0.030) DRKYR*INS(p=0.047)
	Abnormal	20	2.0	15	1.2	1.74 (0.88,3.47)	0.110	
	Normal	957	98.0	1,231	98.8			
CNS Summary Index	n	1,015		1,286				DIAB(p=0.003) OCC(p=0.018)
	Abnormal	48	4.7	38	3.0	1.57 (1.01,2.43)	0.042	
	Normal	967	95.3	1,248	97.0			

These statistics were quite similar to the unadjusted tests, and showed borderline significance for tremor, nonsignificance for gait, and significance for the CNS summary index. The unexpected inverse relationship of tremor abnormalities to diabetic classification is again noted. The borderline group-by-insecticide interaction was investigated, and the results are given in Table 11-7. As shown, the relative risk for Ranch Hands exposed to insecticides was statistically significant (RR: 2.60, 95% C.I.: [1.15,2.90], p=0.022), whereas the relative risk for unexposed Ranch Hands was nonsignificant. This finding may have both an operational and biologic foundation, because records indicate that some Ranch Hands were exposed to the insecticide Malathion®, a cholinesterase inhibitor, during insecticide missions for malaria prevention. Comparisons, by definition, did not fly these missions.

EXPOSURE INDEX ANALYSES

Exposure index analyses were conducted within each occupation cohort of the Ranch Hand group to search for dose-response relationships (see Chapter 8 for details on the exposure index). All 27 variables and three summary indices were explored (unadjusted for any covariates) as with the unadjusted tests for group differences discussed previously in this chapter. These variables were investigated using Pearson's chi-square test and Fisher's exact

test. Adjusted analyses were performed by logistic regression for the 10 variables (7 neurological parameters and 3 summary indices) for which adjusted analyses of group differences were previously examined. These analyses were accomplished, adjusted for age, diabetic class, insecticide exposure, and drink-years (all discretized), and any significant pairwise interactions between the exposure index and these covariates. Race was not included in adjusted analyses because of the absence of any race effect in the previous group difference analyses. Overall significance in the proportion of abnormalities among the exposure index levels of low, medium, and high was determined, as well as contrasts in the proportion of abnormalities between the medium and low exposure levels, and between the high and low exposure levels. Exclusions were made as described previously.

Results of the adjusted analysis are presented in Table 11-12, and results for unadjusted analyses appear in Table I-1 of Appendix I. Results from further study of exposure index-by-covariate interactions are given in Table I-2 of Appendix I.

Unadjusted analyses revealed borderline significant differences among exposure index levels for pin prick in enlisted groundcrew ($p=0.052$) and Achilles reflex in enlisted flyers ($p=0.059$). The data did not support an increase in the proportion of abnormalities with increasing exposure levels, however.

Adjusted analyses yielded similar conclusions, in that significant or borderline significant results did not support an increase in the proportion of abnormalities with increasing exposure, and that very few significant results were observed. The pattern of abnormalities with the 10 variables was studied, and in no occupational strata was an increasing dose-response relationship evident. In fact, the high exposure level often had a smaller (although nonsignificant) proportion of abnormalities than the low and medium levels.

Interactions were present for 5 of the 10 variables, and occurred primarily in the enlisted groundcrew stratum. A summary of these interactions is presented in Table 11-13.

Meaningful interpretation of the interactions was difficult, due to the small numbers of abnormalities within a covariate strata. No significant adverse effects to participants with higher exposure levels were evident, however, in this analysis.

In summary, no evidence of an increasing dose-response relationship at the followup examination was observed. No increase in prevalence rates was seen as exposure levels increased. These results essentially were in agreement with the findings of the Baseline Study.

TABLE 11-12.

Adjusted Exposure Index Analyses for Neurological Variables by Occupation

Variable	Occupation	Exposure Index: Low Total	Exposure Index: Medium Total	Exposure Index: High Total	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Neck Range of Motion	Officer	125	127	120	Overall		0.906
					M vs. L	0.82 (0.31,2.18)	0.686
					H vs. L	0.97 (0.37,2.56)	0.955
	Enlisted Flyer	51	61	53	Overall		0.940
					M vs. L	0.79 (0.20,3.20)	0.744
					H vs. L	0.83 (0.21,3.31)	0.786
	Enlisted Groundcrew	148	160	132	Overall		0.299
					M vs. L	0.93 (0.27,3.21)	0.908
					H vs. L	0.36 (0.09,1.51)	0.163
Cranial Nerve Function Index	Officer	120	127	119	Overall		0.551
					M vs. L	0.63 (0.28,1.44)	0.277
					H vs. L	0.78 (0.35,1.78)	0.560
	Enlisted Flyer	51	60	53	Overall		0.808
					M vs. L	1.00 (0.29,3.43)	0.999
					H vs. L	0.68 (0.18,2.59)	0.569
	Enlisted Groundcrew	145	158	131	Overall		****(1)
					M vs. L	****(1)	****(1)
					H vs. L	****(1)	****(1)

TABLE 11-12. (continued)

Adjusted Exposure Index Analyses for Neurological Variables by Occupation

Variable	Occupation	Exposure Index: Low Total	Exposure Index: Medium Total	Exposure Index: High Total	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Cranial Nerve Function (Neck Range of Motion Excluded)	Officer	120	127	119	Overall		0.148
					M vs. L	0.30 (0.08,1.22)	0.093
					H vs. L	0.36 (0.09,1.45)	0.150
	Enlisted Flyer	51	60	53	Overall		0.860
					M vs. L	1.04 (0.13,8.27)	0.969
					H vs. L	0.56 (0.05,6.58)	0.642
	Enlisted Groundcrew	145	158	131	Overall		0.894
					M vs. L	0.75 (0.23,2.45)	0.639
					H vs. L	0.84 (0.25,2.76)	0.773
Pin Prick	Officer	124	124	119	Overall		0.277
					M vs. L	0.43 (0.13,1.38)	0.156
					H vs. L	0.49 (0.17,1.43)	0.191
	Enlisted Flyer	51	60	53	Overall		0.399
					M vs. L	0.33 (0.05,2.35)	0.267
					H vs. L	1.02 (0.23,4.60)	0.979
	Enlisted Groundcrew	146	159	128	Overall		0.108
					M vs. L	0.86 (0.32,2.34)	0.765
					H vs. L	0.28 (0.07,1.07)	0.062

TABLE 11-12. (continued)

Adjusted Exposure Index Analyses for Neurological Variables by Occupation

Variable	Occupation	Exposure Index: Low Total	Exposure Index: Medium Total	Exposure Index: High Total	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Light Touch	Officer	124	124	119	Overall		0.047
					M vs. L	0.39 (0.11,1.40)	0.148
					H vs. L	0.20 (0.05,0.83)	0.027
	Enlisted Flyer	51	60	53	Overall		****(2)
					M vs. L	****(2)	****(2)
					H vs. L	****(2)	****(2)
	Enlisted Groundcrew	146	159	128	Overall		0.777
					M vs. L	1.27 (0.34,4.80)	0.725
					H vs. L	0.74 (0.16,3.35)	0.699
Muscle Status	Officer	125	127	120	Overall		0.105
					M vs. L	0.15 (0.02,1.01)	0.051
					H vs. L	0.57 (0.14,2.30)	0.433
	Enlisted Flyer	51	61	53	Overall		0.979
					M vs. L	0.90 (0.04,22.10)	0.946
					H vs. L	0.74 (0.04,14.77)	0.841
	Enlisted Groundcrew	148	160	132	Overall		****(3)
					M vs. L	****(3)	****(3)
					H vs. L	****(3)	****(3)

TABLE 11-12. (continued)

Adjusted Exposure Index Analyses for Neurological Variables by Occupation

Variable	Occupation	Exposure Index: Low Total	Exposure Index: Medium Total	Exposure Index: High Total	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Achilles Reflex	Officer	122	126	120	Overall		0.384
					M vs. L	0.43 (0.13,1.46)	0.175
					H vs. L	0.65 (0.21,1.99)	0.448
	Enlisted Flyer	51	60	53	Overall		0.021
					M vs. L	--	--
					H vs. L	0.65 (0.16,2.76)	0.564
	Enlisted Groundcrew	147	160	132	Overall		****(3)
					M vs. L	****(3)	****(3)
					H vs. L	****(3)	****(3)
Tremor	Officer	125	127	120	Overall		0.219
					M vs. L	0.19 (0.02,1.66)	0.132
					H vs. L	0.63 (0.14,2.89)	0.548
	Enlisted Flyer	51	61	53	Overall		0.625
					M vs. L	2.11 (0.19,23.39)	0.542
					H vs. L	2.95 (0.29,30.43)	0.364
	Enlisted Groundcrew	148	160	132	Overall		0.396
					M vs. L	0.91 (0.22,3.66)	0.889
					H vs. L	0.28 (0.03,2.44)	0.248

TABLE 11-12. (continued)

Adjusted Exposure Index Analyses for Neurological Variables by Occupation

Variable	Occupation	Exposure Index: Low Total	Exposure Index: Medium Total	Exposure Index: High Total	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Gait	Officer	125	127	120	Overall		0.483
					M vs. L	0.26 (0.02,3.25)	0.298
					H vs. L	0.89 (0.12,6.76)	0.912
	Enlisted Flyer	51	61	53	Overall		0.188
					M vs. L	0.64 (0.07,6.05)	0.693
					H vs. L	--	--
	Enlisted Groundcrew	148	160	132	Overall		0.576
					M vs. L	0.42 (0.07,2.51)	0.343
					H vs. L	0.88 (0.19,3.99)	0.868
CNS Summary Index	Officer	125	127	120	Overall		0.123
					M vs. L	0.22 (0.04,1.10)	0.066
					H vs. L	0.57 (0.15,2.10)	0.399
	Enlisted Flyer	51	60	53	Overall		0.930
					M vs. L	1.21 (0.25,5.92)	0.818
					H vs. L	0.90 (0.17,4.80)	0.899
	Enlisted Groundcrew	148	160	132	Overall		****(2)
					M vs. L	****(2)	****(2)
					H vs. L	****(2)	****(2)

--No abnormal participants present in medium exposure index level for Achilles reflex (or high level for gait) in enlisted flyers.

****(1)Exposure index-by-diabetic class interaction--relative risk and p-value not presented.

****(2)Exposure index-by-insecticide exposure interaction--relative risk, confidence interval, and p-value not presented.

****(3)Exposure index-by-age interaction--relative risk, confidence interval, and p-value not presented.

TABLE 11-13.

