

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,⁵ 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 interview²¹ 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 pre-disposition, 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 Schedule²⁸), 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 subscale²⁴ 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)²⁵ 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***

Type of Illness	Group Abnormalities				Total	p-Value**
	Ranch Hand		Comparison			
	Number	Percent	Number	Percent		
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^{2,3} 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				Est. Relative Risk (95% C.I.)	p-Value
		Ranch Hand		Comparison			
		Number	Percent	Number	Percent		
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				Est. Relative Risk (95% C.I.)	p-Value
		Ranch Hand		Comparison			
		Number	Percent	Number	Percent		
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 ($0.05 < p \leq 0.10$).

**Not used in adjusted analyses.

TABLE 12-4.

Adjusted Analyses for MMPI by Group

Variable	Group		Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
	Ranch Hand Total	Comparison Total			
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		Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
	Ranch Hand Total	Comparison Total			
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		Est. Relative Risk (95% C.I.)	p-Value
		Ranch Hand	Comparison		
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	0.146
	1-10 (Medium)	408 40.9%	484 38.2%	1.14 (0.96,1.35)	
	>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	0.003
	1-3 (Medium)	449 49.1%	504 43.9%	1.33 (1.11, 1.60)	
	4-8 (High)	105 11.5%	107 9.3%	High vs. Low 1.46 (1.08,1.98)	0.013

^aTransformed 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 ($0.05 < p < 0.10$).

**Not used in adjusted analyses.

TABLE 12-7.

Adjusted Analyses for CMI Variables by Group

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

*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		Group		Est./Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks*
		Ranch Hand Number	Percent	Comparison Number	Percent			
Unadjusted Analysis	n	1,006		1,283		1.06 (0.89,1.26)	0.533	N/A
	Abnormal	348	34.6	427	33.3			
	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

^aBased 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			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Anxiety	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
	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)
Consistency	Officer	n	125	126	120	Overall		0.274
						M vs. L	1.10 (0.14,8.59)	0.925
						H vs. L	-----	-----
	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			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Defensiveness	Officer	n	125	126	120	Overall		0.518
						M vs. L	----	----
						H vs. L	----	----
	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
Denial	Officer	n	125	126	120	Overall		****(2)
						M vs. L	****(2)	****(2)
						H vs. L	****(2)	****(2)
	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			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Depression	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
	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)
Hypochondria	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
	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			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Hysteria	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
	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)	
Mania/ Hypomania	Officer	n	125	126	120	Overall		****(4)
						M vs. L	****(4)	****(4)
						H vs. L	****(4)	****(4)
	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	

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TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Masculinity/ Femininity	Officer	n	125	126	120	Overall		****(3)
						M vs. L	****(3)	****(3)
						H vs. L	****(3)	****(3)
	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	
Paranoia	Officer	n	125	126	120	Overall		****(2)
						M vs. L	****(2)	****(2)
						H vs. L	****(2)	****(2)
	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			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Psychopathic/ Deviate	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
	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)
Schizophrenia	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
	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

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TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

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

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TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
Total CMI	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)
	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
M-R Subscore	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
	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

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TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

Variable	Occupation	Statistic*	Exposure Index			Contrast	Adj. Relative Risk (95% C.I.)	p-Value
			Low	Medium	High			
	Officer	n	111	109	112	Overall	0.78 (0.44, 1.37)	0.546
						M vs. L		0.383
						H vs. L		0.311
A-H Area Subscore	Enlisted Flyer	n	45	57	45	Overall	****(3,4)	****(3,4)
						M vs. L		****(3,4)
						H vs. L		****(3,4)
	Enlisted Groundcrew	n	129	145	118	Overall	0.84 (0.50, 1.40)	0.427
						M vs. L		0.499
						H vs. L		0.767
	Officer	n	124	126	118	Overall	0.81 (0.43, 1.53)	0.255
						M vs. L		0.512
						H vs. L		0.103
HRB Impairment Index	Enlisted Flyer	n	47	61	52	Overall	2.28 (0.96, 5.44)	0.159
						M vs. L		0.063
						H vs. L		0.461
	Enlisted Groundcrew	n	145	158	127	Overall	****(1)	****(1)
						M vs. L		****(1)
						H vs. L		****(1)

