

## Table of Contents

---

<b>13</b>	<b>GASTROINTESTINAL ASSESSMENT</b>	<b>13-1</b>
13.1	INTRODUCTION	13-1
13.1.1	Background	13-1
13.1.2	Summary of Previous Analyses of the Air Force Health Study	13-2
13.1.2.1	1982 Baseline Study Summary Results	13-2
13.1.2.2	1985 Follow-up Study Summary Results	13-2
13.1.2.3	1987 Follow-up Study Summary Results	13-3
13.1.2.4	Serum Dioxin Analysis of 1987 Follow-up Study Summary Results	13-3
13.1.2.5	1992 Follow-up Study Summary Results	13-3
13.1.3	Parameters for the 1997 Gastrointestinal Assessment	13-4
13.1.3.1	Dependent Variables	13-4
13.1.3.1.1	Medical Records Data	13-4
13.1.3.1.2	Physical Examination Data	13-4
13.1.3.1.3	Laboratory Examination Data	13-5
13.1.3.2	Covariates	13-5
13.1.4	Statistical Methods	13-6
13.1.4.1	Longitudinal Analysis	13-11
13.2	RESULTS	13-11
13.2.1	Dependent Variable-Covariate Associations	13-11
13.2.1.1	Medical Records Variables	13-11
13.2.1.2	Laboratory Examination Variables	13-12
13.2.2	Exposure Analysis	13-17
13.2.2.1	Medical Records Variables	13-18
13.2.2.1.1	Uncharacterized Hepatitis	13-18
13.2.2.1.2	Jaundice (Unspecified)	13-21
13.2.2.1.3	Acute Necrosis of the Liver	13-24
13.2.2.1.4	Chronic Liver Disease and Cirrhosis (Alcohol-related)	13-24
13.2.2.1.5	Chronic Liver Disease and Cirrhosis (Non-alcohol-related)	13-26
13.2.2.1.6	Liver Abscess and Sequelae of Chronic Liver Disease	13-29
13.2.2.1.7	Enlarged Liver (Hepatomegaly)	13-31
13.2.2.1.8	Other Liver Disorders	13-34
13.2.2.2	Physical Examination Variables	13-36
13.2.2.2.1	Current Hepatomegaly	13-36
13.2.2.3	Laboratory Examination Variables	13-39
13.2.2.3.1	AST (Continuous)	13-39
13.2.2.3.2	AST (Discrete)	13-42
13.2.2.3.3	ALT (Continuous)	13-45
13.2.2.3.4	ALT (Discrete)	13-48
13.2.2.3.5	GGT (Continuous)	13-50
13.2.2.3.6	GGT (Discrete)	13-54
13.2.2.3.7	Alkaline Phosphatase (Continuous)	13-56
13.2.2.3.8	Alkaline Phosphatase (Discrete)	13-59
13.2.2.3.9	Total Bilirubin (Continuous)	13-62
13.2.2.3.10	Total Bilirubin (Discrete)	13-64
13.2.2.3.11	Direct Bilirubin	13-67
13.2.2.3.12	Lactic Dehydrogenase (Continuous)	13-69

13.2.2.3.13	Lactic Dehydrogenase (Discrete).....	13-72
13.2.2.3.14	Cholesterol (Continuous).....	13-74
13.2.2.3.15	Cholesterol (Discrete).....	13-77
13.2.2.3.16	HDL Cholesterol (Continuous).....	13-80
13.2.2.3.17	HDL Cholesterol (Discrete).....	13-82
13.2.2.3.18	Cholesterol-HDL Ratio (Continuous).....	13-85
13.2.2.3.19	Cholesterol-HDL Ratio (Discrete).....	13-88
13.2.2.3.20	Triglycerides (Continuous).....	13-91
13.2.2.3.21	Triglycerides (Discrete).....	13-94
13.2.2.3.22	Creatine Phosphokinase (Continuous).....	13-97
13.2.2.3.23	Creatine Phosphokinase (Discrete).....	13-100
13.2.2.3.24	Serum Amylase (Continuous).....	13-102
13.2.2.3.25	Serum Amylase (Discrete).....	13-105
13.2.2.3.26	Antibodies for Hepatitis A.....	13-108
13.2.2.3.27	Evidence of Prior Hepatitis B.....	13-110
13.2.2.3.28	Current Hepatitis B.....	13-112
13.2.2.3.29	Antibodies for Hepatitis C.....	13-115
13.2.2.3.30	Antibodies for Hepatitis D.....	13-117
13.2.2.3.31	Stool Hemocult.....	13-117
13.2.2.3.32	Prealbumin (Continuous).....	13-120
13.2.2.3.33	Prealbumin (Discrete).....	13-122
13.2.2.3.34	Albumin (Continuous).....	13-125
13.2.2.3.35	Albumin (Discrete).....	13-127
13.2.2.3.36	$\alpha$ -1-Acid Glycoprotein (Continuous).....	13-130
13.2.2.3.37	$\alpha$ -1-Acid Glycoprotein (Discrete).....	13-133
13.2.2.3.38	$\alpha$ -1-Antitrypsin (Continuous).....	13-135
13.2.2.3.39	$\alpha$ -1-Antitrypsin (Discrete).....	13-139
13.2.2.3.40	$\alpha$ -2-Macroglobulin (Continuous).....	13-144
13.2.2.3.41	$\alpha$ -2-Macroglobulin (Discrete).....	13-147
13.2.2.3.42	Apolipoprotein B (mg/dl) (Continuous).....	13-149
13.2.2.3.43	Apolipoprotein B (Discrete).....	13-152
13.2.2.3.44	C3 Complement (mg/dl) (Continuous).....	13-155
13.2.2.3.45	C3 Complement (Discrete).....	13-158
13.2.2.3.46	C4 Complement (Continuous).....	13-161
13.2.2.3.47	C4 Complement (Discrete).....	13-164
13.2.2.3.48	Haptoglobin (Continuous).....	13-166
13.2.2.3.49	Haptoglobin (Discrete).....	13-169
13.2.2.3.50	Transferrin (Continuous).....	13-172
13.2.2.3.51	Transferrin (Discrete).....	13-175
13.2.3	Longitudinal Analysis.....	13-178
13.2.3.1	Laboratory Examination Variables.....	13-179
13.2.3.1.1	AST (Continuous).....	13-179
13.2.3.1.2	AST (Discrete).....	13-182
13.2.3.1.3	ALT (Continuous).....	13-184
13.2.3.1.4	ALT (Discrete).....	13-187
13.2.3.1.5	GGT (Continuous).....	13-189
13.2.3.1.6	GGT (Discrete).....	13-192
13.2.3.1.7	Cholesterol (Continuous).....	13-194
13.2.3.1.8	Cholesterol (Discrete).....	13-197
13.2.3.1.9	HDL Cholesterol (Continuous).....	13-199

13.2.3.1.10	HDL Cholesterol (Discrete).....	13-202
13.2.3.1.11	Cholesterol-HDL Ratio (Continuous).....	13-204
13.2.3.1.12	Cholesterol-HDL Ratio (Discrete).....	13-207
13.2.3.1.13	Triglycerides (Continuous).....	13-209
13.2.3.1.14	Triglycerides (Discrete).....	13-212
13.3	DISCUSSION.....	13-214
13.4	SUMMARY .....	13-217
13.4.1	Model 1: Group Analysis .....	13-217
13.4.2	Model 2: Initial Dioxin Analysis.....	13-221
13.4.3	Model 3: Categorized Dioxin Analysis .....	13-223
13.4.4	Model 4: 1987 Dioxin Level Analysis .....	13-227
13.5	CONCLUSION .....	13-229
<b>REFERENCES.....</b>		<b>13-231</b>

## List of Tables

---

Table 13-1. Statistical Analysis for the Gastrointestinal Assessment .....	13-6
Table 13-2. Number of Participants Excluded or with Missing Data for the Gastrointestinal Assessment.....	13-10
Table 13-3. Analysis of Uncharacterized Hepatitis .....	13-19
Table 13-4. Analysis of Jaundice (Unspecified) .....	13-21
Table 13-5. Analysis of Chronic Liver Disease and Cirrhosis (Alcohol-related) .....	13-24
Table 13-6. Analysis of Chronic Liver Disease and Cirrhosis (Non-alcohol-related) .....	13-27
Table 13-7. Analysis of Liver Abscess and Sequelae of Chronic Liver Disease .....	13-29
Table 13-8. Analysis of Enlarged Liver (Hepatomegaly) .....	13-32
Table 13-9. Analysis of Other Liver Disorders.....	13-34
Table 13-10. Analysis of Current Hepatomegaly.....	13-37
Table 13-11. Analysis of AST (U/l) (Continuous).....	13-39
Table 13-12. Analysis of AST (Discrete) .....	13-42
Table 13-13. Analysis of ALT (U/l) (Continuous) .....	13-45
Table 13-14. Analysis of ALT (Discrete) .....	13-48
Table 13-15. Analysis of GGT (U/l) (Continuous).....	13-51
Table 13-16. Analysis of GGT (Discrete).....	13-54
Table 13-17. Analysis of Alkaline Phosphatase (U/l) (Continuous).....	13-56
Table 13-18. Analysis of Alkaline Phosphatase (Discrete).....	13-60
Table 13-19. Analysis of Total Bilirubin (mg/dl) (Continuous) .....	13-62
Table 13-20. Analysis of Total Bilirubin (Discrete) .....	13-65
Table 13-21. Analysis of Direct Bilirubin.....	13-67
Table 13-22. Analysis of Lactic Dehydrogenase (U/l) (Continuous) .....	13-69
Table 13-23. Analysis of Lactic Dehydrogenase (Discrete) .....	13-72
Table 13-24. Analysis of Cholesterol (mg/dl) (Continuous).....	13-74
Table 13-25. Analysis of Cholesterol (Discrete).....	13-77
Table 13-26. Analysis of HDL Cholesterol (mg/dl) (Continuous) .....	13-80
Table 13-27. Analysis of HDL Cholesterol (Discrete) .....	13-83
Table 13-28. Analysis of Cholesterol-HDL Ratio (Continuous) .....	13-85
Table 13-29. Analysis of Cholesterol-HDL Ratio (Discrete) .....	13-89
Table 13-30. Analysis of Triglycerides (mg/dl) (Continuous).....	13-91
Table 13-31. Analysis of Triglycerides (Discrete).....	13-94
Table 13-32. Analysis of Creatine Phosphokinase (U/l) (Continuous).....	13-97
Table 13-33. Analysis of Creatine Phosphokinase (Discrete).....	13-100