Summary of Exposure Index-by-Covariate Interactions for Neurological Variables

Variable	Occupation	Covariate	p-Value
CNF Summary Index	Enlisted Groundcrew	Diabetic Class	0.045
Light Touch	Enlisted Flyer	Insecticide Exposure	0.026
Muscle Status	Enlisted Groundcrew	Age	0.026
Achilles Reflex	Enlisted Groundcrew	Age	0.014
CNS Summary Index	Enlisted Groundcrew	Insecticide Exposure	0.010

LONGITUDINAL ANALYSES

Two variables, the modified Romberg sign and the Babinski reflex, were investigated to assess longitudinal differences between the 1982 Baseline examination and the 1985 followup examination. Both variables were classified as abnormal or normal. As shown in Table 11-14, 2x2 tables were constructed for each group for each variable. This table shows the number of participants who were abnormal at the Baseline examination and abnormal at the followup examination, abnormal at Baseline and normal at the followup, normal at Baseline and abnormal at the followup, and normal at both Baseline and the followup. The odds ratio is the ratio of the number of participants who were normal at Baseline and abnormal at the followup to the number of participants who were abnormal at Baseline and normal at the followup (the "off-diagonal" elements). The p-value was derived from Pearson's chi-square test of the hypothesis that there was comparable change in the two groups over time.

These data showed no longitudinal difference in the change pattern in the Romberg sign in the two groups, but they did show a significant change in the Babinski reflex. In the Baseline examination, the Ranch Hands had a significantly greater proportion of reflex abnormalities than the Comparisons, but the followup examination showed approximately the same percentage of abnormality in both groups (Est. RR: 1.02, 95% C.I.: [0.27,3.80, p=0.999]).

SUMMARY AND CONCLUSIONS

Interval questionnaire data (1982 through 1985) on neurological illnesses, verified by medical records, revealed no significant group differences. These data were added to verified Baseline historical information to assess possible differences in the lifetime experience of neurological disease. Again, there was no significant difference between the Ranch Hand and Comparison groups.

TABLE 11-14.

Longitudinal Analysis of Romberg Sign and Babinski Reflex: A Contrast of Baseline and First Followup Examination Abnormalities

Variable	Group	1982 Baseline Exam	1985 Followup Exam: Abnormal	1985 Followup Exam: Normal	Odds Ratio (OR)*	p-Value (OR_{RH} vs. OR_C)
Romberg Sign	Ranch Hand	Abnormal	2	188	0	0.38
		Normal	0	777		
	Comparison	Abnormal	0	250	0.004	
		Normal	1	886		
Babinski Reflex	Ranch Hand	Abnormal	1	7	0.43	0.04
		Normal	3	953		
	Comparison	Abnormal	0	1	5.00	
		Normal	5	1,129		

*Odds Ratio: $\frac{\text{Number Normal Baseline, Abnormal Followup}}{\text{Number Abnormal Baseline, Normal Followup.}}$

A detailed neurological examination evaluated neurological integrity in three broad areas: cranial nerve function, peripheral nerve function, and central nervous system (CNS) coordination. The summary analytic results for all measurement variables comprising these three functional areas are presented in Table 11-15.

Assessment of the 12 cranial nerves was based on the measurement of 14 variables. Two summary indices were constructed. Both the unadjusted and adjusted analyses did not disclose any statistically significant group differences, although two variables, speech and tongue position, were of borderline significance, with Ranch Hands faring worse than Comparisons. One of the two cranial nerve summary indices was marginally significant, again with the Ranch Hands at a slight detriment.

The unadjusted and adjusted analyses of peripheral nerve function, as measured by eight variables (four reflexes, three sensory determinations, and muscle mass), did not reveal significant group differences.

CNS coordination was evaluated by four measurements and a constructed summary variable. Hand tremor was found to be of borderline significance, with the Ranch Hands faring slightly worse than the Comparisons. The CNS summary index showed a significant detriment to the Ranch Hands.

The exposure analyses for neurological variables with reasonable counts of abnormalities showed only occasional statistically significant results. No consistent pattern with increasing exposure was evident for any occupational category of the Ranch Hand group.

TABLE 11-15.

Overall Summary Results of Unadjusted and Adjusted Analyses of Neurological Variables

Variable	Unadjusted	Adjusted	Direction of Results**
Questionnaire[a] Physical Examination			
Neurological Disease (Interval)	NS[b]	--	
Neurological Disease (History)	NS	--	
Cranial Nerve Function			
Smell	NS	--	
Visual Fields	NS	--	
Light Reaction	NS	--	
Ocular Movements	NS	--	
Facial Sensation	NS	--	
Corneal Reflex	--[c]	--[c]	
Jaw Clench	NS	--	
Smile	NS	--	
Palpebral Fissures	NS	--	
Balance	NS	--	
Gag Reflex	NS	--	
Speech	NS*	--	RH>C
Tongue Position Relative to Midline	NS*	--	RH>C
Palate and Uvula Movement	NS	--	
Neck Range of Motion	NS	NS	
Cranial Nerve Function Index[d]	NS	NS	
Cranial Nerve Function Index[d] (excluding Neck Range of Motion)	NS*	NS*	RH>C
Peripheral Nerve Function			
Pin Prick	NS	****	
Light Touch	NS	NS	
Muscle Status	NS	NS	
Vibratory Sensation	NS	--	
Patellar Reflex	NS	--	
Achilles Reflex	NS	NS	
Biceps Reflex	NS	--	
Babinski Reflex	NS	--	

TABLE 11-15. (continued)

Overall Summary Results of Unadjusted and Adjusted Analyses of Neurological Variables

Variable	Unadjusted	Adjusted	Direction of Results**
Central Nervous System Coordination			
Tremor	NS*	NS*	RH>C
Coordination	NS	--	
Romberg Sign	NS	--	
Gait	NS	NS	
CNS Summary Index[d]	0.036	0.042	RH>C

**RH>C: More abnormalities in Ranch Hand group than in Comparison group.

[a]Disease categories include: inflammatory diseases, heriditary and degenerative diseases, peripheral disorders, disorders of the eye, disorders of the ear, and other disorders.

NS:Not significant ($p>0.10$).

[b]No inflammatory diseases noted; borderline significant ($p=0.069$, RH>C) for other disorders; not significant for remaining categories.

--Analysis not performed because of sparse number of abnormalities.

[c]No abnormalities present.

NS*Borderline significant ($0.05<p\leq 0.10$).

[d]Constructed variable.

****Group-by-covariate interaction.

In a longitudinal analysis of the Romberg sign and the Babinski reflex, only the Babinski reflex revealed a significant difference between the Baseline and followup examination, with the Ranch Hands converting from significant adverse findings at Baseline to favorable nonsignificant findings at the followup examination.

Overall, the followup examination findings are quite similar to the Baseline findings. However, several distinct patterns were evident from the analyses: (1) The followup examination detected substantially fewer abnormalities for almost all measurement variables, (2) the decrease in abnormalities was equivalent in both groups, (3) most of the covariate effects were classical, although exceptions were evident, (4) the adjusted analyses were uniformly similar to the unadjusted analyses, (5) the constructed summary variables were generally statistically significant, or of borderline significance (however some indices were created after the data were examined), and (6) although statistical significance at the pre-assigned α-level of 0.05 was not achieved for any of the measurement variables, abnormalities tended to cluster in the Ranch Hand group.

Of the three group-by-covariate interactions in the adjusted analyses, only one, a borderline group-by-insecticide exposure interaction for hand tremor, where Ranch Hands exposed to insecticides had a marginally significant adverse effect, was of probable biologic (and operational) significance.

In conclusion, none of the 27 neurological variables demonstrated a significant group difference, although several showed an aggregation of abnormalities in the Ranch Hand group, which merits continued surveillance. Historical reporting of neurologic disease was equal in both groups. The clinical sensitivity in detecting neurological deficits varied substantially between the Baseline and the followup examinations, but the number of statistically significant variables remained about the same. None of the exposure analyses revealed dose-response patterns in the Ranch Hand occupational categories. The longitudinal analyses disclosed a favorable reversal of significant Babinski reflex abnormalities at Baseline to nonsignificant findings at the followup examination for the Ranch Hands. The similarity in results between unadjusted and adjusted statistical tests is evidence of group equality for the traditionally important neurological covariates of age, alcohol, and diabetes. Of three group-by-covariate interactions in the adjusted analyses, only the Ranch Hand insecticide interaction with hand tremor was biologically plausible.

CHAPTER 11

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CHAPTER 12

PSYCHOLOGICAL ASSESSMENT

INTRODUCTION

Emotional illnesses or psychological abnormalities are not recognized as primary clinical endpoints following exposure to chlorophenols, phenoxy herbicides, and dioxin. "Neurobehavioral effects" occasionally ascribed to such exposures have been, in fact, predominantly neurological symptoms for which causation is not disputed (see Chapter 11). Higher CNS functioning, in terms of cognitive skills, personality, and reactivity, may be temporarily or permanently impaired depending on the exposure and the ability to measure accurately the psychological changes.

Animal studies provide little insight into possible human psychological problems. Animal signs of lethargy, stupor, poor coordination, lack of feeding, and agitation have been observed in multiple studies involving many species. These signs have generally been attributed to the "wasting syndrome" or multi-organ toxicity, rather than primary CNS toxicity.[1] A study of "behavioral" effects in rats following single and weekly doses of 2,4-D showed that the central effects of decreased coordination and lever-pressing behavior were transient and reversible.[2] Further, no latent CNS impairment was detected after a d-amphetamine challenge.

Human studies and case reports have occasionally noted psychological disorders or symptom complexes following exposure to herbicides and TCDD. Complaints included headache, anxiety, malaise, depression, abnormal anger, mood changes, sleep disturbances, decreased libido, and impotence. Scientific confirmation of these symptoms by psychological testing is difficult and exclusion of other plausible causes such as age, preexisting psychological abnormalities, or even motivation for compensation is often impossible. Most studies have merely recorded complaints and have not pursued their validation by indepth functional testing.

Early studies of industrial chemical workers first provided the suggestion of psychological effects. Followup studies from the Nitro, West Virginia, accident in 1949, showed "nervousness," fatigue, irritability, cold intolerance, and decreased libido in many of the workers with chloracne, but most of these symptoms subsided over a 4-year period.[3,4] Two followup studies in 1979, by different investigators of expanded (but slightly different) plant cohorts, noted reports of sexual dysfunction and decreased libido.[5,6] One of these studies noted that these observations (and insomnia) were significantly increased in individuals with chloracne.[5] Neither of these followup efforts conducted neurobehavioral tests to validate the reported symptoms.