TABLE 12-9. (continued)

Adjusted Exposure Index Analyses
for Psychological Variables by Occupation

-
- *n: represents total sample size for variable in given occupational stratum.
- (a): marginal exposure index by race interaction ($p=0.055$) -- relative risk, confidence interval, and p-value presented, and additional information provided in interaction summaries.
- (b): converted from log (X+1) scale, where X was the number of questions answered yes.
- ****(1): exposure index-by-race interaction -- relative risk, confidence interval, and p-value not presented.
- ****(2): exposure index-by-age interaction -- relative risk, confidence interval, and p-value not presented.
- ****(3): exposure index-by-education interaction -- relative risk, confidence interval, and p-value not presented.
- ****(4): exposure index-by-drink-year interaction -- relative risk/adjusted mean, confidence interval, and p-value not presented.
- ****(3,4): exposure index-by-education and exposure index-by-drink-year interaction -- relative risk/adjusted mean, confidence interval, and p-value not presented.
- : no relative risk given for Total CMI, which was analyzed as a continuous variable.

Unadjusted analyses revealed a borderline significant difference between the high and low exposure levels for masculinity/femininity in officers (Est. RR: 2.38, 95% C.I.: [0.94,6.06], p=0.075), and for the total CMI in officers (low mean: 7.99, high mean: 10.04, p=0.018; overall p-value: 0.049). These data supported an increase in the proportion of abnormalities with increasing exposure levels. Other significant or marginally significant results were associated with a decrease in the proportion of abnormalities with an increase in exposure level.

The frequency of abnormalities for the different exposure index levels exhibited no graduated pattern across exposure levels. Within the officer stratum, five variables demonstrated an increasing dose-response relationship, although usually nonsignificant; however, four variables showed the opposite pattern, that is, a decreasing proportion of abnormalities with increasing exposure levels.

Few significant results were observed in the adjusted analysis, as in the unadjusted analysis. The medium level of the HRB impairment index for enlisted flyers showed an increased relative risk over the low level (Adj. RR: 2.28, 95% C.I.: [0.96,5.44], p=0.063). Many exposure index-by-covariate interactions were present, however, which prevented a direct comparison.

Interactions were present for 13 of the 18 variables, but no occupational stratum was predominant. A summary of these interactions is presented in Table 12-10.

TABLE 12-10.

Summary of Exposure Index-by-Covariate Interactions
in Adjusted Analyses of Psychological Variables

Variable	Occupation	Covariate	p-Value
Anxiety	Enlisted Groundcrew	Race	0.020
Denial	Officer	Age	0.048
Depression	Enlisted Groundcrew	Race	0.050
Hypochondria	Officer	Education	0.005
Hypochondria	Enlisted Groundcrew	Race	0.033
Hysteria	Officer	Education	0.018
Hysteria	Enlisted Groundcrew	Race	0.007
Mania/Hypomania	Officer	Drink-Years	0.015
Masculinity/Feminity	Officer	Education	0.018
Paranoia	Officer	Age	0.044
Paranoia	Enlisted Flyer	Age	0.004
Paranoia	Enlisted Groundcrew	Race	0.055 (marginal)
Psychopathic/Deviate	Enlisted Groundcrew	Education	0.040
Total CMI	Officer	Drink-Years	0.034
Total CMI	Enlisted Flyer	Education	0.027
Total CMI	Enlisted Flyer	Drink-Years	0.021
M-R Subscore	Enlisted Flyer	Drink-Years	0.042
A-H Area Subscore	Enlisted Flyer	Education	0.009
A-H Area Subscore	Enlisted Flyer	Drink-Years	0.004
HRB Impairment Index	Enlisted Groundcrew	Race	0.031