Table 13-34. Analysis of Serum Amylase (U/l) (Continuous).....	13-102
Table 13-35. Analysis of Serum Amylase (Discrete) .....	13-106
Table 13-36. Analysis of Antibodies for Hepatitis A.....	13-108
Table 13-37. Analysis of Evidence of Prior Hepatitis B.....	13-110
Table 13-38. Analysis of Current Hepatitis B.....	13-113
Table 13-39. Analysis of Antibodies for Hepatitis C.....	13-115
Table 13-40. Analysis of Stool Hemocult .....	13-118
Table 13-41. Analysis of Prealbumin (mg/dl) (Continuous).....	13-120
Table 13-42. Analysis of Prealbumin (Discrete).....	13-123
Table 13-43. Analysis of Albumin (mg/dl) (Continuous).....	13-125
Table 13-44. Analysis of Albumin (Discrete).....	13-128
Table 13-45. Analysis of $\alpha$ -1-Acid Glycoprotein (mg/dl) (Continuous) .....	13-130
Table 13-46. Analysis of $\alpha$ -1-Acid Glycoprotein (Discrete) .....	13-133
Table 13-47. Analysis of $\alpha$ -1-Antitrypsin (mg/dl) (Continuous).....	13-136
Table 13-48. Analysis of $\alpha$ -1-Antitrypsin (Discrete).....	13-140
Table 13-49. Analysis of $\alpha$ -2-Macroglobulin (mg/dl) (Continuous) .....	13-144
Table 13-50. Analysis of $\alpha$ -2-Macroglobulin (Discrete) .....	13-147
Table 13-51. Analysis of Apolipoprotein B (mg/dl) (Continuous) .....	13-150
Table 13-52. Analysis of Apolipoprotein B (Discrete).....	13-153
Table 13-53. Analysis of C3 Complement (mg/dl) (Continuous).....	13-155
Table 13-54. Analysis of C3 Complement (Discrete).....	13-158
Table 13-55. Analysis of C4 Complement (mg/dl) (Continuous).....	13-161
Table 13-56. Analysis of C4 Complement (Discrete).....	13-164
Table 13-57. Analysis of Haptoglobin (mg/dl) (Continuous) .....	13-167
Table 13-58. Analysis of Haptoglobin (Discrete) .....	13-170
Table 13-59. Analysis of Transferrin (mg/dl) (Continuous) .....	13-172
Table 13-60. Analysis of Transferrin (Discrete) .....	13-176
Table 13-61. Normal Ranges from Air Force Health Study Examinations for Dependent Variables Used in Longitudinal Analysis.....	13-179
Table 13-62. Longitudinal Analysis of AST (U/l) (Continuous).....	13-180
Table 13-63. Longitudinal Analysis of AST (Discrete) .....	13-182
Table 13-64. Longitudinal Analysis of ALT (U/l) (Continuous).....	13-185
Table 13-65. Longitudinal Analysis of ALT (Discrete).....	13-187
Table 13-66. Longitudinal Analysis of GGT (U/l) (Continuous) .....	13-190
Table 13-67. Longitudinal Analysis of GGT (Discrete) .....	13-192

Table 13-68. Longitudinal Analysis of Cholesterol (mg/dl) (Continuous) .....	13-195
Table 13-69. Longitudinal Analysis of Cholesterol (Discrete) .....	13-197
Table 13-70. Longitudinal Analysis of HDL Cholesterol (mg/dl) (Continuous).....	13-200
Table 13-71. Longitudinal Analysis of HDL Cholesterol (Discrete).....	13-202
Table 13-72. Longitudinal Analysis of Cholesterol-HDL Ratio (Continuous).....	13-205
Table 13-73. Longitudinal Analysis of Cholesterol-HDL Ratio (Discrete).....	13-207
Table 13-74. Longitudinal Analysis of Triglycerides (mg/dl) (Continuous) .....	13-210
Table 13-75. Longitudinal Analysis of Triglycerides (Discrete) .....	13-212
Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) .....	13-217
Table 13-77. Summary of Initial Dioxin Analysis (Model 2) for Gastrointestinal Variables (Ranch Hands Only) .....	13-221
Table 13-78. Summary of Categorized Dioxin Analysis (Model 3) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) .....	13-224
Table 13-79. Summary of 1987 Dioxin Analysis (Model 4) for Gastrointestinal Variables (Ranch Hands Only) .....	13-228

## 13 GASTROINTESTINAL ASSESSMENT

---

### 13.1 INTRODUCTION

#### 13.1.1 Background

In contrast with the wealth of dioxin research data available in animal models, there is relatively little information about the effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) on the human digestive system. Although the pharmacokinetics of orally ingested dioxin in a human volunteer have been reported (1), the pathologic lesions that have been studied in animals (gastric metaplasia with ulceration and ileitis) have not been described in human populations, in which the principal route of exposure has been transcutaneous. Further, in two reports of extreme phenoxyherbicide toxicity by ingestion in three humans, the primary target organs were the central nervous system with associated coma and the musculoskeletal system with rhabdomyolysis and renal failure, rather than the digestive system (2, 3).

The digestive system and, particularly, the liver (4–9) and stomach (5, 10–14) have been clearly defined as target organs for dioxin toxicity in numerous laboratory animals. Dioxin ingested by rodents (15–20) and adult monkeys (21) is absorbed by the intestinal lymphatics, transported by chylomicrons in the enterohepatic, and preferentially stored in adipose tissue and the liver. Hepatotoxic manifestations, which appear to be dose- and time-dependent, include cellular hypertrophy, parenchymal necrosis (principally centrilobular), fatty degeneration, and the production of altered hepatic foci, a microscopic precursor in hepatic carcinogenesis (9, 22–24). Chronic feeding studies have confirmed the role of dioxin as a hepatic carcinogen in rats (25, 26) and mice (27). Gastric endpoints have been the subject of several reports that have focused on histologic changes (5, 12, 13) and endocrine secretory abnormalities (10, 11, 28) associated with dioxin toxicity.

A host of hepatic biochemical reactions related to dioxin toxicity has been studied, including lipid peroxidation (29–33), hepatic prostaglandin synthetase activity (34), and inhibition of glutathione peroxidase (30). Results from several lines of biochemical investigation have created a bridge between animal and human studies including research into lipid (33, 35–37) and porphyrin metabolism (38–41). In rats, dioxin has been shown to increase the activity of glucuronyl transferase (42), an observation that led to the use of urinary d-glucuronic acid as a marker for dioxin exposure in several human epidemiological studies (43–47). The most recent of these, and the only one to include serum dioxin levels, found no correlation between this index and the body burden of dioxin (47).

In published occupational and environmental studies, acid peptic disease is the only digestive disorder intrinsic to the gastrointestinal tract that has been examined in relation to dioxin exposure. The finding of an increased cumulative incidence of ulcer disease reported in two studies (48, 49) was not confirmed in others (47, 50). In the only occupational study to include serum dioxin levels, the cumulative incidence of gastritis, ulcer disease, and gastrointestinal hemorrhage was similar in exposed workers (mean serum dioxin of 220 picograms [pg] per gram of lipid) and controls (mean of 7 pg per gram of lipid) (47).

Numerous occupational and environmental studies have reported abnormally elevated liver enzymes in association with exposure to dioxin, although in most cases there was no other clinical evidence for underlying liver disease (47–54). In longer-term follow-up studies, abnormalities noted at the time of acute exposure resolved over time (46, 54–57). In two environmental contamination studies conducted in 1984–85 at Quail Run (46) and in 1983 at Times Beach (58), Missouri, there was no evidence for hepatic

enzyme elevations in association with exposure to dioxin. In the 1987-88 National Institute of Occupational Safety and Health study (47), the prevalence of an abnormally elevated liver enzyme gamma glutamyl transferase (GGT) was significantly higher in the exposed cohort, but the association was noted only in those with significant alcohol consumption and did not appear directly related to the body burden of dioxin. Three recently published occupational studies found no significant association between elevated hepatic enzymes and serum dioxin levels (59–61).

Several reports of Vietnam veterans have focused on the potential association of hepatic disease with herbicide exposure. In one retrospective cohort study, in which the self-reporting of a rash during or after duty in Vietnam was used as a surrogate for dioxin exposure, an increased prevalence of liver enzyme abnormalities was noted but was attributed to prior viral hepatitis and alcohol consumption (62). Similarly, chronic alcoholism contributed to increased mortality from digestive diseases (cirrhosis and peptic ulcer) in a study of United States Army Chemical Corps veterans (63). Finally, in the most recent reports of the Air Force Health Study (AFHS), which have included serum dioxin levels in the analyses, there has been no increase in the prevalence of biologically meaningful hepatic or digestive disease in the Ranch Hand versus the Comparison cohorts (64, 65), although GGT and alanine aminotransferase (ALT) have been found to increase with dioxin body burden in Ranch Hand veterans. For example, GGT was significantly increased in the high dioxin category at the 1992 follow-up examination.

### 13.1.2 Summary of Previous Analyses of the Air Force Health Study

#### *13.1.2.1 1982 Baseline Study Summary Results*

The 1982 AFHS examination included an extensive evaluation of hepatic status by questionnaire, physical examination, and laboratory testing. The questionnaire elicited data on liver conditions, liver disease, and symptoms compatible with porphyria cutanea tarda (PCT), as well as detailed information on PCT risk factors (e.g., alcohol consumption, chemical exposures). The physical examination measured hepatomegaly, or enlarged liver, when present and determined liver function and porphyrin patterns by a comprehensive battery of 12 laboratory tests.

The questionnaire showed that Ranch Hands reported more miscellaneous liver conditions (verified by a medical records review) and more skin changes compatible with PCT than their Comparisons. Although the reported skin changes were statistically significant, no cases of PCT were diagnosed at examination in either cohort.

Ranch Hands had significantly higher GGT and lactic dehydrogenase (LDH) means and lower cholesterol means; no differences were found for bilirubin or alkaline phosphatase means. There were no significant group differences in uroporphyrin, coproporphyrin, or d-aminolevulinic acid levels, nor did any test set support a diagnosis of PCT.

A comprehensive hepatic evaluation did not reveal any consistent pattern of significant liver damage in the Ranch Hand group.