Other industrially based studies reported symptoms of fatigue,[7-13] decreased libido,[7] impotence,[7] sleep disturbances,[8,11-13] reduced emotional responses,[8] sensory deficits of smell, taste, and hearing,[9] reading

difficulties,[9] memory loss,[11] and emotional disorders.[12,13] Symptoms of depression and anxiety have been associated with disfiguring chloracne. One study found a relationship between chloracne and hypomania as determined from the MMPI,[14] and another noted that two of three chemists involved in the synthesis of TCDD developed marked personality changes.[15] Although data interpretation problems exist, the Czechoslovakian 10-year followup study cited eight cases of severe dementia in exposed workers and reported that symptoms of anxiety and depression decreased over the followup period.[13]

A contemporary cross-sectional morbidity study of a mobile-home park, environmentally contaminated with dioxin, showed subclinical hepatic, hematologic, immunologic, and psychological changes in exposed residents.[16] Significant abnormalities were recorded in the exposed group for the tension/anxiety and anger/hostility scales of the profile of mood states (POMS) inventory, as well as the vocabulary subtest of the Wechsler adult intelligence scale (WAIS). However, functional testing by the Halstead-Reitan battery (HRB) did not reveal significant group differences. There was no way to differentiate between the primary effects of exposure and the secondary effects of media attention.

In contrast to industrial cohorts, the study of chemically related psychological problems in veterans has proved more difficult because of the confounding effects of combat stress and the post-traumatic stress disorder (PTSD), and the uncertainty of exposure. Of almost 100,000 Vietnam veterans registered in the VA's Agent Orange Registry in 1983, 18 percent complained of "nervousness" and 10 percent cited personality disorders.[17] A psychiatric review of 132 veterans included in the Registry, most of whom had been referred for treatment, disclosed a symptom hierarchy of sleep disorders (53%), mood depression (36%), suicidal thoughts (35%), and irritability (31%).[18] Fifty-three percent of these veterans received the PTSD diagnosis.

In 1980, the American Psychiatric Association established the term "post-traumatic stress disorder" to define a neurosis caused by extreme psychic trauma, e.g., natural disaster, war, imprisonment, or torture.[19] PTSD comprises the symptoms of anxiety, "powder keg" anger, depression, irritability, restlessness, recurrent intrusive dreams, flashbacks, and sleeplessness. Quiescent PTSD may be acutely reactivated in some individuals by specific triggering events (e.g., visiting the Vietnam Memorial).[20] The disorder is equally applicable to civilians following emotionally traumatic experiences. The onset of PTSD may immediately follow the traumatic event or it may occur years afterward. The older war terms shell shock, combat fatigue, and anxiety reaction generally referred to the more immediate symptoms following the trauma although components of PTSD are now recognized in veterans of earlier wars.

The prevalence of PTSD in Vietnam veterans is unknown, and even the qualitative assessments of "common" or "rare" are debatable.[21,22] A 7-month incidence of legal and emotional maladjustments in returning Vietnam veterans occurred at the rate of 23 percent and did not differ significantly from comparable rates in nonveterans.[23] Though a concise definition of PTSD exists, there is controversy as to the best means of diagnosis. Some workers prefer a full and thorough clinical interview[21] while others favor empiric symptom scales.[24] Clearly, each method serves a different, but highly related, purpose: clinical diagnosis in individuals versus an epidemiological/statistical diagnosis in groups.

Risk factors for the development of PTSD may include emotional predisposition, social/ethnic background, parental factors, race, and combat intensity ranging from slight involvement to atrocity behavior.[21,25,26] Parallel conditions to PTSD (or perhaps unrecognized components of PTSD) encompass alcoholism, drug abuse, lawlessness (arrests/felony convictions), personality disorders, and frank psychosis.[21,25-27] This chapter attempts to isolate any psychological disorders attributable to herbicide exposure.

Baseline Summary Results

Extensive psychological parameters were assessed on all participants during the 1982 Baseline questionnaire and physical examination. The expected high degree of concordance between education (college, high school) and military status (officer, enlisted) was observed and validated the sole use of education as a covariate representing socioeconomic status for most analyses.

There were no questionnaire differences for past history of emotional or psychological illnesses between the Ranch Hand and Comparison groups. For the psychological indices of fatigue, anger, erosion, anxiety, and severity of depression (as determined by a modification of the Diagnostic Interview Schedule[28]), no group differences were detected among the college-educated Ranch Hands. However, for the high school-educated stratum, Ranch Hands demonstrated highly significant pathology for fatigue, anger, erosion, and anxiety. An unadjusted analysis of reported depression showed significantly more depression in the Ranch Hands, as did the isolation index adjusted for educational level. Exposure index analyses from the Ranch Hand questionnaire data did not suggest a relationship between exposure and psychological abnormality.

At the time of the physical examination, additional self-reported data were collected with the Cornell Index and the MMPI. The CNS functional testing was conducted by a modified HRB, and intelligence was measured by the WAIS.

The Cornell Index showed a significant increase in psychophysiologic symptoms in the high school-educated Ranch Hands. Six of 10 parameters of the Cornell Index were abnormal in the Ranch Hands (e.g., fear, startle, psychosomatic) as contrasted to the Original Comparisons, and all abnormal responses/parameters were inversely related to education to a statistically significant degree. MMPI results in the high school-educated participants showed differences in the scales of denial, hypochondria, masculinity/femininity, and mania/hypomania as contrasted to the college-educated group. Only the social introversion scale was significant in the college-educated participants. The effect of education was influential ($p<0.01$) in all scales of the MMPI. Race was not a significant covariate. All self-reported data, including those from the in-home questionnaire, were not adjusted for possible group differences in PTSD or combat experience/intensity.

Performance testing by the HRB showed no neuropsychiatric impairment in the Ranch Hands as contrasted to their overall self-administered MMPI and Cornell Index. In fact, Ranch Hand over-reporting was suggested in several parameters, but was not proved. The effect of education on the Halstead-Reitan testing was profound ($p<0.0001$). WAIS intelligence scores revealed very close group similarities in the full-scale and verbal and performance

scales. As expected, the intelligence quotient (IQ) of college graduates was significantly higher than the IQ of high-school graduates. Exposure index analyses of the HRB and WAIS data were negative and disclosed no patterns that suggested an herbicide effect.

Parameters of the 1985 Psychological Assessment

Two of the psychological tests (MMPI, HRB) conducted at the 1982 Baseline examination were repeated at the first followup examination in 1985. Repetitive testing was accomplished for purposes of clinical validation, establishment of comparable longitudinal parameters, and comparable covariate adjustments by concurrently derived PTSD and combat experience indices.

Questions from the Diagnostic Interview Schedule were deleted from the followup questionnaire and were replaced by questions on combat experience in Vietnam. An updated history of mental and emotional disorders was obtained on all participants. A PTSD indicator was derived from a new MMPI subscale[24] and was used for covariate adjustments of non-MMPI psychological data. The WAIS IQ assessment was deleted, but all parameters of the MMPI and HRB were retained. The Cornell Medical Index (CMI)[29] was substituted for the Cornell Index in the 1985 psychological assessment.

The dependent variables and covariates of the followup examination are similar to those analyzed at the Baseline. Longitudinal analyses of the MMPI scales of denial and depression consider the change of psychological test indices between groups.

All statistical analyses are based on 1,016 Ranch Hands and 1,293 Comparisons. No individuals were excluded from the analysis of the psychological data for medical reasons. Sample size differences in the tables below reflect missing data from scale or battery test results, or from relevant covariates. The statistical tests use log-linear models, logistic regression models, Kolmogorov-Smirnov nonparametric tests, Fisher's exact test, and Pearson's chi-square test. Parallel analyses using Original Comparisons are in Tables J-8 through J-18 of Appendix J.

RESULTS AND DISCUSSION

Questionnaire Data

At the followup interview, each participant was asked whether he had ever had a mental or emotional disorder. Whenever possible, the conditions were coded using ICD-9-CM. Reported disorders for which treatment was obtained were subsequently verified by reviews of medical records. Table 12-1 contains a tabulation of the distribution of these psychological illnesses, with information from the Baseline and followup studies combined.

None of the types of illness categories showed statistically significant differences between groups; however, the "other neuroses" category is significant ($p=0.037$), with the Ranch Hands showing more adverse effects, when only Original Comparisons are used (see Table J-8 of Appendix J).

TABLE 12-1.

Unadjusted Analyses for Reported Psychological Illnesses by Group: Baseline and First Followup Studies Combined*

	Group Abnormalities					
	Ranch Hand		Comparison			
Type of Illness	Number	Percent	Number	Percent	Total	p-Value**
Psychoses	14	1.4	9	0.7	23	0.138
Alcohol Dependence	9	0.9	8	0.6	17	0.473
Anxiety	7	0.7	13	1.0	20	0.501
Other Neuroses	72	7.1	74	5.7	146	0.197

*Analyses based on 1,016 Ranch Hands and 1,293 Comparisons; some participants may have had more than one illness.

**Fisher's exact test.

Psychological Examination Data

The MMPI is a self-administered test consisting of 566 questions on various aspects of behavior and personality. The results of the MMPI are numerical scores for 14 scales. The scales are anxiety (psychasthenia), consistency (F-scale), defensiveness (L-scale), denial (K-scale), depression, hypochondria, hysteria, mania/hypomania, masculinity/femininity, paranoia, psychopathic/deviate, schizophrenia, social introversion, and validity. The normal range of scores from 30 to 70 was used to categorize the results as normal or abnormal for all scales except validity. For validity (the number of unanswered questions) categories of 0 or greater than 0 were used. The test was administered to all 2,309 participants. A participant was considered nonresponsive in the MMPI if more than 30 questions (approximately 5%) were unanswered. Due to nonresponse, data on six participants, (two Ranch Hands and four Comparisons) were omitted from the analysis of all variables except validity. Thus, the MMPI analyses were based on 1,014 Ranch Hands and 1,289 Comparisons.