Significant or borderline significant results in these interactions, suggestive of a dose-response relationship (i.e., increasing abnormalities or more abnormal means as exposure increases), were as follows:

- (1) Hysteria in college-educated officers, overall p-value = 0.025; high versus low contrast (Adj. RR: 3.49, 95% C.I.: [1.17,10.32], p=0.024); increase in the proportion of abnormalities with increasing exposure levels.
- (2) Mania/Hypomania in officers with greater than 50 drink-years, high versus low contrast, p=0.067; analysis affected by sparse cell sizes, however.
- (3) Masculinity/Femininity in college-educated officers, medium versus low contrast (Adj. RR: 3.05, 95% C.I.: [1.01,9.08], p=0.048); increase in the proportion of abnormalities with increasing exposure levels.
- (4) Total CMI in high school-educated, nondrinking, enlisted flyers, medium versus low contrast, p=0.018.
- (5) Total CMI in college-educated, nondrinking, enlisted flyers, overall p-value =0.060; analysis affected by sparse cell sizes, however.
- (6) M-R subscore in nondrinking, enlisted flyers, overall p-value = 0.060; analysis affected by sparse cell sizes, however.
- (7) A-H area subscore in high school-educated, nondrinking, enlisted flyers, overall p-value = 0.007; analysis affected by sparse cell sizes, however.
- (8) HRB impairment index in nonblack enlisted groundcrew, medium versus low contrast (Adj. RR: 1.88, 95% C.I.: [1.09,3.25], p=0.024).

All other significant interaction results were not consistent with a dose-response relationship.

In summary, no consistent or strong patterns of increasing dose-response relationship were evident throughout the psychological exposure index analyses.

LONGITUDINAL ANALYSES

Two scales for the MMPI, depression and denial, were significantly different by group at Baseline and were investigated to assess the longitudinal differences between the 1982 Baseline examination and the 1985 followup examination. Both variables are scores and were classified as abnormal or normal according to criteria given previously. These variables have been stratified by education level. As shown in Table 12-11, 2x2 tables were constructed for each group for each variable. These tables show the number of participants who were abnormal at Baseline and abnormal at followup, abnormal at Baseline and normal at followup, normal at Baseline and abnormal at followup, and normal at both Baseline and followup examinations.

TABLE 12-11.

Longitudinal Analysis of Depression and Denial:
A Contrast of Baseline and First
Followup Examination Abnormalities

Variable	Education	Group	1982		1985		Odds Ratio (OR)*	p-Value (OR _{RH} vs/OR _C)
			Baseline Exam		Followup Exam			
				Abnormal	Normal			
Depression	High School	Ranch Hand	Abnormal	59	48	0.65	0.04	
			Normal	31	570			
	Comparison	Abnormal	44	43	1.21			
		Normal	52	695				
College	Ranch Hand	Abnormal	11	9	1.11	0.73		
			Normal	10			227	
	Comparison	Abnormal	7	11	1.36			
		Normal	15	276				
Denial	High School	Ranch Hand	Abnormal	2	5	2.20	0.56	
			Normal	11	690			
	Comparison	Abnormal	6	10	3.20			
		Normal	32	786				
College	Ranch Hand	Abnormal	0	3	1.67	0.32		
			Normal	5			249	
	Comparison	Abnormal	5	3	4.33			
		Normal	13	288				

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

The odds ratio given is the ratio of the number of participants who were normal at the Baseline and abnormal at the followup to the number of participants who were abnormal at the Baseline and normal at the followup (the "off-diagonal" elements). The changes in normal/abnormal status within each group are contrasted between the Ranch Hand and Comparison groups, and the p-value is derived from Pearson's chi-square test of the hypothesis that the pattern of change in the two groups is the same.