#### *13.1.2.2 1985 Follow-up Study Summary Results*

The 1985 AFHS examination continued the emphasis on hepatic function and expanded the porphyrin test battery to six assays. The interval questionnaire revealed sparse reporting of liver disorders from 1982 to 1985. Reported liver diseases were verified by medical records, and these data were added to the verified baseline history to assess possible lifetime differences. No significant differences were found.

The physical examination disclosed a marginally significant increase of hepatomegaly in the Ranch Hand group. Emphasis was placed on nine laboratory test variables measuring liver functions: aspartate aminotransferase (AST), ALT, GGT, alkaline phosphatase, total and direct bilirubin, LDH, cholesterol, and triglycerides. In addition, uroporphyrin and coproporphyrin measurements were obtained to assess the likelihood of PCT.

Only four variables produced differences of any note. The results showed a significantly lower mean ALT level, a greater mean alkaline phosphatase level, a lower mean uroporphyrin level, and a marginally significant greater mean coproporphyrin level in Ranch Hands. The risk of alkaline phosphatase abnormality was marginally significantly increased in Ranch Hands.

Overall, the 1985 follow-up examination laboratory data showed no adverse clinical or exposure patterns. The continuous statistical tests detected significant mean shifts that were not mirrored by the discrete tests. These findings were generally consistent with the 1982 baseline examination data. Slight differences in analytic results probably were due to the use of more fully adjusted models for the 1985 follow-up examination data.

Interval reporting of PCT-like symptoms of skin patches, bruises, and sensitivity was significantly increased in Ranch Hands. When these historic data were contrasted to both uroporphyrin and coproporphyrin abnormalities, no correlation was apparent, nor were there any significant group differences. The likelihood of bona fide PCT among Ranch Hands appeared to be remote.

#### *13.1.2.3 1987 Follow-up Study Summary Results*

Overall, the gastrointestinal assessment did not find the health of the Ranch Hand group to be significantly different from that of the Comparison group. Group differences based on verified historical data from the questionnaire were not significant for eight categories of liver disease. No significant group difference was found for past or present occurrence of peptic ulcers. The prevalence of hepatomegaly diagnosed at the physical examination also was not significantly different between the two groups. The only significant finding from the laboratory examination variables was that Ranch Hands had a higher mean alkaline phosphatase than Comparisons, also noted at the 1985 follow-up examination. Group differences for the other laboratory variables (AST, ALT, GGT, total bilirubin, direct bilirubin, LDH, cholesterol, high-density lipoprotein [HDL], cholesterol-HDL ratio, triglycerides, and creatine phosphokinase) were not significant.

#### *13.1.2.4 Serum Dioxin Analysis of 1987 Follow-up Study Summary Results*

The 1987 serum dioxin analyses did not show a significant association with any of the verified historical liver disorder variables. The analyses of the laboratory variables detected significant associations between dioxin (current and estimated initial) and lipid-related health indices such as cholesterol, HDL cholesterol, the cholesterol-HDL ratio, and triglycerides. These findings were consistent with significant associations seen for fat-related variables in other clinical assessments, such as the body fat results in the general health assessment and the diabetes and glucose results noted in the endocrine assessment, and may represent a dioxin mediated alteration of biochemical processes.

#### *13.1.2.5 1992 Follow-up Study Summary Results*

The gastrointestinal assessment found isolated significant differences between Ranch Hands and Comparisons, but overall, the health of the two groups did not differ substantially. The serum dioxin analyses indicated that estimated initial dioxin generally was not associated with historical liver disorders

or current laboratory measurements. The analyses did reveal that current dioxin levels were often highly associated with lipid-related health indices, such as cholesterol, HDL cholesterol, the cholesterol-HDL ratio, and triglycerides, as well as with some of the hepatic enzymes (ALT and GGT) and proteins. These seemingly discordant results may have been explained in part because the initial dioxin analyses adjusted for differential half-life elimination related to body fat, while no adjustment was made in the analyses of current dioxin. These significant findings may have been the result of a subclinical dioxin effect on lipid metabolism.

### 13.1.3 Parameters for the 1997 Gastrointestinal Assessment

#### *13.1.3.1 Dependent Variables*

Questionnaire, physical examination, and laboratory data were used in the gastrointestinal assessment. The questionnaire data were organized by International Classification of Diseases, 9<sup>th</sup> Revision, Clinical Modification (ICD-9-CM) medical coding categories.

##### *13.1.3.1.1 Medical Records Data*

During the 1997 health interview, each study participant was asked about the occurrence of hepatitis, jaundice, cirrhosis, enlarged liver, and other liver conditions. This self-reported information was elicited in the questionnaire and combined with information from the baseline, 1985, 1987, and 1992 follow-up examinations and verified by a medical records review. The verified results were grouped into eight categories of disorders for analysis: uncharacterized hepatitis (non-A, non-B, non-C, and non-D), jaundice (unspecified, not of the newborn), acute necrosis of the liver, chronic liver disease and cirrhosis (alcohol-related and non-alcohol-related cirrhosis were analyzed separately), liver abscess and sequelae of chronic liver disease, enlarged liver (hepatomegaly), and other disorders of the liver. The purpose of the uncharacterized hepatitis (non-A, non-B, non-C, and non-D) category was to define a category that was neither clearly A nor B nor C nor D, so that liver disease misdiagnosed as “viral hepatitis” could be detected. This approach to historical hepatitis created a group of cases that could have been chemically induced. The following ICD-9-CM codes were used for these disorders: uncharacterized hepatitis (ICD-9-CM codes 070.49, 070.59, 070.6, 070.9, 571.40, 571.41, 571.49, and 573.3), jaundice (ICD-9-CM code 782.4), acute necrosis of the liver (ICD-9-CM code 570), alcohol-related chronic liver disease and cirrhosis (ICD-9-CM codes 571.0–571.3), non-alcohol-related chronic liver disease and cirrhosis (ICD-9-CM codes 571.40–571.9), liver abscess and sequelae of chronic liver disease (ICD-9-CM codes 572.0–572.4, 572.8), enlarged liver (ICD-9-CM code 789.1), and other disorders of the liver (ICD-9-CM codes 573.0–573.9, 790.4, 790.5, and 794.8).

For each condition, participants with a pre-Southeast Asia (SEA) diagnosis were excluded from the analysis. Also, the analysis of alcohol-related chronic liver disease and cirrhosis excluded participants with zero lifetime alcohol history because nondrinkers were not at risk for alcohol-related liver disease.

##### *13.1.3.1.2 Physical Examination Data*

One variable from the 1997 physical examination, current hepatomegaly, was analyzed in the gastrointestinal assessment. This variable was coded as “yes” or “no.” Participants whose blood contained hepatitis B surface antigen or hepatitis C antibodies were excluded from the analysis of current hepatomegaly to account for the effects of these viruses on chronic hepatic disease.

### 13.1.3.1.3 Laboratory Examination Data

The 1997 examination emphasized the evaluation of laboratory data through the analysis of 29 measurements. These laboratory variables were AST (U/l), ALT (U/l), GGT (U/l), alkaline phosphatase (U/l), total bilirubin (mg/dl), direct bilirubin (mg/dl), LDH (U/l), cholesterol (mg/dl), HDL (mg/dl), cholesterol-HDL ratio, triglycerides (mg/dl), creatine phosphokinase (U/l), serum amylase (U/l), antibodies for hepatitis A, serological evidence of prior hepatitis B infection (positive hepatitis B core antibody), current hepatitis B (positive hepatitis B surface antigen), antibodies for hepatitis C, antibodies for hepatitis D, stool hemocult, and 10 components (in mg/dl) in a protein profile (prealbumin, albumin,  $\alpha$ -1-acid glycoprotein,  $\alpha$ -1-antitrypsin,  $\alpha$ -2-macroglobulin, apolipoprotein B, C3 complement, C4 complement, haptoglobin, and transferrin). IgA, IgG, and IgM were also part of this profile, but they were analyzed in the immunologic assessment (see Chapter 17).

All assays for the 1997 gastrointestinal assessment were performed by Scripps Clinic. Dade RxL<sup>®</sup> equipment was used to quantify AST, ALT, GGT, alkaline phosphatase, total bilirubin, direct bilirubin, LDH, cholesterol, HDL, triglycerides, creatine phosphokinase, serum amylase, and albumin. The Beckman Array Protein System<sup>®</sup> quantified all components of the protein profile except albumin.

Abbott Commander<sup>®</sup> equipment was used to determine the presence or absence of antibodies of hepatitis A, serological evidence of prior hepatitis B infection, current hepatitis B, and antibodies of hepatitis C. Abbott Quantum<sup>®</sup> equipment was used to determine the presence or absence of hepatitis D antibodies. Hepatitis D testing was performed only on participants who showed serological evidence of prior hepatitis B infection or current hepatitis B, as determined by a positive hepatitis B surface antigen.

All laboratory variables were analyzed in both continuous and discrete forms except for direct bilirubin, antibodies for hepatitis A, serological evidence of present or prior hepatitis B infection, current hepatitis B, antibodies for hepatitis C, antibodies for hepatitis D, and stool hemocult, which were analyzed only in discrete form. Direct bilirubin was analyzed only in its discrete form because there were few distinct measurements, precluding a meaningful continuous analysis.

Participants whose blood contained hepatitis B surface antigen, hepatitis C antibodies, or hepatitis D antibodies were excluded from the analysis of all laboratory variables except antibodies for hepatitis A, serological evidence of prior hepatitis B infection, current hepatitis B, antibodies for hepatitis C, and antibodies for hepatitis D. Participants with body temperatures greater than or equal to 100° Fahrenheit also were excluded from the analysis of these variables. For the five hepatitis variables, no participants were excluded. Attempts were made to determine, from a medical records review, which occurrences of the types of hepatitis described above were pre-SEA, but the date of hepatitis onset was not available for the majority of participants. Consequently, all occurrences of hepatitis are included in these variables.

### 13.1.3.2 Covariates

Statistical analyses of all medical records variables were adjusted for age, race, military occupation, lifetime alcohol history, lifetime industrial chemical exposure, and lifetime degreasing chemical exposure.

Statistical analyses of the physical examination variable and all of the laboratory variables except alkaline phosphatase and  $\alpha$ -1-antitrypsin were adjusted for age, race, military occupation, current alcohol use, lifetime alcohol history, lifetime industrial chemical exposure, and lifetime industrial chemical exposure. Wine consumption showed a strong negative association with alkaline phosphatase in the 1985, 1987, and 1992 follow-up examinations. The negative association persisted in the 1992 and 1997 follow-up examination data; therefore, current wine consumption and lifetime wine history replaced current alcohol use and lifetime alcohol history as covariates in the adjusted analyses of alkaline phosphatase. Current

wine consumption also replaced current alcohol use in the adjusted analysis of  $\alpha$ -1-antitrypsin based on covariate associations in the 1997 follow-up examination data, which showed that  $\alpha$ -1-antitrypsin was highly associated with current wine consumption but not associated with current alcohol use.