The CMI is a self-administered instrument used to collect a substantial amount of medical and psychiatric data. The 195 questions of the CMI are partitioned into 18 sections (A to R) with the number of questions within a section ranging from 6 to 23. The analysis of the CMI was based on three scores: the total CMI score, an M-R subscore, and an A-H area subscore. The total CMI score is the number of affirmative responses on the entire questionnaire and is analyzed as a continuous variable. The M-R subscore, which deals with mood and feeling patterns, is a useful indicator of

emotional ill-health. This subscore is the total number of affirmative responses to the 51 questions in sections M-R and is trichotomized as 0, 1 to 10, or greater than 10 for the analysis. The A-H area subscore is a measure of the scatter of complaints, indicating a diffuse medical problem, although other interpretations are possible. An abnormal A-H area subscore is defined as the number of sections (of A-H) with three or more affirmative responses. The A-H area subscore, which ranges from 0 to 8, is trichotomized as 0, 1 to 3, or 4 to 8 for the analysis.

Consistent with the 5 percent nonresponse exclusion used for the MMPI, analysis of the total CMI score is based on scores with at least a 95 percent response rate or no more than 10 unanswered items from the total 195. M-R subscores are deleted from the analyses if three or more questions were unanswered from the 51 questions. For the A-H area subscore, participants who failed to answer all items were excluded from the analyses. Using these response criteria, analyses of the total CMI score are based on the scores of 1,000 Ranch Hands (16 deleted) and 1,268 Comparisons (25 deleted); the M-R subscore analyses use the results of 998 Ranch Hands (18 deleted) and 1,267 Comparisons (26 deleted); and the A-H area subscore analyses use 914 Ranch Hands (102 deleted) and 1,148 Comparisons (145 deleted).

The HRB is a neuropsychological test that was administered to all participants to assess the functional integrity of the CNS. The battery consists of seven subtests: category (abstract recognition and analysis), total-time tactile performance, memory tactile performance, localization tactile performance, rhythm, speech, and finger tapping. In addition, other tests were performed (e.g., trailmaking, tests of recent memory) but do not contribute to the impairment index. For each participant who completed all seven subtests, an impairment index, equal to the number of subtests in which the participant scored abnormally, is computed. This variable is dichotomized as normal (impairment index <3) or abnormal (impairment index ≥ 3). Twenty participants (10 in each group) refused or did not complete one or more of the seven subtests. Thus, the analyses of the HRB impairment index are based on data from 1,006 Ranch Hands and 1,283 Comparisons. Fisher's exact test was used to contrast the number of excluded participants between groups. A significant difference was not observed ($p=0.654$).

The analyses of the psychological variables were adjusted for age (born in 1942 or after, born between 1923 and 1941, born in 1922 or before), race (Black, nonblack), education (high school, college), and drink-years (0, greater than 0 to 50, greater than 50). Education was dichotomized into high school and college categories, for purposes of analysis, from the classifications of (1) no high school diploma, (2) high school diploma, (3) attended college, and (4) college diploma. This variable was based on Baseline education levels, and participants with incomplete information were classified as high school educated. In addition, the analyses of the MMPI scales were adjusted for the combat index, a surrogate measure for PTSD. This index was constructed from 15 self-administered questions on combat experiences (see Appendix C, page C-15, AFHS Form 8). Associations of these 15 variables with PTSD, as measured from a subset of the MMPI questions, were examined, and responses to four questions showed statistically significant or marginally significant associations with PTSD. The four questions were (1) flew in aircraft that received battle damage, (2) had a close friend killed in action, (3) encountered mines or booby traps, and (4) wounded. An index, equal to the number of affirmative responses to these four questions, was computed and used as a trichotomized covariate (low, [0; n=708 (30.7%)],

medium [1; n=814 (35.4%)], high [2-4; n= 781 (33.9%)], 6 missing participants, as with MMPI scales) for the analyses of the MMPI scales. While this index was associated with PTSD, it does not necessarily measure stress but does measure combat experience.

The analyses of the CMI and HRB tests were adjusted for PTSD, based on the number of affirmative responses to a subset of 49 questions of the MMPI. For these analyses, PTSD was dichotomized as yes/no using greater than 30 affirmative responses[23] as a positive indicator of PTSD. Sixteen participants (10 Ranch Hands, 6 Comparisons) were classified as having PTSD under this guideline. (Note that this indicator of PTSD was not used as a covariate for the analyses of MMPI scales, because the variable was based on the responses used in the calculation of the MMPI scores.)

Current alcohol use (yes/no) and occupation were examined as potential covariates and are provided in the summary tables for inspection. Current alcohol use was highly correlated with drink-years, which better explained the dependent variables under study. Similarly, occupation was highly correlated with education ($p<0.001$). In this case, education was selected.

Statistical Analysis

Minnesota Multiphasic Personality Inventory (MMPI)

The distributions of the Ranch Hand and Comparison groups for the 14 MMPI variables were contrasted using the Kolmogorov-Smirnov nonparametric tests and stratified by occupation (officer, enlisted flyer, enlisted groundcrew), for a total of 42 tests. Unadjusted analyses were performed using Fisher's exact test. Covariate analyses, using Fisher's exact or Pearson's chi-square test, were conducted for age, race, education, drink-years, combat index, current alcohol use, and occupation. Logistic regression techniques were used to conduct the adjusted analyses. In the adjusted analyses, all covariates were used as discrete variables with the exception of age, which was used as a continuous variable. Current alcohol use and occupation were not used in the adjusted analysis. Using a two-sided α-level of 0.05, and with power of 0.80, the sample sizes are sufficient to detect a 38 percent increase in the rate of abnormal scores for depression, a 61 percent increase in the rate of abnormal scores for denial, and a 119 percent increase in the rate of abnormal scores for social introversion.

Distributional Analyses

The Kolmogorov-Smirnov tests identified no statistically significant differences between the Ranch Hand and Comparison distributions for the 14 MMPI variables at the 0.05 significance level for each occupational category. Only 2 of the 42 tests even approached significance, mania/hypomania (Ranch Hand and Comparison officers, $p=0.092$) and psychopathic/deviate (Ranch Hand and Comparison enlisted flyers, $p=0.088$). Results of the Kolmogorov-Smirnov tests are provided in Tables J-1 to J-3 of Appendix J. It is noted that stratification by occupation reduced the sample size for each test and consequently decreased the power; that is, a larger maximum difference between the Ranch Hand and Comparison distributions is needed to show significance when the sample size is decreased, as is the case when stratification by occupation is performed.

Unadjusted and Adjusted Analyses

The unadjusted results, covariate tests of association, and adjusted results of the analyses for the 14 MMPI variables are summarized in Tables 12-2 to 12-4, respectively. Summary tables, which investigate interactions involving group, are provided in Table J-4 of Appendix J. The results of the tests of association for current alcohol use and occupation are presented in Table 12-3 for inspection, but are not discussed in the text since the measure of total drink-years was more appropriate for use in the analyses.

Anxiety

The unadjusted analysis showed no statistically significant difference in the anxiety scale between the Ranch Hands and the Comparisons ($p=0.311$).

The tests of association with the covariates, using the pooled group categorical data, revealed statistically significant effects for age ($p=0.010$) and education ($p<0.001$). For age, 8.4 percent of the participants born in or after 1942 were scored as abnormal, as were 5.3 percent of those born from 1923 to 1941, and 4.6 percent of those born in or before 1922. The high school subgroup had a higher percentage (8.5%) of abnormalities than the college subgroup (4.4%). For the test of association, drink-years was marginally significant ($p=0.058$), based on the percent of abnormalities for 0, greater than 0 to 50, and greater than 50 drink-years: 10.0 percent, 5.9 percent, and 8.2 percent, respectively.

In the adjusted analysis, there was no statistically significant difference between groups ($p=0.512$). In this analysis, education (EDUC) showed a statistically significant effect ($p<0.001$). The interaction, age-by-combat-index (CI), was also statistically significant ($p=0.008$). A group-(GRP)-by-education interaction was marginally significant ($p=0.057$). Further investigation of this interaction revealed an adjusted relative risk of 1.39 for the high school stratum and 0.68 for the college stratum. However, these relative risks were not significantly different from 1.00 ($p=0.114$, $p=0.233$, respectively). The exploration of this interaction is shown in Table J-4 of Appendix J.

Consistency

The unadjusted test of the MMPI consistency scale revealed no statistically significant difference between the Ranch Hand and Comparison groups ($p=0.222$).

Based on the tests of association, education was statistically significant ($p=0.010$) with 3.9 percent abnormalities in the high school category and 2.0 percent abnormalities in the college category. In addition, the test of association with drink-years was statistically significant ($p=0.021$); the categories 0 and greater than 0 to 50 drink-years each had a percent abnormal frequency of 2.7, whereas there were 5.6 percent abnormalities in the greater than 50 drink-years category.

In the adjusted analysis of the consistency scale, a group-by-education interaction was statistically significant ($p=0.013$). Further analysis of the interaction (shown in Table J-4 of Appendix J) revealed that the high school

TABLE 12-2.

Unadjusted Analyses for MMPI by Group

Variable	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Comparison Number	Comparison Percent	Est. Relative Risk (95% C.I.)	p-Value
Anxiety	n	1,014		1,289			
	Abnormal	73	7.2	79	6.1	1.19 (0.86,1.65)	0.311
	Normal	941	92.8	1,210	93.9		
Consistency	n	1,014		1,289			
	Abnormal	36	3.6	34	2.6	1.36 (0.84,2.19)	0.222
	Normal	978	96.4	1,255	97.4		
Defensiveness	n	1,014		1,289			
	Abnormal	23	2.3	35	2.7	0.83 (0.49,1.42)	0.592
	Normal	991	97.7	1,254	97.3		
Denial	n	1,014		1,289			
	Abnormal	17	1.7	58	4.5	0.36 (0.21,0.63)	<0.001
	Normal	997	98.3	1,231	95.5		
Depression	n	1,014		1,289			
	Abnormal	114	11.2	126	9.8	1.17 (0.89,1.53)	0.272
	Normal	900	88.8	1,163	90.2		
Hypochondria	n	1,014		1,289			
	Abnormal	119	11.7	129	10.0	1.20 (0.92,1.56)	0.198
	Normal	895	88.3	1,160	90.0		
Hysteria	n	1,014		1,289			
	Abnormal	123	12.1	125	9.7	1.29 (0.99,1.67)	0.067
	Normal	891	87.9	1,164	90.3		

TABLE 12-2. (continued)

Unadjusted Analyses for MMPI by Group

Variable	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Comparison Number	Comparison Percent	Est. Relative Risk (95% C.I.)	p-Value
Mania/Hypomania	n	1,014		1,289			
	Abnormal	63	6.2	88	6.8	0.90 (0.65,1.26)	0.611
	Normal	951	93.8	1,201	93.2		
Masculinity/ Femininity	n	1,014		1,289			
	Abnormal	66	6.5	120	9.3	0.68 (0.50,0.93)	0.017
	Normal	948	93.5	1,169	90.7		
Paranoia	n	1,014		1,289			
	Abnormal	31	3.1	28	2.2	1.42 (0.85,2.38)	0.187
	Normal	983	96.9	1,261	97.8		
Psychopathic/ Deviate	n	1,014		1,289			
	Abnormal	120	11.8	149	11.6	1.03 (0.80,1.33)	0.845
	Normal	894	88.2	1,140	88.4		
Schizophrenia	n	1,014		1,289			
	Abnormal	94	9.3	101	7.8	1.20 (0.90,1.61)	0.228
	Normal	920	90.7	1,188	92.2		
Social Introversion	n	1,014		1,289			
	Abnormal	26	2.6	19	1.5	1.76 (0.97,3.20)	0.069
	Normal	988	97.4	1,270	98.5		
Validity	n	1,016		1,293			
	>0	224	22.0	271	21.0	1.07 (0.87,1.30)	0.540
	0	792	78.0	1,022	79.0		

TABLE 12-3.