The data showed a significant difference ($p=0.04$) in the depression scores in the two groups between examinations for the high school-educated stratum: significantly more Comparisons developed depression in the interval. The percentage of Ranch Hands with abnormalities for depression decreased from the Baseline examination to the followup examination, in contrast to the Comparison group, which showed an increase in depression abnormalities. No significant difference in the pattern of change for depression was found in the college-educated stratum, nor were any significant differences observed for denial.

DISCUSSION

The MMPI is a comprehensive, self-administered questionnaire containing 566 questions that broadly assess behavior, personality, and validity and consistency indicators of the responses. The MMPI data are divided into 14 scales that are not mutually exclusive for specific questions. In this study, an additional MMPI scale for the characterization of PTSD is used to identify highly correlated combat experiences of the participants. Four combat questions were selected as a surrogate measure of PTSD, and an index of these questions is used as a covariate in all of the adjusted analyses of the MMPI subscales.

Distributional testing for the 14 scales of the MMPI, stratified by occupation, yielded no significant differences or discernible patterns between the two groups. In contrast, both unadjusted and adjusted analyses showed significant group differences for the denial and masculinity/femininity scales, with the Comparisons having higher proportions of abnormalities than the Ranch Hands. Also, borderline significant associations ($0.05 < p < 0.10$) were observed for the hysteria and social introversion scales, with the Ranch Hands having slightly higher proportions of abnormalities than the Comparisons. The discrepancy in results between Kolmogorov-Smirnov distributional testing and the refined statistical models was also noted in the 1984 Baseline Report.

The unadjusted and adjusted results were completely comparable with respect to group differences when direct contrast was possible, i.e., when no group-by-covariate interactions were present. Of the seven group interactions noted in the adjusted analyses, three involved the covariate of education, with the high school-educated Ranch Hands faring worse than high school-educated Comparisons. Further, the high school strata usually exhibited a higher frequency of abnormalities than the college-educated strata. Overall education showed a profound effect either as a main effect or by an interaction with another covariate. The strong influence of education was also detected in the Baseline data. Analyses using only the Original Comparisons often showed stronger group differences than the analyses based upon the total Comparison group (see Tables J-13 to J-18 of Appendix J).

A direct comparison of the MMPI results between the Baseline and followup examinations is hampered by the small change in cohorts and the difference in statistical models. In general, at the followup the Ranch Hands manifested more MMPI scale abnormalities than the Comparisons, as judged by the number of relative risks greater than one. However, the highly significant results for the denial scale, with the Comparisons having a higher proportion of abnormalities than the Ranch Hands, suggested that the Comparisons may be underreporting on all of the MMPI scales, and consequently more relative risks greater than one would be expected. A contrast of the adjusted Baseline MMPI results to the adjusted (and unadjusted results where interactions are noted in the adjusted tests) results of the followup suggest a relatively consistent pattern of narrowing group differences over time (e.g., hypochondria, depression, hysteria, schizophrenia scales), either by a decrease in Ranch Hand abnormalities or an increase of Comparison abnormalities. This trend was also suggested in the longitudinal analysis of two scales (depression and denial) although only the "favorable" Ranch Hand change in depression for the high school stratum reached statistical significance. Overall, the followup MMPI data suggested a subtle, but consistent, decrease in reporting of concerns (or strength of concerns) in the Ranch Hands.

Only 16 participants were identified as possibly having PTSD by the MMPI subscale. Further, only 4 of 15 combat experience questions manifested strong correlation to these possible PTSD cases. Most PTSD surveys have focused on U.S. Army ground personnel, obscuring direct comparisons to U.S. Air Force personnel because of inherent differences in combat experience, education, proportion of officers, and career motivation.