Age, race, and military occupation were determined from military records. Lifetime alcohol (or wine) history was based on information from the 1997 questionnaire and combined with similar information gathered at the 1987 and 1992 follow-up examinations. Each participant was asked about his drinking patterns throughout his lifetime. When a participant's drinking patterns changed, he was asked to describe how his alcohol consumption differed and the duration of time that the drinking pattern lasted. The participant's average daily alcohol consumption was determined for each of the reported drinking pattern periods throughout his lifetime, and an estimate of the corresponding total number of drink-years was derived. One drink-year was the equivalent of drinking 1.5 ounces of an 80-proof alcoholic beverage, one 12-ounce beer, or one 5-ounce glass of wine per day for 1 year. Current alcohol use (or wine consumption) was based on the average number of drinks per day during the month prior to completing the questionnaire.

The participants' lifetime exposures through 1992 to degreasing and industrial chemicals were updated with information reported in the 1997 questionnaire.

Age, current alcohol use (or wine consumption), and lifetime alcohol (or wine) history were treated as continuous variables wherever possible for all adjusted analyses. Degreasing chemical exposure and industrial chemical exposure were categorized as "yes" or "no" for all analyses.

#### 13.1.4 Statistical Methods

Table 13-1 summarizes the statistical analysis performed for the gastrointestinal assessment. The first part of this table lists the dependent variables analyzed, source of the data, form of the data (discrete or continuous), cutpoints, covariates, and statistical methods. The second part of this table provides a further description of the covariates examined. A covariate was used in its continuous form whenever possible for all adjusted analyses; if the covariate was inherently discrete (e.g., military occupation), or if a categorized form was needed to develop measures of association with the dependent variables, the covariate was categorized as shown in Table 13-1.

Cutpoints for cholesterol are age-dependent. Consequently, normal and abnormal levels were constructed according to a participant's laboratory value and age at the physical examination. The age-specific cutpoints are listed in Table 13-1, and the reference ages for these cutpoints are given in parentheses following the cutpoints.

**Table 13-1. Statistical Analysis for the Gastrointestinal Assessment**

**Dependent Variables**

Variable (Units)	Data Source	Data Form	Cutpoints	Covariates <sup>a</sup>	Exclusions <sup>b</sup>	Statistical Analysis and Methods
Uncharacterized Hepatitis	MR-V	D	Yes	(1)	(a)	U:LR
			No			A:LR
Jaundice (Unspecified)	MR-V	D	Yes	(1)	(a)	U:LR,CS
			No			A:LR

**Table 13-1. Statistical Analysis for the Gastrointestinal Assessment (Continued)**

Variable (Units)	Data Source	Data Form	Cutpoints	Covariates <sup>a</sup>	Exclusions <sup>b</sup>	Statistical Analysis and Methods
Acute Necrosis of the Liver	MR-V	D	Yes No	(1)	(a)	--
Chronic Liver Disease and Cirrhosis (Alcohol-related)	MR-V	D	Yes No	(1)	(b)	U:LR A:LR
Chronic Liver Disease and Cirrhosis (Non-alcohol-related)	MR-V	D	Yes No	(1)	(a)	U:LR A:LR
Liver Abscess and Sequelae of Chronic Liver Disease	MR-V	D	Yes No	(1)	(a)	U:LR,CS A:LR
Enlarged Liver (Hepatomegaly)	MR-V	D	Yes No	(1)	(a)	U:LR A:LR
Other Disorders of the Liver	MR-V	D	Yes No	(1)	(a)	U:LR A:LR
Current Hepatomegaly	PE	D	Yes No	(2)	(c)	U:LR,CS A:LR
AST (U/l)	LAB	D/C	High: >37 Normal: ≤37	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
ALT (U/l)	LAB	D/C	High: >65 Normal: ≤65	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
GGT (U/l)	LAB	D/C	High: >85 Normal: ≤85	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
Alkaline Phosphatase (U/l)	LAB	D/C	High: >136 Normal: ≤136	(3)	(d)	U:LR,GLM A:LR,GLM
Total Bilirubin (mg/dl)	LAB	D/C	High: >1.0 Normal: ≤1.0	(2)	(d)	U:LR,GLM A:LR,GLM
Direct Bilirubin (mg/dl)	LAB	D	High: >0.3 Normal: ≤0.3	(2)	(d)	U:LR,CS A:LR
Lactic Dehydrogenase (LDH) (U/l)	LAB	D/C	High: >190 Normal: ≤190	(2)	(d)	U:LR,GLM A:LR,GLM
Cholesterol (mg/dl)	LAB	D/C	High: >260 (Age 45–49) >250 (Age ≥50) Normal: ≤260 (Age 45–49) ≤250 (Age ≥50)	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
HDL Cholesterol (mg/dl)	LAB	D/C	Low: <32 Normal: ≥32	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
Cholesterol-HDL Ratio	LAB	D/C	High: >5 Normal: ≤5	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM

**Table 13-1. Statistical Analysis for the Gastrointestinal Assessment (Continued)**

Variable (Units)	Data Source	Data Form	Cutpoints	Covariates <sup>a</sup>	Exclusions <sup>b</sup>	Statistical Analysis and Methods
Triglycerides (mg/dl)	LAB	D/C	High: >200 Normal: ≤200	(2)	(d)	U:LR,GLM A:LR,GLM L:LR,GLM
Creatine Phosphokinase (U/l)	LAB	D/C	High: >232 Normal: ≤232	(2)	(d)	U:LR,GLM A:LR,GLM
Serum Amylase (U/l)	LAB	D/C	High: >115 Normal: ≤115	(2)	(d)	U:LR,GLM A:LR,GLM
Antibodies for Hepatitis A	LAB	D	Yes No	(2)	None	U:LR A:LR
Serological Evidence of Prior Hepatitis B Infection	LAB	D	Yes No	(2)	(e)	U:LR A:LR
Current Hepatitis B	LAB	D	Yes No	(2)	None	U:LR,CS A:LR
Antibodies for Hepatitis C	LAB	D	Yes No	(2)	None	U:LR A:LR
Antibodies for Hepatitis D	LAB	D	Yes No	(2)	None	--
Stool Hemocult	LAB	D	Yes No	(2)	(d)	U:LR A:LR
Protein Profile: Prealbumin (mg/dl)	LAB	D/C	Low: <18 Normal: ≥18	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: Albumin (mg/dl)	LAB	D/C	Low: <3,350 Normal: ≥3,350	(2)	(d)	U:LR,CS,GLM A:LR,GLM
Protein Profile: α-1-Acid Glycoprotein (mg/dl)	LAB	D/C	High: >125 Normal: ≤125	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: α-1-Antitrypsin (mg/dl)	LAB	D/C	Abnormal Low: <93 Normal: 93-224 Abnormal High: >224	(4)	(d)	U:PR,CS,GLM A:PR,GLM
Protein Profile: α-2-Macroglobulin (mg/dl)	LAB	D/C	High: >293 Normal: ≤293	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: Apolipoprotein B (mg/dl)	LAB	D/C	High: >109 Normal: ≤109	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: C3 Complement (mg/dl)	LAB	D/C	Low: <85 Normal: ≥85	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: C4 Complement (mg/dl)	LAB	D/C	Low: <12 Normal: ≥12	(2)	(d)	U:LR,CS,GLM A:LR,GLM
Protein Profile: Haptoglobin (mg/dl)	LAB	D/C	High: >163 Normal: ≤163	(2)	(d)	U:LR,GLM A:LR,GLM
Protein Profile: Transferrin (mg/dl)	LAB	D/C	Low: <212 Normal: ≥212	(2)	(d)	U:LR,GLM A:LR,GLM

**Table 13-1. Statistical Analysis for the Gastrointestinal Assessment (Continued)**

<sup>a</sup>Covariates:

(1): age, race, military occupation, lifetime alcohol history, industrial chemical exposure, degreasing chemical exposure.

(2): age, race, military occupation, current alcohol use, lifetime alcohol history, industrial chemical exposure, degreasing chemical exposure.

(3): age, race, military occupation, current wine consumption, lifetime wine history, industrial chemical exposure, degreasing chemical exposure.

(4): age, race, military occupation, current wine consumption, lifetime alcohol history, industrial chemical exposure, degreasing chemical exposure.

<sup>b</sup>Exclusions:

(a): participants with a pre-SEA history of the disorder.

(b): participants with a pre-SEA history of the disorder, participants with no lifetime alcohol history.

(c): participants whose blood contained hepatitis B surface antigen, hepatitis C antibodies, or hepatitis D antibodies.

(d): participants whose blood contained hepatitis B surface antigen, hepatitis C antibodies, or hepatitis D antibodies, participants with body temperatures greater than or equal to 100° Fahrenheit.

(e): participants who had received the hepatitis B vaccine.

**Covariates**

Variable (Units)	Data Source	Data Form	Cutpoints
Age (years)	MIL	D/C	Born ≥1942 Born <1942
Race	MIL	D	Black Non-Black
Occupation	MIL	D	Officer Enlisted Flyer Enlisted Groundcrew
Current Alcohol Use (drinks/day)	Q-SR	D/C	0–1 >1–4 >4
Lifetime Alcohol History (drink-years)	Q-SR	D/C	0 >0–40 >40
Current Wine Consumption (drinks of wine/day)	Q-SR	D/C	0 >0
Lifetime Wine History (drink-years of wine)	Q-SR	D/C	0 >0
Industrial Chemical Exposure	Q-SR	D	Yes No
Degreasing Chemical Exposure	Q-SR	D	Yes No

**Abbreviations**

Data Source:      LAB: 1997 laboratory results  
                          MIL: Air Force military records  
                          MR-V: Medical records (verified)  
                          PE: 1997 physical examination  
                          Q-SR: Health questionnaires (self-reported)

**Table 13-1. Statistical Analysis for the Gastrointestinal Assessment (Continued)**

Data Form: D: Discrete analysis only  
D/C: Discrete and continuous analysis for dependent variables; appropriate form for analysis (either discrete or continuous) for covariates

Statistical Analysis: U: Unadjusted analysis  
A: Adjusted analysis  
L: Longitudinal analysis

Statistical Methods: CS: Chi-square contingency table analysis (continuity-adjusted)  
GLM: General linear models analysis  
LR: Logistic regression analysis  
PR: Polytomous logistic regression analysis

Table 13-2 provides a summary of the number of participants with missing dependent variable and covariate data. In addition, the number of participants excluded because of medical conditions is given.