Association Between MMPI Variables and the Covariates in the Combined Ranch Hand and Comparison Groups

MMPI Scale	Age	Race	Education	Drink-Years	Combat Index	Current** Alcohol Use	Occupation**
Anxiety	0.010	NS	<0.001	NS*	NS	0.001	<0.001
Consistency	NS	NS	0.010	0.021	NS	NS	<0.001
Defensiveness	0.028	0.025	<0.001	<0.001	NS*	0.001	<0.001
Denial	0.037	NS	NS	NS	NS	NS	NS
Depression	NS	NS	<0.001	0.002	NS	NS	<0.001
Hypochondria	0.031	0.025	<0.001	0.041	0.027	0.044	<0.001
Hysteria	0.044	NS	<0.001	0.006	NS	0.027	<0.001
Mania/Hypomania	NS	NS	NS	0.011	0.001	NS	0.022
Masculinity/ Femininity	0.005	NS	<0.001	NS	NS	NS	0.005
Paranoia	0.022	NS	NS	NS	NS	NS*	0.014
Psychopathic/ Deviate	NS	0.001	0.001	<0.001	NS	NS*	<0.001
Schizophrenia	NS	NS	<0.001	0.014	NS	NS*	<0.001
Social Introversion	0.003	NS	NS*	NS	NS	NS*	<0.001
Validity	NS	<0.001	NS	NS	NS*	NS	NS

NS - Not significant ($p>0.10$).

*Borderline significant ($0.05<p\leq0.10$).

**Not used in adjusted analyses.

TABLE 12-4.

Adjusted Analyses for MMPI by Group

Variable	Group: Ranch Hand Total	Group: Comparison Total	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
Anxiety	1,012	1,285	1.12 (0.80,1.57)	0.512	EDUC (p<0.001) AGE*CI (p=0.008) GRP*EDUC (marginal: p=0.057)
Consistency	974	1,246	****	****	AGE (p=0.007) DRKYR (p=0.026) CI (p=0.041) GRP*EDUC (p=0.013)
Defensiveness	976	1,250	0.77 (0.45,1.33)	0.347	EDUC (p<0.001) DRKYR (p<0.001)
Denial	1,012	1,285	0.37 (0.21,0.66)	<0.001	EDUC*CI (p=0.044)
Depression	974	1,246	1.10 (0.84,1.45)	0.497	EDUC (p<0.001) DRKYR (p=0.013) GRP*CI (marginal: p=0.055)
Hypochondria	1,012	1,285	1.12 (0.85,1.47)	0.431	AGE (p=0.002) RACE (p=0.026) EDUC (p<0.001) CI (p=0.043)
Hysteria	1,014	1,289	1.27 (0.97,1.66)	0.077	AGE (p=0.003) EDUC (p<0.001)
Mania/Hypomania	974	1,246	0.80 (0.56,1.13)	0.203	DRKYR (p=0.006) AGE*CI (p=0.046)

TABLE 12-4. (continued)

Adjusted Analyses for MMPI by Group

Variable	Group: Ranch Hand Total	Group: Comparison Total	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
Masculinity/ Femininity	1,014	1,289	0.69 (0.50,0.95)	0.020	EDUC (p<0.001) RACE*AGE (p=0.008)
Paranoia	1,012	1,285	****	****	AGE*CI (p=0.003) GRP*AGE (p=0.036)
Psychopathic/ Deviate	974	1,246	1.04 (0.79,1.36)	0.780	EDUC (p=0.011) AGE*CI (p=0.003) RACE*DRKYR (p=0.015)
Schizophrenia	976	1,250	****	****	RACE*DRKYR (p=0.017) GRP*EDUC (p=0.010)
Social Introversion	1,012	1,285	****	****	AGE (p=0.004) GRP*CI (p=0.037)
Validity	1,014	1,289	****	****	AGE*CI (p=0.030) GRP*RACE (p=0.012)

*Abbreviations:

EDUC: education
CI: combat index
GRP: group
DRKYR: drink-years of alcohol

****Group-by-covariate interaction -- adjusted relative risk, confidence interval, and p-value are not presented.

Ranch Hand category had a marginally significantly higher percentage of abnormal participants (5.6%) than the high school Comparisons (2.9%) ($p=0.051$). The adjusted relative risk for the high school classification was 1.81 with 95 percent confidence bounds of 1.00 and 3.28. In contrast, the percentage of abnormalities in the Comparison college-educated stratum was higher than the corresponding Ranch Hand subgroup (2.6 percent, 1.4 percent, respectively), but the difference was not statistically significant ($p=0.110$). Age, drink-years (DRKYR), and combat index were also statistically significant ($p=0.007$, $p=0.026$, $p=0.041$, respectively) in the adjusted analyses.

Defensiveness

For the MMPI defensiveness scale, there was no significant difference between groups, based on the unadjusted analysis ($p=0.592$).

The tests of association showed statistically significant differences for all variables except combat index, which was marginally different statistically. The percentage of abnormalities for the age categories (born in or after 1942, born between 1923 and 1941, and born in or before 1922) were 3.3, 1.8, and 4.6, respectively ($p=0.028$). There were 2.3 percent abnormalities for nonblacks as compared to 5.6 percent for Blacks ($p=0.025$). The percent abnormalities for the high school- and college-educated categories were 3.8 and 1.0, respectively ($p<0.001$). For the 0 drink-years category, there were 10.0 percent abnormalities; the percent abnormalities for the greater than 0 to 50 and greater than 50 drink-years were 2.4 and 0.6, respectively ($p<0.001$). For combat index, which was only marginally statistically significant ($p=0.093$), the percent abnormalities were 3.5 for the low, 2.1 for the medium, and 1.9 for the high categorizations.

In the adjusted analysis, there was no significant difference between the Ranch Hand and Comparison groups ($p=0.347$). In this analysis, the covariates of education ($p<0.001$) and drink-years ($p<0.001$) were statistically significant.

Denial

Based on the unadjusted analysis, there was a statistically significant difference between the two groups on the MMPI denial scale ($p<0.001$), with 4.5 percent abnormalities in the Comparison group as contrasted to only 1.7 percent in the Ranch Hand group. The estimated relative risk was 0.36 with a 95 percent confidence interval of 0.21 to 0.63.

The tests of association found only age as a statistically significant covariate ($p=0.037$). Men born in or after 1942 and those born between 1923 and 1941 had 3.0 percent and 3.1 percent abnormalities, respectively, as compared to 8.0 percent abnormalities for those born in or before 1922.

The adjusted analysis showed a statistically significant difference between groups ($p<0.001$). The adjusted relative risk estimate was 0.37 with 95 percent confidence bounds of 0.21 and 0.66. For this analysis, the education-by-combat index interaction was also statistically significant ($p=0.044$).

Depression

The unadjusted analysis of the depression scale revealed no statistically significant difference between the two groups ($p=0.272$).

In the covariate tests of association, education and drink-years showed statistically significant effects ($p<0.001$, $p=0.002$, respectively). There was a higher percentage of abnormalities in the high school-educated category (13.1%) than in the college-educated category (7.2%). For drink-years, the highest rate of abnormality was in the highest category of alcohol use (15.8%), followed by the nondrinker with 10.7 percent abnormalities and the moderate category with 9.4 percent.

In the adjusted analysis, there was no statistically significant difference between groups ($p=0.497$), but there was a marginally significant group-by-combat index interaction ($p=0.055$). This interaction was explored further and is shown in Table J-4 of Appendix J. The analysis of the group-by-combat index interaction revealed a marginal difference within the low (0) category of the combat index ($p=0.055$), but not within the medium and high categories. In contrasting the 192 Ranch Hands and the 490 Comparisons in the 0 category, there were 14.6 percent abnormalities in the Ranch Hand group versus 8.2 percent in the Comparisons ($p=0.039$). The adjusted relative risk for the 0 category of the combat index was 1.73 with a 95 percent confidence interval of 1.03 to 2.91. Education ($p<0.001$) and drink-years ($p=0.013$) also exhibited statistically significant effects in the adjusted analysis.

Hypochondria

There was no statistically significant difference for the MMPI hypochondria scale between the Ranch Hand and Comparison groups ($p=0.198$).

In the covariate tests of association, all five variables were statistically significant. Of men born in or after 1942, 8.8 percent had abnormalities as compared to 12.2 percent and 12.6 percent of those born between 1923 and 1941 and in or before 1922, respectively ($p=0.031$). The rates of abnormalities for Blacks and nonblacks were 16.8 percent and 10.4 percent, respectively ($p=0.025$). There was a highly statistically significant difference for education ($p<0.001$) with the high school-educated category having 13.9 percent abnormalities and the college-educated category having 7.0 percent. There was also a statistically significant difference for drink-years ($p=0.041$). The lowest rate of abnormalities was in the greater than 0 to 50 drink-years category with 9.9 percent; the corresponding percentages for the 0 drink-year and greater than 50 drink-year categories were 12.7 and 14.3, respectively. The percent abnormalities in the low, medium, and high combat index categories were 9.8, 9.4, and 13.2, respectively ($p=0.027$).