The CMI revealed a significant group difference for the total score and the A-H area subscore, with the Ranch Hands exhibiting higher mean scores or higher frequencies of abnormal scores. There was no group difference for the M-R subscore. These results differed slightly from the distributional tests which showed one statistically significant stratum, where the Ranch Hand mean was greater than the Comparison mean, for each covariate (see Table J-5 of Appendix J). Because the Baseline CMI was in a different format, direct comparison of each psychological parameter to the followup CMI is not feasible. However, the Baseline CMI noted statistically significant group differences for 5 of 10 parameters, which is in approximate accord with the magnitude and direction of the results found at the followup examination. This analysis of the total CMI analyzed at followup has sufficient statistical power to detect a mean difference of one response out of 195 questions (0.5% difference, at power=0.8) between the groups. Education showed the same profound effect on the adjusted analyses as was noted at Baseline.

The functional integrity of the CNS, as measured by the HRB impairment index, showed no significant group differences. There was similarity (Adj. RR: 1.04, 95% C.I.: [0.86,1.25], p=0.697) in results of the impairment index. As in the Baseline analysis, education was a major covariate in the followup examination; the additionally strong effects of age and race were also noted at the followup examination. Although valid differences exist between groups for some measures, there is no indication that these differences are manifest or confirmed by impaired CNS function, a reasonable medical expectation for chemically induced neurobehavioral pathology. Adjustment of the HRB results for PTSD (not feasible at the Baseline analysis) suggests that some group differences lack organic basis.

SUMMARY AND CONCLUSIONS

Questionnaire data (verified by medical record reviews) for the lifetime events of psychotic illness, alcohol dependence, anxiety, or other neuroses disclosed no significant differences between groups for these conditions.

Analyses of the followup psychological examination emphasized 14 scales from the Minnesota Multiphasic Personality Inventory (MMPI), 3 parameters of the Cornell Medical Index (CMI), and the Halstead-Reitan Battery (HRB) impairment index.

The similarity of the group distribution for the 14 MMPI variables, each stratified by the 3 occupational categories, was examined, and only 2 of the 42 tests approached statistical significance. The group distributions of the total CMI score were similarly contrasted, with separate analyses performed with stratification by the five covariates of age, race, occupation, education, and current drinking status. For one stratum of each of these covariates, a significant difference in the distribution of the Ranch Hand and Comparison scores was found. In all cases for the CMI, the Ranch Hand mean was greater than the Comparison mean. Distributional analyses using Original Comparisons generally reflected the same results as those involving the total Comparison group.

Results of unadjusted and adjusted analyses on all of the 18 psychological variables are given in Table 12-12.

The unadjusted analyses showed a significant difference for the MMPI scales of denial ($p < 0.001$) and masculinity/femininity ($p = 0.017$), the total CMI ($p < 0.001$), and the Section A-H area subscore ($p = 0.003$). A borderline significant difference was observed for the MMPI scales of hysteria ($p = 0.067$) and social introversion ($p = 0.069$). Comparisons had a greater percentage of abnormal scores for the denial and masculinity/femininity scales, whereas Ranch Hands showed adverse findings for the other four variables. The overall MMPI results have been interpreted in light of the significant increased denial in the Comparison group.

The covariates age, education, drink-years, current alcohol use, and occupation had pronounced effects on the psychological variables, with a significant association or a borderline significant association with at least two-thirds of the 18 psychological variables. Many dependent variables in this chapter were affected by age in an expected pattern. Very few variables exhibited this pattern of consistency with drink-years. The intermediate category of greater than 0 to 50 drink-years often had the smallest proportion of abnormalities. The post-traumatic stress disorder (PTSD) variable, derived from a subset of the MMPI, was strongly associated with the CMI measures, but not with the HRB Impairment Index. Race and the Vietnam combat index (used for the MMPI subscales) had significant associations with a lesser amount of the psychological variables (6 of 18 variables and 3 of 14 variables, for race and combat index, respectively).

The adjusted analyses were generally quite similar to the unadjusted analyses with respect to group differences, although a direct comparison of these analyses was often clouded by the presence of a substantial number of interactions (six group-by-covariate interactions were significant, and three interactions approached significance [$0.05 < p < 0.10$]). The MMPI scales of denial and masculinity/femininity were statistically significant in both the

TABLE 12-12.