**Table 13-2. Number of Participants Excluded or with Missing Data for the Gastrointestinal Assessment**

Variable	Variable Use	Group		Dioxin (Ranch Hands Only)		Categorized Dioxin	
		Ranch Hand	Comparison	Initial	1987	Ranch Hand	Comparison
Lactic Dehydrogenase	DEP	0	2	0	0	0	2
HDL	DEP	1	1	1	1	1	1
Cholesterol-HDL Ratio	DEP	1	1	1	1	1	1
Triglycerides	DEP	1	0	0	1	1	0
Antibodies for Hepatitis A	DEP	0	1	0	0	0	1
Serological Evidence of Prior Hepatitis B Infection	DEP	0	1	0	0	0	1
Stool Hemocult	DEP	27	35	13	25	25	32
Current Alcohol Use	COV	1	0	0	1	1	0
Lifetime Alcohol History	COV	6	2	3	6	6	1
Current Wine Consumption	COV	1	0	0	1	1	0
Lifetime Wine History	COV	4	2	2	4	4	1
Pre-SEA Jaundice	EXC	24	32	13	24	24	31
Pre-SEA Chronic Liver Disease and Cirrhosis (Alcohol-related)	EXC	1	4	1	1	1	4
No Lifetime Alcohol History	EXC	54	64	34	54	54	62
Pre-SEA Chronic Liver Disease and Cirrhosis (Non-alcohol-related)	EXC	0	1	0	0	0	1
Pre-SEA Enlarged Liver	EXC	1	2	1	1	1	2
Pre-SEA Other Liver Disorders	EXC	4	11	1	4	4	11
Body Temperature $\geq 100^{\circ}$ Fahrenheit at the Time of the Physical Exam	EXC	1	0	1	1	1	0
Hepatitis B Surface Antigen (Current Hepatitis B)	EXC	1	2	1	1	1	2

**Table 13-2. Number of Participants Excluded or with Missing Data for the Gastrointestinal Assessment (Continued)**

Variable	Variable Use	Group		Dioxin (Ranch Hands Only)		Categorized Dioxin	
		Ranch Hand	Comparison	Initial	1987	Ranch Hand	Comparison
Antibodies for Hepatitis C	EXC	9	18	4	9	9	17
Antibodies for Hepatitis D	EXC	1	0	1	1	1	0
Vaccinated for Hepatitis B	EXC	1	1	1	1	1	1

Note: DEP = Dependent variable.  
 COV = Covariate.  
 EXC = Exclusion.  
 870 Ranch Hands and 1,251 Comparisons.  
 482 Ranch Hands for initial dioxin; 863 Ranch Hands for 1987 dioxin.  
 863 Ranch Hands and 1,213 Comparisons for categorized dioxin.

#### 13.1.4.1 Longitudinal Analysis

The longitudinal analysis of the gastrointestinal assessment examined seven laboratory variables (AST, ALT, GGT, cholesterol, HDL cholesterol, the cholesterol-HDL ratio, and triglycerides). Each variable was analyzed in both its continuous and discrete forms. These longitudinal analyses were used to assess any relation between herbicide exposure or dioxin levels and hepatic changes across time.

## 13.2 RESULTS

### 13.2.1 Dependent Variable-Covariate Associations

Covariate tests of association were performed to examine the relation between the covariates used in the adjusted analyses and the dependent variables. These associations are pairwise between the dependent variable and the covariate and are not adjusted for any other covariates. Appendix Table F-5 provides summary results of these analyses, including correlation coefficients (r), percents abnormal, means, and p-values to test the statistical significance of the associations. Statistically significant ( $p \leq 0.05$ ) associations are discussed below.

#### 13.2.1.1 Medical Records Variables

The association between a history of uncharacterized hepatitis and lifetime alcohol consumption was significant ( $p=0.010$ ). Uncharacterized hepatitis decreased as lifetime alcohol consumption increased.

Tests of covariate association showed race ( $p=0.025$ ), lifetime alcohol history ( $p=0.001$ ), and industrial chemical exposure ( $p=0.024$ ) to be significantly associated with alcohol-related chronic liver disease. Black participants had a higher prevalence of alcohol-related chronic liver disease than non-Blacks (9.5% vs. 4.5%). The percentage of participants with chronic liver disease increased as lifetime alcohol consumption increased. Participants who reported exposure to industrial chemicals had a higher percentage of alcohol-related chronic liver disease (5.6%) than participants who did not report exposure (3.3%).

Non-alcohol-related chronic liver disease was significantly associated with lifetime alcohol history ( $p=0.011$ ). Moderate drinkers (in terms of drink-years) had the highest percentage of non-alcohol-related chronic liver disease (1.8%), followed by nondrinkers (1.7%) and heavier drinkers (0.2%).

The percentage of participants with enlarged livers increased with age ( $p=0.038$ ) and lifetime alcohol history ( $p=0.001$ ).

Other liver disorders were significantly associated with race ( $p=0.001$ ) and lifetime alcohol history ( $p=0.043$ ). The prevalence of other liver disorders was greater for Blacks (43.0%) than for non-Blacks (25.6%). The percentage of participants with a history of other liver disorders increased as drinking increased.

### *13.2.1.2 Laboratory Examination Variables*

AST in its continuous form increased with current alcohol use ( $p<0.001$ ) and lifetime alcohol history ( $p=0.002$ ). Dichotomized AST showed an increase in the percentage of high AST levels as current alcohol use increased ( $p=0.001$ ).

ALT in its discrete form was significantly associated with age ( $p<0.001$ ) and occupation ( $p=0.009$ ). Younger participants had a larger percentage of high ALT values than did older participants (10.0% vs. 5.4%). Enlisted flyers had the highest percentage of high ALT values (10.1%), followed by enlisted groundcrew (8.2%), then officers (5.4%). ALT in its continuous form significantly decreased with age ( $p<0.001$ ) and increased with current alcohol use ( $p=0.009$ ).

For GGT in its continuous form, tests of covariate association were significant for age ( $p<0.001$ ), race ( $p=0.012$ ), occupation ( $p=0.026$ ), current alcohol use ( $p<0.001$ ), and lifetime alcohol history ( $p<0.001$ ). Levels of GGT decreased with age. Black participants showed significantly higher mean GGT levels than non-Blacks (48.65 U/l versus 42.70 U/l). Enlisted flyers had the highest mean GGT levels (44.91 U/l), followed by the enlisted groundcrew (43.87 U/l) and officers (41.38 U/l). GGT levels increased with current alcohol use and lifetime alcohol history. Tests of covariate association for GGT in its discrete form showed similar results, except that race was not significantly associated with the discrete form of GGT.

Alkaline phosphatase in its continuous form was significantly associated with occupation ( $p<0.001$ ), current wine consumption ( $p<0.001$ ), and lifetime wine history ( $p<0.001$ ). Mean alkaline phosphatase levels decreased with current wine consumption and lifetime wine history. Enlisted flyers had the highest mean alkaline phosphatase level (83.60 U/l), followed by enlisted groundcrew (82.29 U/l) and officers (77.43 U/l).

Total bilirubin in its continuous form increased with age ( $p=0.005$ ) and current alcohol use ( $p<0.001$ ). Occupation ( $p=0.001$ ) and degreasing chemical exposure ( $p=0.020$ ) also were associated significantly with total bilirubin in its continuous form. Officers showed the highest mean total bilirubin level (0.544 mg/dl), followed by enlisted flyers (0.502 mg/dl) and enlisted groundcrew (0.504 mg/dl). Participants who reported exposure to degreasing chemicals had a higher mean total bilirubin level (0.536 mg/dl) than did those who did not report exposure (0.510 mg/dl). Results of the test for discretized total bilirubin revealed a significant association with current alcohol use ( $p=0.023$ ). Participants who were currently moderate drinkers (in terms of drinks per day) had the lowest prevalence of high total bilirubin values (5.4%), followed by those who were lighter drinkers (5.7%) and those who were heavier drinkers (15.2%). The percentage of participants with high direct bilirubin levels increased with current alcohol use ( $p=0.004$ ) and lifetime drinking history ( $p=0.013$ ).

Lactic dehydrogenase in its continuous form increased with age ( $p<0.001$ ).

Tests of covariate association for cholesterol in its continuous form showed a significant association with age ( $p=0.025$ ), occupation ( $p=0.004$ ), and current alcohol use ( $p<0.001$ ). Cholesterol levels decreased with age and increased with current alcohol use. Enlisted flyers had the highest mean cholesterol levels (215.7 mg/dl), followed by the enlisted groundcrew (212.9 mg/dl) and officers (208.5 mg/dl).

Cholesterol in its discretized form showed significant associations with current alcohol use ( $p=0.009$ ) and lifetime alcohol history ( $p=0.047$ ). Participants who were moderate drinkers had the highest prevalence of high cholesterol levels (19.8%), followed by heavier drinkers (19.6%) and participants who were lighter drinkers (13.7%). The percentage of participants with high cholesterol levels increased with lifetime alcohol history.

HDL cholesterol in its continuous form increased with current alcohol use ( $p<0.001$ ) and lifetime alcohol history ( $p<0.001$ ). Race ( $p=0.002$ ), occupation ( $p<0.001$ ), industrial chemical exposure ( $p=0.005$ ), and degreasing chemical exposure ( $p=0.001$ ) also were associated significantly with HDL cholesterol. Black participants had higher mean HDL cholesterol levels than non-Blacks (48.17 mg/dl vs. 44.70 mg/dl). Officers had higher mean HDL cholesterol levels (46.67 mg/dl), followed by enlisted flyers (44.24 mg/dl) and enlisted groundcrew (43.59 mg/dl). Participants who reported exposure to industrial chemicals had lower mean HDL cholesterol levels (44.33 mg/dl) than those who did not report exposure (45.81 mg/dl). Similarly, participants who reported exposure to degreasing chemicals had lower mean HDL cholesterol levels (44.25 mg/dl) than those who did not report exposure (46.07 mg/dl).