The adjusted analysis showed no significant difference between the Ranch Hand and Comparison groups ($p=0.431$). In this analysis, age ($p=0.002$), race ($p=0.026$), education ($p<0.001$), and combat index ($p=0.043$) were statistically significant covariates.

Hysteria

Based on the unadjusted analysis of the MMPI hysteria scale, the difference between the two groups approached statistical significance ($p=0.067$). The percent abnormalities were 12.1 and 9.7 for the Ranch Hand and Comparison groups, respectively. The estimated relative risk was 1.29 with a 95 percent confidence interval of 0.99 to 1.67.

The covariate tests of association showed that there were statistically significant differences for age ($p=0.044$), education ($p<0.001$), and drink-years ($p=0.006$). There were 12.6 percent, 12.1 percent, and 8.9 percent abnormalities in the age categories born in or after 1942, born between 1923 and 1941, and born in or before 1922, respectively. The high school-educated category had a higher percentage of abnormalities (12.9%) than the college-educated category (8.2%). The drink-years category with the lowest percentage of abnormalities was greater than 0 to 50 with 9.6 percent; the 0 drink-years and the greater than 50 drink-years categories had 14.0 and 14.9 percent abnormalities, respectively.

The adjusted analysis also approached significance ($p=0.077$). The adjusted relative risk was 1.27 with 95 percent confidence bounds of 0.97 and 1.66. Age and education were statistically significant covariates in the adjusted model ($p=0.003$, $p<0.001$, respectively). Drink-years was marginally significant ($p=0.068$) in the presence of other covariates, but was not included in the final adjusted model.

Mania/Hypomania

For the unadjusted analysis of the mania/hypomania scale of the MMPI, there was no statistical difference between the Ranch Hand and the Comparison groups ($p=0.611$).

In the covariate tests of association, there were statistically significant differences for drink-years and combat index ($p=0.011$, and $p=0.001$, respectively). For the mania/hypomania scale, the 0 drink-years category had 6.7 percent abnormalities, the greater than 0 to 50 drink-years category had 5.8 percent, and the greater than 50 drink-years category contained 10.2 percent. The frequencies of abnormalities increased from the low to the high level of the combat index; the percentages were 5.0, 5.3, and 9.4, respectively.

Based on the adjusted analysis, there was no statistically significant difference between the two groups ($p=0.203$). Drink-years was a significant covariate ($p=0.006$), as was the age-by-combat index interaction ($p=0.046$).

Masculinity/Femininity

The masculinity/femininity scale of the MMPI measures the stereotype "macho" attitudes of the test subjects. There was a statistically significant group difference for this scale of the MMPI, unadjusted for covariates ($p=0.017$). There was a higher percentage of abnormalities in the Comparison group (9.3%) than in the Ranch Hand group (6.5%). The estimated relative risk was 0.68, and the 95 percent confidence interval was 0.50 to 0.93.

There was a statistically significant difference detected for age ($p=0.005$) and for education ($p<0.001$), based on the pooled group data in the covariate tests of association. The highest rate of abnormalities was found in men born in or after 1942 (10.2%); whereas those born between 1923 and 1941 had 6.4 percent, and those born in or before 1922 had 8.0 percent. For education, the college-educated category showed an abnormal rate of 10.3 percent versus the high school category with 6.2 percent abnormalities.

The adjusted analysis also showed a statistically significant difference between the two groups ($p=0.020$), with an adjusted relative risk of 0.69 (95% C.I.: [0.50,0.95]). Education and a race-by-age interaction were statistically significant in the adjusted analysis ($p<0.001$, $p=0.008$, respectively). These covariate associations follow expectations.

Paranoia

The unadjusted analysis of the MMPI paranoia scale did not reveal a statistically significant group difference ($p=0.187$).

Based on the pooled group data, the covariate test of association for age was statistically significant ($p=0.022$). There was 3.6 percent abnormalities for men born in or after 1942, 2.0 percent for those born between 1923 and 1941, and no abnormalities for men born in or before 1922. The adjusted analysis revealed a significant group-by-age interaction ($p=0.036$). The age-by-combat index interaction was also statistically significant ($p=0.003$). The group interaction was examined by combining the participants born between 1923 and 1941 with those born in or before 1922, and basing the test on two age categories (born in or after 1942 and born before 1942), due to problems with 0 counts (see Table J-4 of Appendix J). The analysis showed a higher percentage of abnormal Ranch Hands than abnormal Comparisons for participants born before 1942 (2.7% and 1.2%, respectively; $p=0.027$). The relative risk estimate for this age category was 2.63 (95% C.I.: [1.11,6.20]). In contrast, for the stratum born in or after 1942, the frequencies of abnormalities were nearly the same in each group (3.7% for Ranch Hands, 3.5% for Comparisons; $p=0.712$).

Psychopathic/Deviate

No significant difference between the two groups was identified in the unadjusted analysis of this MMPI scale ($p=0.845$).

In the covariate tests of association, there were statistically significant differences for race, education, and drink-years. There were 21.0 percent abnormalities for Blacks as compared to 11.1 percent for non-blacks ($p=0.001$). For education, there were 13.8 percent abnormalities in the high school-educated category and 9.1 percent in the college-educated category ($p=0.001$). The highest rate of abnormalities in the drink-year categories was 20.2 percent for the category of greater than 50 drink-years; the percent abnormalities for the 0 and greater than 0 to 50 categories were 11.3 and 10.1, respectively ($p<0.001$).

Based on the adjusted analysis, there was no significant difference between the Ranch Hand and Comparison groups ($p=0.780$). In this analysis, education ($p=0.011$), the age-by-combat index interaction ($p=0.003$), and the

race-by-drink-year interaction (p=0.015) were statistically significant adjusting variables.

Schizophrenia

The unadjusted tests showed no significant difference between the Ranch Hand and Comparison groups for the MMPI schizophrenia scale (p=0.228).

Based on the pooled group data, the covariate tests of association revealed that education (p<0.001) and drink-years (p=0.014) had statistically significant effects. The high school-educated category had a statistically significant higher rate of abnormalities (11.0%) than the college-educated category (5.4%). For drink-years, the highest percent of abnormalities was in the greater than 50 drink-year category (12.6%), followed by the 0 drink-year category with 8.7 percent, and the greater than 0 to 50 drink-year category, which had 7.7 percent abnormalities.

In the adjusted analysis, the group-by-education interaction was significant (p=0.010) (see Table J-4 of Appendix J). The race-by-drink-year interaction was also statistically significant (p=0.017). Analysis of the high school and college strata showed a higher percentage of abnormal Ranch Hands than abnormal Comparisons in the high school classification (13.4% versus 9.5%, respectively; p=0.033). The relative risk estimate for high school participants was 1.51, with 95 percent confidence bounds of 1.05 and 2.16. The college-educated stratum revealed a nonsignificant group difference, but the Ranch Hands had a lower rate of schizophrenia abnormalities than the Comparison group (4.1% and 6.3%, respectively).

Social Introversion

Based on the unadjusted analysis, the difference between the two groups approached significance (p=0.069). The Ranch Hand group had 2.6 percent abnormalities as contrasted to 1.5 percent abnormalities in the Comparison group. The 95 percent confidence bounds on the estimated relative risk of 1.76 were 0.97 and 3.20.

Age was the only statistically significant covariate (p=0.003). The participants who were born in or after 1942 had a higher percentage of abnormalities (3.1%) than either those born between 1923 and 1941 or those born in or before 1922; both of these latter age categories had a 1.1 percent frequency of abnormalities. Education was of marginal significance (p=0.099) with 2.4 percent of the high school-educated participants scored as abnormal as compared to 1.4 percent of the college-educated participants. The group-by-combat index interaction was statistically significant in the adjusted analysis (p=0.037) (see Table J-4 of Appendix J).

The analysis of the group-by-combat index interaction showed a difference within the low (0) combat index category with the Ranch Hands having a significantly higher percentage of abnormalities than the Comparisons (5.6% and 1.2%, respectively; p=0.002). The adjusted relative risk for this combat index category was 4.86, with a 95 percent confidence interval of 1.77 to 13.36. The medium and high combat index strata showed no statistically significant group differences (p=0.478, p=0.677, respectively). In this adjusted model, age also had a significant effect (p=0.004).

Validity

For the MMPI validity scale, the unadjusted tests showed no significant difference between the Ranch Hand and Comparison groups ($p=0.540$).

The covariate tests of association showed that Blacks had a significantly higher frequency of abnormalities (35.0%) than nonblacks (20.5%) ($p<0.001$). The adjusted analysis revealed a statistically significant group-by-race interaction ($p=0.012$). A covariate interaction, age-by-combat index, was also found to be statistically significant ($p=0.030$). Further investigation of the group interaction disclosed a higher percentage of Black Comparisons with scores greater than 0 than Black Ranch Hands (42.2%, 25.0%, respectively), with an adjusted relative risk of 0.46 ($p=0.038$, 95% C.I.: [0.22,0.96]). In contrast, the nonblack stratum revealed a slightly higher proportion of abnormalities in the Ranch Hands, with an adjusted relative risk of 1.20 (95% C.I.: [0.97,1.49], $p=0.095$) (see Table J-4 of Appendix J).

Cornell Medical Index (CMI)

Three variables derived from the CMI were analyzed: the total CMI, M-R subscore, and the A-H area subscore. The total CMI was analyzed as a continuous variable, using a log (X+1) transformation, where X was the number of affirmative answers. Based on the Kolmogorov-Smirnov test, the distributions of the Ranch Hand and Comparison total CMI scores were contrasted. For this set of analyses, the data were stratified separately by the covariates of age, race, education, current alcohol use, and occupation. The unadjusted analysis of total CMI was based on the two-sample t-test. Analysis of variance and two-sample t-tests were used to analyze the covariates, and the adjusted analysis on the total CMI was based on analysis of covariance techniques, using SAS®-GLM. Age was analyzed as a continuous variable in the adjusted analysis. Using a two-sided α-level of 0.05, and with power of 0.80, the sample sizes were sufficient to detect a 10.2 percent mean shift in the total CMI score relative to the mean observed in the Comparison group.

Pearson's chi-square test was used to conduct the unadjusted analyses and the covariate tests of association of the M-R subscore and the A-H area subscore, which were trichotomized into low, medium, and high classes. The adjusted analyses of these two variables were conducted by log-linear techniques using BMDP®-4F.

In all three CMI variables, a higher score is associated with a higher degree of abnormality.