Overall Summary Results of Adjusted and Unadjusted
Analyses of Psychological Variables

Variable	Unadjusted	Adjusted	Direction of Results ^a
<u>Questionnaire:</u>			
Psychological Illness	NS	--	
<u>Psychological Examination:</u>			
MMPI			
Anxiety	NS	NS	
Consistency	NS	****	
Defensiveness	NS	NS	
Denial	<0.001	<0.001	C>RH
Depression	NS	NS	
Hypochondria	NS	NS	
Hysteria	NS* ^b	NS* ^b	RH>C
Mania/Hypomania	NS	NS	
Masculinity/Femininity	0.017	0.020	C>RH
Paranoia	NS	****	
Psychopathic/Deviate	NS	NS	
Schizophrenia	NS	****	
Social Introversiion	NS* ^b	****	RH>C
Validity	NS	****	
CMI			
Total CMI	<0.001	****	RH>C
M-R Subscore	NS	NS	
A-H Area Subscore	0.003	0.040	RH>C
HRB			
Impairment Index	NS	NS	

^aRH>C - more abnormalities in Ranch Hands; C>RH - more abnormalities in Comparisons.

^bIllnesses include psychosis, alcohol dependence, anxiety, and other neuroses.

--Analysis not performed.

NS: Not significant.

NS*: Borderline significant (0.05 < p < 0.10).

****Interaction involving group.

adjusted and unadjusted analyses, where Comparisons showed an adverse effect over Ranch Hands. The A-H area subscore of the CMI (suggesting diffuse medical problems) was also significant, where the Ranch Hands had higher mean scores than the Comparisons, suggesting the Ranch Hands had more illness. Education was often involved in significant group interactions with high school-educated Ranch Hands demonstrating a higher percentage of abnormal scores than high school-educated Comparisons. No group differences were observed in the college-educated stratum. The M-R subscore of the CMI, a broad indicator of emotional health, was not statistically different between the two groups.

The HRB impairment index, a measure of central nervous system (CNS) functional integrity, did not differ significantly between the Ranch Hand and Comparison groups. Strong covariates in the adjusted analysis were age, race, and education.

Because of alternate statistical models and slightly different psychological testing parameters, a direct contrast between the psychological results of the Baseline and followup examinations was not always possible. However, several broad patterns were observed: (1) the discordance between distributional tests and results from traditional statistical models of the MMPI variables was noted with data from both examinations; (2) there was a narrowing of group differences at the followup examination for most subjective variables, either by a decrease in Ranch Hand reporting, or by an increase in Comparison reporting; and (3) as at the Baseline, functional CNS testing, as measured by the HRB impairment index, showed no group differences, and did not support an organic basis for differences in self-reported symptomatology. The longitudinal analysis of two MMPI scales, depression and denial, showed a significant reversal of depression seen at Baseline in the high school-educated Ranch Hands.

The determination of PTSD in both Air Force cohorts by a relatively new MMPI scale showed a prevalence rate of less than 1 percent. This low rate is strongly influenced by characteristics of the study population (e.g., age, education, and officer ratio).

Unadjusted exposure index analyses did not reveal any patterns consistent with a dose-response relationship. For the adjusted exposure analyses, approximately one-third presented exposure interactions with the covariates of race, education, and age, but no consistent pattern could be identified.

In conclusion, some test measures of psychological health (MMPI and CMI) did not show substantial adverse effects for either group. Significant test results were present in both groups or were noted in specific subgroups of a covariate. Educational level, age, and alcohol use showed strong effects on the psychological scales and scores in this psychological assessment. There was a subtle but consistent trend for more favorable subjective test results at the followup examination for the Ranch Hands relative to the Comparisons. Testing of the CNS by the HRB demonstrated an almost identical prevalence of pathology in both groups.

CHAPTER 12

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