Tests of covariate association for HDL cholesterol in its discrete form showed similar results. Significant covariates were occupation ( $p=0.002$ ), current alcohol use ( $p=0.001$ ), lifetime alcohol history ( $p=0.001$ ), industrial chemical exposure ( $p=0.028$ ), and degreasing chemical exposure ( $p=0.023$ ). Race was not significantly associated with HDL cholesterol in its discrete form. Enlisted flyers had the highest percentage of low HDL cholesterol levels (10.2%), followed by the enlisted groundcrew (9.1%) and officers (5.2%). Participants who were currently light drinkers had the highest percentage of low HDL cholesterol levels (9.0%), followed by heavier drinkers (4.3%) and moderate drinkers (2.4%). The prevalence of low HDL cholesterol levels decreased as lifetime alcohol consumption increased. In each of the analyses of industrial chemical exposure and degreasing chemical exposure, participants who reported exposure had a higher percentage of low HDL cholesterol levels.

The cholesterol-HDL ratio in its continuous form decreased with age ( $p=0.003$ ), current alcohol use ( $p<0.001$ ), and lifetime alcohol history ( $p<0.001$ ). Significant associations also were found with race ( $p=0.011$ ), occupation ( $p<0.001$ ), industrial chemical exposure ( $p<0.001$ ), and degreasing chemical exposure ( $p<0.001$ ). Non-Blacks had a higher mean cholesterol-HDL ratio than Blacks (4.69 vs. 4.39). Enlisted groundcrew had the highest mean cholesterol-HDL ratio (4.85), followed by enlisted flyers (4.84) and officers (4.43). For both industrial chemical exposure and degreasing chemical exposure covariates, participants who reported exposure had higher mean cholesterol-HDL ratios.

The tests of covariate association for the cholesterol-HDL ratio in its discrete form showed similar results. Younger participants had a higher prevalence of high cholesterol-HDL ratios than did the older participants (44.5% vs. 38.7%,  $p=0.008$ ). Non-Blacks had a larger percentage of high cholesterol-HDL ratios than Blacks (42.0% vs. 28.3%,  $p=0.004$ ). Occupation was significantly associated with the discrete form of the cholesterol-HDL ratio ( $p=0.001$ ). Enlisted groundcrew had the highest prevalence of low cholesterol-HDL ratios (48.2%), followed by enlisted flyers (43.4%) and officers (32.6%). The percentage of participants with high cholesterol-HDL ratios decreased with increased current alcohol use ( $p=0.001$ ) and increased lifetime alcohol history ( $p=0.001$ ). For both industrial chemical exposure and degreasing chemical exposure covariates, participants who reported exposure had higher percentages of high cholesterol-HDL ratios ( $p=0.001$  for both covariates).

Triglycerides in its continuous form significantly decreased with age ( $p=0.001$ ). Significant associations with race ( $p<0.001$ ), occupation ( $p<0.001$ ), industrial chemical exposure ( $p=0.013$ ), and degreasing chemical exposure ( $p=0.002$ ) also were revealed. Non-Black participants had a higher mean triglycerides level than Blacks (123.5 mg/dl vs. 93.0 mg/dl). Enlisted flyers had the highest mean triglycerides level (131.3 mg/dl), followed by enlisted groundcrew (126.1 mg/dl) and officers (113.0 mg/dl). Participants who reported exposure to industrial chemicals had higher mean triglyceride levels than those who did not report exposure (124.9 mg/dl vs. 116.4 mg/dl). Similarly, participants who reported exposure to degreasing chemicals had higher mean triglyceride levels (125.6 mg/dl) than those who did not report exposure (114.7 mg/dl).

The tests of covariate association for triglycerides in its discrete form showed significant associations with age ( $p=0.003$ ), race ( $p=0.001$ ), occupation ( $p=0.002$ ), industrial chemical exposure ( $p=0.035$ ), and degreasing chemical exposure ( $p=0.012$ ). The prevalence of high triglyceride levels was higher among the younger participants than the older participants (24.0% vs. 18.6%). Non-Blacks had a larger percentage of high triglycerides than Blacks (21.8% vs. 6.7%). Enlisted flyers had the highest percentage of high triglyceride levels (24.2%), followed by the enlisted groundcrew (23.2%) and officers (17.1%). For both industrial chemical exposure and degreasing chemical exposure covariates, participants who reported exposure had higher percentages of high triglyceride levels.

Creatine phosphokinase in its continuous form significantly decreased with age ( $p<0.001$ ) and current alcohol use ( $p=0.013$ ). Also significant were race ( $p<0.001$ ) and occupation ( $p=0.038$ ). Black participants had a higher mean creatine phosphokinase level than non-Blacks (195.9 U/l vs. 102.0 U/l). Enlisted groundcrew had the highest mean creatine phosphokinase levels (109.2 U/l), followed by officers (104.9 U/l), then enlisted flyers (99.2 U/l).

Tests of covariate association for creatine phosphokinase in its discrete form showed a significant association with age ( $p=0.006$ ), race ( $p=0.001$ ), and current alcohol use ( $p=0.018$ ). Younger participants had a larger percentage of high creatine phosphokinase values than did the older participants (11.0% vs. 7.4%). Black participants had a larger percentage of high creatine phosphokinase values than non-Blacks (34.2% vs. 7.1%). Participants who were currently heavier drinkers had the highest prevalence of high creatine phosphokinase values (10.9%), followed by lighter drinkers (9.7%) and moderate drinkers (5.1%).

Serum amylase in its continuous form showed significant associations with race ( $p<0.001$ ) and current alcohol use ( $p=0.001$ ). Blacks had a higher mean serum amylase level (72.71 U/l) than non-Blacks (56.04 U/l). Serum amylase levels decreased as current alcohol use increased. The discrete form of serum amylase was significantly associated with race ( $p=0.001$ ). Blacks had a larger percentage of high serum amylase values than non-Blacks (10.8% vs. 2.5%).

Tests of covariate association for the presence of antibodies for hepatitis A showed significant associations with age ( $p=0.001$ ), race ( $p=0.012$ ), occupation ( $p=0.001$ ), and lifetime alcohol history ( $p=0.001$ ). A higher percentage of the older participants had hepatitis A antibodies (40.9%) than the younger participants (23.5%). Black participants had a higher prevalence of hepatitis A antibodies than did non-Black participants (43.8% vs. 32.5%). Enlisted flyers had the highest percentage of participants with antibodies for hepatitis A (47.3%), followed by enlisted groundcrew (33.6%) and officers (27.0%). The highest percentage of positive results for hepatitis A antibodies was among nondrinkers (45.8%), followed by heavy lifetime drinkers (35.9%) and moderate lifetime drinkers (30.9%).

Evidence of prior hepatitis B infection was significantly associated with race ( $p=0.001$ ), occupation ( $p=0.001$ ), and lifetime alcohol history ( $p=0.001$ ). Black participants had a higher percentage of prior hepatitis B infections than non-Blacks (26.8% vs. 10.7%). Enlisted flyers had the highest percentage of prior hepatitis B infections (16.6%), followed by enlisted groundcrew (14.9%) and officers (6.0%). The

percentage of participants with serological evidence of prior hepatitis B infections increased with lifetime alcohol consumption.

Current hepatitis B was significantly associated with race ( $p=0.001$ ) and current alcohol use ( $p=0.002$ ). Black participants had a higher percentage of positive current hepatitis B results than did non-Black participants (1.6% vs. 0.1%). Participants who were currently heavier drinkers had the highest prevalence of current hepatitis B (2.0%), followed by lighter drinkers (0.1%) and moderate drinkers (0.0%).

The presence of hepatitis C antibodies was significantly associated with race ( $p=0.002$ ), occupation ( $p=0.024$ ), current alcohol use ( $p=0.004$ ), and industrial chemical exposure ( $p=0.022$ ). Black participants had a higher percentage of positive hepatitis C results than non-Blacks (4.7% vs. 1.1%). Enlisted groundcrew had the highest prevalence of positive results for hepatitis C antibodies (2.0%), followed by enlisted flyers (0.9%) and officers (0.6%). Participants who were currently heavier drinkers had the highest percentage of positive hepatitis C results (6.0%), followed by lighter drinkers (1.2%) and moderate drinkers (0.5%). Participants who reported exposure to industrial chemicals had a higher percentage of positive hepatitis C results than did participants who did not report exposure (1.7% vs. 0.5%).

The results of the tests of covariate association for stool hemocult revealed that age and industrial chemical exposure were statistically significant ( $p=0.006$  and  $p=0.021$ , respectively). Older participants had a higher percentage of positive stool hemocult results (5.1%) than did the younger participants (2.6%). Participants who did not report exposure to industrial chemicals had a higher prevalence of positive stool hemocult results (5.4%) than did those who reported exposure (3.2%).

Prealbumin in its continuous form significantly decreased with age ( $p<0.001$ ) and increased with current alcohol use ( $p<0.001$ ). Covariate association tests for discretized prealbumin revealed significant associations with current alcohol use ( $p=0.003$ ) and lifetime alcohol history ( $p=0.003$ ). The prevalence of low prealbumin levels increased with current alcohol use. Heavy lifetime drinkers had a higher prevalence of low prealbumin levels (2.3%), followed by nondrinkers (1.7%) and moderate lifetime drinkers (0.6%).

Albumin in its continuous form was significantly associated with age ( $p<0.001$ ) and degreasing chemical exposure ( $p=0.017$ ). Albumin was inversely associated with age, and participants who reported exposure to degreasing chemicals had a lower mean albumin level than those who did not report exposure (4,185.8 mg/dl vs. 4,222.3 mg/dl). Dichotomized albumin was only significantly associated with current alcohol use ( $p=0.047$ ). The percentage of participants with low albumin levels increased with current alcohol use.

Tests of covariate association for  $\alpha$ -1-acid glycoprotein in its continuous form showed significant associations with occupation ( $p<0.001$ ), current alcohol use ( $p<0.001$ ), and lifetime alcohol history ( $p<0.001$ ). Levels of  $\alpha$ -1-acid glycoprotein increased with current alcohol use and lifetime alcohol history. Enlisted groundcrew had the highest mean  $\alpha$ -1-acid glycoprotein level (86.34 mg/dl), followed by enlisted flyers (85.71 mg/dl) and officers (81.68 mg/dl).

The discrete form of  $\alpha$ -1-acid glycoprotein was significantly associated with current alcohol use ( $p=0.003$ ). The prevalence of high  $\alpha$ -1-acid glycoprotein values increased as current alcohol use increased.