The results of the unadjusted analysis, covariate tests of association, and the adjusted analyses on the three CMI variables are summarized in Tables 12-5 to 12-7, respectively. As discussed for the MMPI variables, the results of the covariate tests of association for current alcohol use and for occupation are provided in the summary table for information only.

TABLE 12-5.

Unadjusted Analyses for the Cornell Medical Index (CMI) by Group

Variable	Statistic	Group: Ranch Hand		Group: Comparison		Est. Relative Risk (95% C.I.)	p-Value
Total CMI	n	1,000		1,268			
	Mean[a]	11.74		10.42		--	<0.001
	95% C.I.[a]	(11.17,12.35)		(9.95,10.90)			
M-R Subscore	n	998		1,267		Overall	0.252
	Number/%						
	-0 (Low)	538	53.9%	726	57.3%	Medium vs. Low	
	1-10 (Medium)	408	40.9%	484	38.2%	1.14 (0.96,1.35)	0.146
	>10 (High)	52	5.2%	57	4.5%	High vs. Low	
						1.23 (0.83,1.82)	0.314
A-H Area Subscore	n	914		1,148		Overall	0.003
	Number/%						
	-0 (Low)	360	39.4%	537	46.8%	Medium vs. Low	
	1-3 (Medium)	449	49.1%	504	43.9%	1.33 (1.11, 1.60)	0.003
	4-8 (High)	105	11.5%	107	9.3%	High vs. Low	
						1.46 (1.08,1.98)	0.013

[a]Transformed from log (X+1) scale, where x was the number of questions answered "yes."
--No relative risk given for Total CMI, which was analyzed as a continuous variable.

TABLE 12-6.

Association Between CMI Variables and the Covariates in the Combined Ranch Hand and Comparison Groups

CMI Variable	Age	Race	Education	Drink-Years	PTSD	Current* Alcohol Use	Occupation*
Total CMI	<0.001	NS	<0.001	<0.001	<0.001	<0.001	<0.001
M-R Subscore	<0.001	0.022	<0.001	NS*	<0.001	0.043	<0.001
A-H Area Subscore	<0.001	NS	<0.001	<0.001	<0.001	0.010	<0.001

NS: Not significant ($p>0.10$).

NS*: Borderline significant ($0.05<p\leq0.10$).

**Not used in adjusted analyses.

TABLE 12-7.

Adjusted Analyses for CMI Variables by Group

Variable	Statistic	Group: Ranch Hand	Group: Comparison	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
Total CMI	n	962	1,229			PTSD (p<0.001)
	Adj. Mean	****	****	----	****	RACE*DRKYR (p=0.039)
	95% C.I.	****	****			AGE*EDUC (p=0.005)
						GRP*EDUC (p=0.003)
M-R Subscore	n	998	1,265	Overall	0.339	AGE (p<0.001)
				Medium vs. Low:	0.152	EDUC (p<0.001)
				1.14 (0.95,1.35)	0.598	PTSD (p<0.001)
				High vs. Low:		GRP*EDUC
				1.12 (0.74,1.70)		(marginal: p=0.067)
A-H Area Score	n	881	1,113	Overall	0.040	AGE (p<0.001)
				Medium vs. Low:	0.011	EDUC (p<0.001)
				1.27 (1.06,1.53)	0.190	PTSD (p<0.001)
				High vs. Low:		DRKYR (p=0.014)
				1.24 (0.90,1.71)		

*Additional Abbreviations:

PTSD: Post-Traumatic Stress Disorder

****Group-by-covariate interaction--adjusted mean, confidence interval, and p-value not presented.

----No relative risk given for total CMI, which was analyzed as a continuous variable.

Distributional Analyses

The Kolmogorov-Smirnov tests showed statistically significant differences between the Ranch Hand and Comparison distributions for the total CMI for one category for each of the covariates. For age, the distribution of Ranch Hands born in or after 1942 was statistically different from the corresponding distribution for the Comparisons ($p<0.001$). The distributions of the nonblack Ranch Hand and Comparison responses also differed significantly ($p=0.003$). The contrast of the high school-educated Ranch Hand and Comparison distributions revealed a statistically significant difference ($p<0.001$). The distributions for Ranch Hand and Comparison current drinkers were also statistically different ($p=0.024$). For occupation, the enlisted groundcrew distributions for Ranch Hands and Comparisons were statistically different ($p=0.007$). Except for the covariate age, all significant differences in distributions for each covariate were found in the category having the largest sample size. The results of the 12 Kolmogorov-Smirnov tests are summarized in Table J-5 of Appendix J.

Unadjusted and Adjusted Analyses

Total Cornell Medical Index

Based on the unadjusted analysis, as depicted in Table 12-5, the total CMI means of the Ranch Hand and Comparison groups were statistically different ($p<0.001$). The mean, as transformed from the log (X+1) scale, of the 1,000 Ranch Hands was 11.74 as compared to 10.42 for the Comparisons.

The covariate tests of association identified that age, education, drink-years, and PTSD were highly significant ($p<0.001$ for all). For age, the (transformed) means of the categories showed an increase; the means of those born in or after 1942, between 1923 and 1941, and in or before 1922 were 10.08, 11.49, and 14.53, respectively. The mean of the high school-educated category (12.97) was statistically higher than the mean of the college-educated category (8.99). The mean of the greater than 50 drink-years was 14.49 as compared to means of 10.37 and 10.34 for the 0 and greater than 0 to 50 drink-years, respectively. The mean of the participants with a positive measure of PTSD was 71.77, whereas 10.83 was the mean of those without a positive measure of PTSD.

In the adjusted analysis, there was a significant group-by-education interaction ($p=0.003$). Further analysis of the interaction (see Table J-4 of Appendix J) showed that the high school-educated Ranch Hands had a higher adjusted mean total CMI than the high school-educated Comparisons ($p<0.001$). No significant difference was seen in the college stratum. PTSD was a significant covariate ($p<0.001$). The covariate interactions, race-by-drink-years and age-by-education, were also significant in the adjusted model ($p=0.039$, $p=0.005$, respectively).

M-R Subscore

The results of the unadjusted analysis on the M-R subscore, an indicator of emotional health, revealed no significant difference between groups ($p=0.252$).

The covariate tests of association on the pooled group data showed that age ($p<0.001$), race ($p=0.022$), education ($p<0.001$), and PTSD ($p<0.001$) were statistically significant covariates. For age, participants born in or after 1942 had a higher percentage of scores greater than 0 when compared to the other categories. Blacks had a higher percentage of scores greater than 0 than nonblacks. For education, the college-educated category had a higher percentage of 0 scores. The M-R subscores were distributed differently for participants with and without PTSD. For example, 15 of 16 participants with PTSD had an M-R subscore greater than 10, whereas only 4.2 percent of the participants without PTSD had a similar score. Drink-years showed a marginally significant effect ($p=0.054$); the greater than 50 drink-year category exhibited the largest percentage of participants with scores greater than 0.

No significant difference between the two groups was identified in the adjusted analysis. There was a marginally significant group-by-education interaction ($p=0.067$). Further investigation of this interaction (see Table J-4 of Appendix J) showed a significant difference for the high school-educated stratum ($p=0.030$) but not for the college-educated stratum. This difference results from the contrast of the medium (1 to 10) and low (0) categories, with the Ranch Hands having a higher percentage of participants in the medium category for the M-R subscore than in the low category (Adj. RR: 1.37, 95% C.I.: [1.07,1.75], $p=0.014$). In this analysis, age, education, and PTSD were highly significant adjusting variables ($p<0.001$ for all).

A-H Area Subscore

Based on the unadjusted results, the A-H area subscore--an indicator of diffuse medical problems--revealed a significant difference between the Ranch Hand and Comparison groups ($p=0.003$). This was due to the increased percentage of Ranch Hands over Comparisons in both the medium (1 to 3) and the high (4 to 8) categories ($p=0.003$, $p=0.013$, respectively).

The covariate tests on the A-H area subscore showed that age, education, drink-years, and PTSD were highly significant covariates ($p<0.001$ for all). Older participants (born in or before 1922) had the lowest percentage of 0 scores. The college-educated category had a higher percentage of 0 scores than the high school-educated category. For drink-years, the lowest percentage of 0 scores was in the greater than 50 drink-years category. Twelve of 16 participants with PTSD had scores of 4 to 8, as compared to 9.7 percent of participants without PTSD.

Results of the adjusted analysis were similar to the unadjusted analysis and indicated that the two groups were statistically different ($p=0.040$). The overall group difference was predominately due to an increased adjusted percentage of Ranch Hands over Comparisons in the medium (1 to 3) versus low (0) contrast ($p=0.011$). The adjusted relative risk for this contrast was 1.27 with 95 percent confidence bounds of 1.06 and 1.53. In the adjusted model, age, education, and PTSD were significant covariates ($p<0.001$ for all); drink-years was also statistically significant ($p=0.014$).

Halstead-Reitan Battery (HRB)

The unadjusted analysis of the impairment index, the one variable from the HRB, was performed by using Fisher's exact test. Fisher's exact test and

Pearson's chi-square test were used to conduct the covariate tests of association. The adjusted analysis was based on logistic regression techniques using BMDP®-LR. The results of the analyses of the HRB impairment index are summarized in Table 12-8.

The unadjusted contrast of the 1,006 Ranch Hand scores and the 1,283 Comparison scores for the HRB impairment index revealed no statistically significant group differences ($p=0.533$).

The covariate tests of association showed that age, race, and education were highly significant covariates ($p<0.001$ for all), and drink-years also was statistically significant ($p=0.002$). For age, the highest percent frequency of abnormalities was in the category of participants born in or before 1922 (66.3%); the corresponding frequencies for the participants born between 1923 and 1941 and for those born in or after 1942 were 38.3 percent and 25.1 percent, respectively. Blacks had a significantly higher percentage of abnormal scores, with 57.1 percent as compared to 32.3 percent for non-blacks. The college-educated category had a 22.3 percent frequency of abnormalities versus 43.5 percent for the high school-educated category. With respect to drink-years, the highest percentage of abnormalities (41.2%) was for greater than 50 drink-years; the 0 drink-year and greater than 0 to 50 drink-year categories had 38.0 percent and 32.0 percent, respectively.

There was no significant difference identified between the two groups based on the adjusted analysis ($p=0.697$). Age, race, and education were statistically significant covariates ($p<0.001$ for all).