The continuous form of  $\alpha$ -1-antitrypsin increased with age ( $p<0.001$ ) and lifetime alcohol history ( $p=0.001$ ) and decreased with current wine consumption ( $p<0.001$ ). Race ( $p=0.006$ ), occupation ( $p<0.001$ ), industrial chemical exposure ( $p=0.001$ ), and degreasing chemical exposure ( $p=0.023$ ) also were significant. Non-Black participants had a higher mean  $\alpha$ -1-antitrypsin level than did Black participants (148.3 mg/dl vs. 141.8 mg/dl). Enlisted flyers had the highest mean  $\alpha$ -1-antitrypsin level

(153.0 mg/dl), followed by the enlisted groundcrew (150.2 mg/dl) and officers (143.4 mg/dl). In both industrial chemical exposure and degreasing chemical exposure, participants who reported exposure had higher mean  $\alpha$ -1-antitrypsin levels.

The trichotomous form of  $\alpha$ -1-antitrypsin was significantly associated with occupation ( $p=0.022$ ), industrial chemical exposure ( $p=0.037$ ), and current wine consumption ( $p=0.031$ ). Officers had the highest percentage of abnormally low  $\alpha$ -1-antitrypsin levels (2.3%), followed by enlisted groundcrew (0.9%) and enlisted flyers (0.6%). Enlisted flyers and enlisted groundcrew each had 0.9 percent abnormally high  $\alpha$ -1-antitrypsin values, followed by officers with 0.2 percent abnormally high  $\alpha$ -1-antitrypsin values. Participants who did not report exposure to industrial chemicals had a higher percentage of abnormally low  $\alpha$ -1-antitrypsin levels (2.1%), as well as a higher percentage of abnormally high  $\alpha$ -1-antitrypsin levels (0.9%) than participants who reported exposure to industrial chemicals (0.9 percent abnormally low and 0.5 percent abnormally high). Participants who currently drank wine had a higher percentage of abnormally low  $\alpha$ -1-antitrypsin values than those who did not drink wine (1.9% vs. 1.0%). Participants who currently did not drink wine had a higher percentage of abnormally high  $\alpha$ -1-antitrypsin values than did those who currently did drink wine (0.9% vs. 0.2%).

The continuous form of  $\alpha$ -2-macroglobulin increased with age ( $p<0.001$ ) and decreased with current alcohol use ( $p=0.031$ ). Race and occupation were associated significantly with  $\alpha$ -2-macroglobulin ( $p<0.001$  and  $p=0.013$ , respectively). Non-Black participants had a higher mean  $\alpha$ -2-macroglobulin level than did Black participants (172.2 mg/dl vs. 152.1 mg/dl). Enlisted flyers had the highest mean  $\alpha$ -2-macroglobulin level (177.2 mg/dl), followed by officers (170.8 mg/dl) and enlisted groundcrew (169.0 mg/dl).

Tests of covariate association for discretized  $\alpha$ -2-macroglobulin found significant covariate associations with age and lifetime alcohol history ( $p=0.001$  each). The prevalence of high  $\alpha$ -2-macroglobulin levels increased with age. Nondrinkers had the highest percentage of high  $\alpha$ -1-macroglobulin levels, followed by heavy drinkers and moderate lifetime drinkers (9.3%, 3.3%, and 2.9%, respectively).

In its continuous form, tests of covariate association showed apolipoprotein B levels significantly decreased with age ( $p=0.023$ ). Occupation also was associated significantly with apolipoprotein B ( $p<0.001$ ). Enlisted flyers had the highest mean apolipoprotein B level (114.3 mg/dl), followed by the enlisted groundcrew (112.4 mg/dl) and officers (108.3 mg/dl). Apolipoprotein B in its discrete form showed a significant covariate association with occupation ( $p=0.004$ ). Enlisted flyers had the highest prevalence of high apolipoprotein B values (56.1%), followed by enlisted groundcrew (53.7%) and officers (47.1%).

C3 complement in its continuous form decreased with age ( $p=0.027$ ), current alcohol use ( $p<0.001$ ), and lifetime alcohol history ( $p=0.034$ ). Race ( $p=0.002$ ), occupation ( $p<0.001$ ), industrial chemical exposure ( $p<0.001$ ), and degreasing chemical exposure ( $p<0.001$ ) also were associated significantly with C3 complement. Non-Black participants had a lower mean C3 complement level than Black participants (118.4 mg/dl vs. 124.0 mg/dl). Officers had the lowest mean C3 complement level (114.7 mg/dl), followed by enlisted flyers (120.5 mg/dl) and enlisted groundcrew (121.6 mg/dl). For each of the industrial chemical exposure and degreasing chemical exposure covariates, participants who did not report exposure had lower mean C3 complement levels.

Current alcohol use was significantly associated with C3 complement in its discrete form ( $p=0.001$ ). Participants who were currently moderate drinkers had the highest percentage of low C3 complement values (4.6%), followed by lighter drinkers (1.6%) and heavier drinkers (0.0%).

Tests of covariate association showed C4 complement in its continuous form to be significantly associated with race ( $p < 0.001$ ), occupation ( $p < 0.001$ ), and industrial chemical exposure ( $p = 0.029$ ). Non-Black participants had a lower mean C4 complement level than Black participants (25.65 mg/dl vs. 29.00 mg/dl). Officers had the lowest mean C4 complement level (25.21 mg/dl), followed by enlisted flyers (25.95 mg/dl) and enlisted groundcrew (26.35 mg/dl). Participants who did not report exposure to industrial chemicals had a lower mean C4 complement level than those who reported exposure (25.51 mg/dl vs. 26.02 mg/dl).

C4 complement in its discrete form was significantly associated with degreasing chemical exposure ( $p = 0.031$ ). Participants who did not report exposure had a higher prevalence of low C4 complement values (0.5%) than those who reported exposure (0.0%).

In its continuous form, tests of covariate association showed haptoglobin levels increased significantly with current alcohol use and lifetime alcohol history ( $p = 0.013$  and  $p < 0.001$ , respectively). Occupation, industrial chemical exposure, and degreasing chemical exposure also were associated significantly with haptoglobin ( $p < 0.001$ ,  $p = 0.013$ , and  $p = 0.001$ , respectively). Enlisted flyers had the highest mean haptoglobin level (142.0 mg/dl), followed by enlisted groundcrew (136.3 mg/dl) and officers (118.7 mg/dl). In each of the industrial chemical exposure and degreasing chemical exposure covariates, participants who reported exposure had higher mean haptoglobin levels.

In its discrete form, tests of covariate association for haptoglobin showed similar results to the continuous analysis. Significant covariates were occupation ( $p = 0.001$ ), current alcohol use ( $p = 0.005$ ), lifetime alcohol history ( $p = 0.018$ ), industrial chemical exposure ( $p = 0.010$ ), and degreasing chemical exposure ( $p = 0.003$ ). Enlisted flyers had the highest percentage of high haptoglobin levels (36.1%), followed by enlisted groundcrew (33.8%) and officers (22.9%). The prevalence of high haptoglobin levels increased with current alcohol use. Heavy lifetime drinkers had the largest percentage of high haptoglobin values (34.2%), followed by nondrinkers (30.5%) and moderate lifetime drinkers (27.8%). In each of the analyses of industrial chemical exposure and degreasing chemical exposure, participants who reported exposure had a larger percentage of high haptoglobin levels.

Transferrin in its continuous form significantly decreased with age ( $p = 0.022$ ) and increased with current alcohol use ( $p = 0.022$ ). Also significantly associated with transferrin were race ( $p < 0.001$ ) and degreasing chemical exposure ( $p = 0.009$ ). Black participants had a lower mean transferrin level than non-Blacks (237.8 mg/dl vs. 251.7 mg/dl). Participants who reported exposure to degreasing chemicals had a lower mean transferrin level than those who were exposed (248.2 mg/dl vs. 252.4 mg/dl).

Tests of covariate association for discretized transferrin showed age and race to be significantly associated with transferrin ( $p = 0.043$  and  $p = 0.001$ , respectively). Older participants had a higher prevalence of low transferrin levels than did younger participants (11.0% vs. 8.2%). Blacks had a higher percentage of low transferrin levels than non-Blacks (20.8% vs. 9.1%).

### 13.2.2 Exposure Analysis

The following section presents results of the statistical analyses of the dependent variables shown in Table 13-1. Dependent variables were derived from a medical records review and verification of self-reported gastrointestinal conditions, a 1997 physical examination determination of hepatomegaly, and numerous laboratory measurements conducted at the 1997 follow-up examination.

Four models were examined for each dependent variable given in Table 13-1. The analyses of these models are presented below. Further details on dioxin and the modeling strategy are found in Chapters 2 and 7, respectively. These analyses were performed both unadjusted and adjusted for relevant covariates. Model 1 examined the relation between the dependent variable and group (i.e., Ranch Hand or Comparison). In this model, exposure was defined as “yes” for Ranch Hands and “no” for Comparisons

without regard to the magnitude of the exposure. As an attempt to quantify exposure, three contrasts of Ranch Hands and Comparisons were performed along with the overall Ranch Hand versus Comparison contrast. These three contrasts compared Ranch Hands and Comparisons within each occupational category (i.e., officers, enlisted flyers, and enlisted groundcrew). As described in previous reports, the average levels of exposure to dioxin were highest for enlisted groundcrew, followed by enlisted flyers, then officers.

Model 2 explored the relation between the dependent variable and an extrapolated initial dioxin measure for Ranch Hands who had a 1987 dioxin measurement greater than 10 parts per trillion (ppt). If a participant did not have a 1987 dioxin level, the 1992 level was used to estimate the initial dioxin level. If a participant did not have a 1987 or a 1992 dioxin level, the 1997 level was used to estimate the initial dioxin level. A statistical adjustment for the percentage of body fat at the time of the participant's blood measurement of dioxin was included in this model to account for body-fat-related differences in elimination rate (66).