EXPOSURE INDEX ANALYSES

Exposure index analyses were conducted within each occupational cohort of the Ranch Hand group (see Chapter 8 for details on the exposure index). All variables, except the total CMI, were investigated, (unadjusted for any covariates), using Pearson's chi-square test and Fisher's exact test. Analyses of the total CMI were accomplished by t-tests and analysis of variance and covariance techniques. A log transformation was used in both adjusted and unadjusted analyses, and participants with PTSD were deleted. Adjusted analyses were performed using logistic regression, incorporating the covariates of race, age, education, and drink-years, as well as any significant pairwise interactions between the exposure index and these covariates. Age was treated as a continuous variable in the analyses. For the MMPI variables, combat index was also included as a covariate. For the HRB impairment index, participants classified as having PTSD were deleted from the analysis. The M-R subscore and the A-H area subscore were collapsed into 2 categories for analysis: 0 and greater than 0. Participants with PTSD were also deleted from this analysis.

Overall significance in the proportion of abnormalities among the exposure index levels of low, medium, and high was determined, as well as contrasts in the proportion of abnormalities between the medium and low exposure levels, and between the high and low exposure levels. Results of the adjusted analyses are presented in Table 12-9, and parallel results for unadjusted analyses are presented in Table J-6 of Appendix J. Results from further study of exposure index-by-covariate interactions are given in Table J-7 of Appendix J.

TABLE 12-8.

Summary Results for the Halstead-Reitan Battery Impairment Index Analyses

Analysis	Statistic	Group: Ranch Hand Number	Ranch Hand Percent	Comparison Number	Comparison Percent	Est./Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
Unadjusted Analysis	n	1,006		1,283				
	Abnormal	348	34.6	427	33.3	1.06 (0.89,1.26)	0.533	N/A
	Normal	658	65.4	856	66.7			
Covariate Tests of Association[a]								AGE (p<0.001) RACE (p<0.001) EDUC (p<0.001) DRKYR (p=0.002) PTSD (p=0.431) ALC (p=0.004) OCC (p<0.001)
Adjusted Analysis	n	1,006		1,283		1.04 (0.86,1.25)	0.697	AGE (p<0.001) RACE (p<0.001) EDUC (p<0.001)

*Additional Abbreviations:
ALC: current alcohol use (yes/no)
OCC: occupation

[a]Based on pooled group data; current alcohol use (ALC) and occupation (OCC) provided for information only.

TABLE 12-9.

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		0.562
						M vs. L	2.46 (0.36,16.82)	0.358
						H vs. L	2.43 (0.35,16.81)	0.367
Anxiety	Enlisted Flyer	n	50	61	53	Overall		0.215
						M vs. L	0.44 (0.12,1.70)	0.235
						H vs. L	0.28 (0.05,1.44)	0.127
	Enlisted Groundcrew	n	148	160	131	Overall		****(1)
						M vs. L	****(1)	****(1)
						H vs. L	****(1)	****(1)
	Officer	n	125	126	120	Overall		0.274
						M vs. L	1.10 (0.14,8.59)	0.925
						H vs. L	----	----
Consistency	Enlisted Flyer	n	50	61	53	Overall		0.425
						M vs. L	0.39 (0.06,2.37)	0.304
						H vs. L	0.30 (0.03,2.93)	0.303
	Enlisted Groundcrew	n	148	160	131	Overall		0.550
						M vs. L	0.87 (0.32,2.34)	0.781
						H vs. L	0.56 (0.18,1.67)	0.296

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		0.518
						M vs. L	----	----
						H vs. L	----	----
Defensiveness	Enlisted Flyer	n	50	61	53	Overall		0.613
						M vs. L	0.17 (0.001,29.09)	0.503
						H vs. L	1.37 (0.02,77.86)	0.878
	Enlisted Groundcrew	n	148	160	131	Overall		0.737
						M vs. L	0.79 (0.23,2.78)	0.719
						H vs. L	1.31 (0.40,4.23)	0.656
	Officer	n	125	126	120	Overall		****(2)
						M vs. L	****(2)	****(2)
						H vs. L	****(2)	****(2)
Denial	Enlisted Flyer	n	50	61	53	Overall		0.234
						M vs. L	1.03 (0.09,11.69)	0.984
						H vs. L	----	----
	Enlisted Groundcrew	n	148	160	131	Overall		0.109
						M vs. L	----	----
						H vs. L	1.41 (0.18,11.09)	0.747

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		0.411
						M vs. L	0.62 (0.20,1.88)	0.393
						H vs. L	1.24 (0.46,3.33)	0.669
Depression	Enlisted Flyer	n	50	61	53	Overall		0.160
						M vs. L	0.55 (0.18,1.67)	0.295
						H vs. L	0.31 (0.09,1.10)	0.070
	Enlisted Groundcrew	n	148	160	131	Overall		****(1)
						M vs. L	****(1)	****(1)
						H vs. L	****(1)	****(1)
	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
Hypochondria	Enlisted Flyer	n	50	61	53	Overall		0.195
						M vs. L	0.33 (0.09,1.18)	0.087
						H vs. L	0.74 (0.26,2.14)	0.581
	Enlisted Groundcrew	n	148	160	131	Overall		****(1)
						M vs. L	****(1)	****(1)
						H vs. L	****(1)	****(1)

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
Hysteria	Enlisted Flyer	n	50	61	53	Overall		0.306
						M vs. L	0.55 (0.18,1.74)	0.312
						H vs. L	0.41 (0.12,1.37)	0.148
	Enlisted Groundcrew	n	148	160	131	Overall		****(1)
						M vs. L	****(1)	****(1)
						H vs. L	****(1)	****(1)
	Officer	n	125	126	120	Overall		****(4)
						M vs. L	****(4)	****(4)
						H vs. L	****(4)	****(4)
Mania/ Hypomania	Enlisted Flyer	n	50	61	53	Overall		0.474
						M vs. L	2.51 (0.55,11.53)	0.236
						H vs. L	1.66 (0.35,7.89)	0.527
	Enlisted Groundcrew	n	148	160	131	Overall		0.597
						M vs. L	0.97 (0.38,2.45)	0.945
						H vs. L	0.61 (0.21,1.75)	0.356

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
Masculinity/ Femininity	Enlisted Flyer	n	50	61	53	Overall		0.045
						M vs. L	----	----
						H vs. L	----	----
	Enlisted Groundcrew	n	148	160	131	Overall		0.479
						M vs. L	0.50 (0.16,1.57)	0.234
						H vs. L	0.75 (0.25,2.24)	0.604
	Officer	n	125	126	120	Overall		****(2)
						M vs. L	****(2)	****(2)
						H vs. L	****(2)	****(2)
Paranoia	Enlisted Flyer	n	50	61	53	Overall		****(2)
						M vs. L	****(2)	****(2)
						H vs. L	****(2)	****(2)
	Enlisted Groundcrew (a)	n	148	160	131	Overall		0.789
						M vs. L	1.06 (0.31,3.66)	0.922
						H vs. L	1.47 (0.44,4.92)	0.530

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	125	126	120	Overall		0.427
						M vs. L	1.01 (0.34,2.98)	0.985
						H vs. L	1.78 (0.65,4.83)	0.259
Psychopathic/ Deviate	Enlisted Flyer	n	50	61	53	Overall		0.759
						M vs. L	1.20 (0.42,3.41)	0.731
						H vs. L	0.79 (0.24,2.54)	0.689
	Enlisted Groundcrew	n	148	160	131	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
	Officer	n	125	126	120	Overall		0.511
						M vs. L	0.72 (0.18,2.97)	0.654
						H vs. L	0.38 (0.07,2.12)	0.269
Schizophrenia	Enlisted Flyer	n	50	61	53	Overall		0.615
						M vs. L	0.70 (0.21,2.35)	0.559
						H vs. L	0.52 (0.14,1.97)	0.338
	Enlisted Groundcrew	n	148	160	131	Overall		0.682
						M vs. L	1.32 (0.66,2.61)	0.429
						H vs. L	1.30 (0.64,2.64)	0.471

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
Social Introversion	Officer	n	125	126	120	Overall		0.247
						M vs. L	1.86 (0.16,21.91)	0.620
						H vs. L	----	----
	Enlisted Flyer	n	50	61	53	Overall		0.521
						M vs. L	0.20 (0.01,4.85)	0.321
						H vs. L	0.30 (0.02,5.61)	0.418
	Enlisted Groundcrew	n	148	160	131	Overall		0.394
						M vs. L	0.47 (0.15,1.49)	0.199
						H vs. L	0.87 (0.28,2.67)	0.805
Validity	Officer	n	125	126	120	Overall		0.049
						M vs. L	0.97 (0.53,1.76)	0.920
						H vs. L	0.48 (0.24,0.93)	0.031
	Enlisted Flyer	n	51	61	53	Overall		0.479
						M vs. L	0.67 (0.23,1.94)	0.459
						H vs. L	1.26 (0.47,3.40)	0.649
	Enlisted Groundcrew	n	148	160	131	Overall		0.718
						M vs. L	1.22 (0.71,2.11)	0.470
						H vs. L	1.22 (0.69,2.14)	0.499

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index Low	Medium	High	Contrast	Adj. Relative Risk (95% C.I.)	p-Value
	Officer	n	124	124	120	Overall		****(4)
		Adj. Mean	****(4)	****(4)	****(4)	M vs. L	----	****(4)
		95% C.I.	****(4)	****(4)	****(4)	H vs. L	----	****(4)
Total CMI	Enlisted Flyer	n	48	61	51	Overall		****(3,4)
		Adj. Mean	****(3,4)	****(3,4)	****(3,4)	M vs. L	----	****(3,4)
		95% C.I.	****(3,4)	****(3,4)	****(3,4)	H vs. L	----	****(3,4)
	Enlisted Groundcrew	n	145	154	125	Overall		0.608
		Adj. Mean(b)	13.67	12.48	13.09	M vs. L	----	0.319
		95% C.I.(b)	(11.33, 16.45)	(10.30, 15.09)	(10.81, 15.82)	H vs. L	----	0.655
	Officer	n	123	124	119	Overall		0.301
						M vs. L	0.72 (0.41,1.28)	0.265
						H vs. L	1.11 (0.64,1.93)	0.715
M-R Subscore	Enlisted Flyer	n	48	61	51	Overall		****(4)
						M vs. L	****(4)	****(4)
						H vs. L	****(4)	****(4)
	Enlisted Groundcrew	n	146	152	127	Overall		0.427
						M vs. L	0.82 (0.51,1.31)	0.403
						H vs. L	0.73 (0.44,1.19)	0.201