Model 3 divided the Ranch Hands examined in Model 2 into two categories based on their initial dioxin measures. These two categories are referred to as "low Ranch Hand" and "high Ranch Hand." Two additional categories, Ranch Hands with 1987 serum dioxin levels at or below 10 ppt and Comparisons with 1987 serum dioxin levels at or below 10 ppt, were formed and included in the model. Ranch Hands with 1987 serum dioxin levels at or below 10 ppt are referred to as the "background Ranch Hand" category. Dioxin levels in 1992 were used if the 1987 level was not available, and dioxin levels in 1997 were used if the 1987 and 1992 levels were not available. These four categories—Comparisons, background Ranch Hands, low Ranch Hands, and high Ranch Hands—were used in Model 3 analyses. The relation between the dependent variable in each of the three Ranch Hand categories and the dependent variable in the Comparison category was examined. A fourth contrast, exploring the relation of the dependent variable in the combined low and high Ranch Hand categories relative to Comparisons, also was conducted. This combination is referred to in the tables as the "low plus high Ranch Hand" category. As in Model 2, a statistical adjustment for the percentage of body fat at the time of the participant's blood measurement of dioxin was included in this model.

Model 4 examined the relation between the dependent variable and 1987 lipid-adjusted dioxin levels in all Ranch Hands with a dioxin measurement. If a participant did not have a 1987 dioxin measurement, the 1992 measurement was used to determine the dioxin level. If a participant did not have a 1987 or a 1992 dioxin measurement, the 1997 measurement was used to determine the dioxin level.

### *13.2.2.1 Medical Records Variables*

#### *13.2.2.1.1 Uncharacterized Hepatitis*

All unadjusted and adjusted analyses of the appearance of uncharacterized hepatitis for Models 1 through 4 were nonsignificant (Table 13-3(a-h):  $p > 0.18$  for all analyses).

**Table 13-3. Analysis of Uncharacterized Hepatitis**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>863</i>	<i>17 (2.0)</i>	<i>1.17 (0.61,2.23)</i>	<i>0.634</i>
	<i>Comparison</i>	<i>1,244</i>	<i>21 (1.7)</i>		
Officer	Ranch Hand	338	5 (1.5)	1.03 (0.32,3.28)	0.958
	Comparison	488	7 (1.4)		
Enlisted Flyer	Ranch Hand	151	4 (2.6)	1.67 (0.37,7.57)	0.507
	Comparison	187	3 (1.6)		
Enlisted Groundcrew	Ranch Hand	374	8 (2.1)	1.11 (0.44,2.78)	0.826
	Comparison	569	11 (1.9)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>			
Occupational Category	Adjusted Relative Risk (95% C.I.)		p-Value
<i>All</i>	<i>1.18 (0.62,2.26)</i>		<i>0.617</i>
Officer	1.05 (0.33,3.35)		0.935
Enlisted Flyer	1.62 (0.35,7.40)		0.533
Enlisted Groundcrew	1.13 (0.45,2.85)		0.795

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	3 (1.9)	1.10 (0.67,1.80)	0.705
Medium	161	3 (1.9)		
High	159	3 (1.9)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
475	1.02 (0.58,1.79)	0.936

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race, industrial chemical exposure, and degreasing chemical exposure because of the sparse number of Ranch Hands with uncharacterized hepatitis.

**Table 13-3. Analysis of Uncharacterized Hepatitis (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,206	21 (1.7)		
Background RH	378	8 (2.1)	1.27 (0.56,2.92)	0.568
Low RH	237	4 (1.7)	0.96 (0.33,2.82)	0.938
High RH	241	5 (2.1)	1.15 (0.43,3.10)	0.779
Low plus High RH	478	9 (1.9)	1.05 (0.48,2.32)	0.902

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,205		
Background RH	375	1.39 (0.59,3.27)	0.450
Low RH	236	1.00 (0.34,2.97)	0.999
High RH	239	1.04 (0.38,2.89)	0.932
Low plus High RH	475	1.02 (0.46,2.28)	0.957

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	287	6 (2.1)	0.86 (0.61,1.21)	0.377
Medium	283	5 (1.8)		
High	286	6 (2.1)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-3. Analysis of Uncharacterized Hepatitis (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
850	0.78 (0.55,1.12)	0.184

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

*13.2.2.1.2 Jaundice (Unspecified)*

The unadjusted Model 1 analysis revealed a significant overall group difference in the percentage of individuals with jaundice (Table 13-4(a): Est. RR=0.49, p=0.025). The percentage of Ranch Hands with jaundice was 1.4 percent versus 2.9 percent of the Comparisons. After stratifying by occupation, marginally significant differences were seen between Ranch Hand and Comparison officers, as well as enlisted groundcrew (Table 13-4(a): Est. RR=0.45, p=0.091; Est. RR=0.30, p=0.057, respectively). The percentage of officers and enlisted groundcrew with jaundice was higher among the Comparisons than the Ranch Hands.

**Table 13-4. Analysis of Jaundice (Unspecified)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<b>846</b>	<b>12 (1.4)</b>	<b>0.49 (0.25,0.94)</b>	<b>0.025</b>
	<i>Comparison</i>	<b>1,219</b>	<b>35 (2.9)</b>		
Officer	Ranch Hand	329	6 (1.8)	0.45 (0.18,1.14)	0.091
	Comparison	478	19 (4.0)		
Enlisted Flyer	Ranch Hand	149	3 (2.0)	3.70 (0.38,35.9)	0.260
	Comparison	181	1 (0.6)		
Enlisted Groundcrew	Ranch Hand	368	3 (0.8)	0.30 (0.09,1.04)	0.057
	Comparison	560	15 (2.7)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<b>0.49 (0.25,0.96)</b>	<b>0.028</b>
Officer	0.46 (0.18,1.17)	0.103
Enlisted Flyer	3.47 (0.36,33.8)	0.284
Enlisted Groundcrew	0.29 (0.08,1.03)	0.055

**Table 13-4. Analysis of Jaundice (Unspecified) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	154	0 (0.0)	1.03 (0.21,5.02)	0.973
Medium	160	1 (0.6)		
High	155	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
466	1.01 (0.20,5.08)	0.995

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are adjusted only for percent body fat at the time of the blood measurement of dioxin and lifetime alcohol history because of the sparse number of Ranch Hands with jaundice.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,182	34 (2.9)		
Background RH	370	11 (3.0)	1.05 (0.52,2.11)	0.890
Low RH	232	0 (0.0)	--	0.017 <sup>c</sup>
High RH	237	1 (0.4)	0.14 (0.02,1.04)	0.055
Low plus High RH	469	1 (0.2)	--	0.001 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of Ranch Hands with unspecified jaundice.

--: Results not presented because of the sparse number of Ranch Hands with unspecified jaundice.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-4. Analysis of Jaundice (Unspecified) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,181		
Background RH	367	0.99 (0.49,2.03)	0.988
Low RH	231	--	--
High RH	235	0.16 (0.02,1.20)	0.075
Low plus High RH	466	--	--

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

--: Results not presented because of the sparse number of Ranch Hands with unspecified jaundice.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	281	8 (2.8)	0.44 (0.28,0.69)	<0.001
Medium	276	3 (1.1)		
High	282	1 (0.4)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
833	0.39 (0.24,0.65)		<0.001

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

After covariate adjustment, the overall group difference remained significant (Table 13-4(b): Adj. RR=0.49, p=0.028). Stratifying by occupation revealed a marginally significant difference between Ranch Hands and Comparisons among the enlisted groundcrew (Table 13-4(b): Adj. RR=0.29, p=0.055).

Only one Ranch Hand had an extrapolated initial dioxin value. The Model 2 unadjusted analysis of jaundice was not significant (Table 13-4(c): p=0.973), nor was the adjusted analysis (Table 13-4(d): p=0.995).

The Model 3 unadjusted and adjusted analyses of jaundice each revealed a marginally significant difference between Ranch Hands in the high dioxin category and Comparisons (Table 13-4(e,f): Est. RR=0.14, p=0.055, for the unadjusted analysis; Adj. RR=0.16, p=0.075, for the adjusted analysis). The percentage of Ranch Hands in the high dioxin category with jaundice was 0.4 percent versus 2.9

percent among the Comparisons. There were no Ranch Hands in the low dioxin category. Unadjusted chi-square tests of association revealed a significantly smaller percentage of Ranch Hands in the low dioxin category with jaundice than Comparisons (Table 13-4(e):  $p=0.017$ ). A significantly smaller percentage of Ranch Hands in the low and high dioxin categories combined also had jaundice than did Comparisons (Table 13-4(e):  $p=0.001$ ).

The unadjusted and adjusted Model 4 analyses revealed a significant relation between 1987 dioxin and jaundice (Table 13-4(g,h): Est. RR=0.44,  $p<0.001$ ; Adj. RR=0.39,  $p<0.001$ , respectively). The percentages of participants with jaundice in the low, medium, and high 1987 dioxin categories were 2.8, 1.1, and 0.4, respectively.

### 13.2.2.1.3 Acute Necrosis of the Liver

Only one participant had an acute necrosis of the liver. The participant was a non-Black, Comparison officer. Further statistical analysis was not performed.

### 13.2.2.1.4 Chronic Liver Disease and Cirrhosis (Alcohol-related)

All unadjusted and adjusted analyses of alcohol-related chronic liver disease and cirrhosis were nonsignificant (Table 13-5(a–h):  $p>0.22$  for all analyses).

**Table 13-5. Analysis of Chronic Liver Disease and Cirrhosis (Alcohol-related)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>815</i>	<i>39 (4.8)</i>	<i>1.01 (0.67,1.54)</i>	<i>0.958</i>
	<i>Comparison</i>	<i>1,183</i>	<i>56 (4.7)</i>		
Officer	Ranch Hand	326	15 (4.6)	1.58 (0.75,3.32)	0.229
	Comparison	472	14 (3.0)		
Enlisted Flyer	Ranch Hand	138	7 (5.1)	0.75 (0.29,1.95)	0.553
	Comparison	180	12 (6.7)		
Enlisted Groundcrew	Ranch Hand	351	17 (4.8)	0.85 (0.46,1.57)	0.602
	Comparison	531	30 (5.6)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.93 (0.60,1.45)</i>	<i>0.762</i>
Officer	1.50 (0.71,3.19)	0.290
Enlisted Flyer	0.70 (0.26,1.88)	0.474
Enlisted Groundcrew	0.75 (0.39,1.45)	0.390

**Table 13-5. Analysis of Chronic Liver Disease and Cirrhosis (Alcohol-related)  
(Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	152	7 (4.6)	1.06 (0.78,1.45)	0.708
Medium	151	8 (5.3)		
High	144	8 (5.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
444	1.06 (0.72,1.57)	0.765

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,147	54 (4.7)		
Background RH	361	16 (4.4)	0.97 (0.55,1.73)	0.924
Low RH	226	11 (4.9)	1.02 (0.53,1.99)	0.946
High RH	221	12 (5.4)	1.12 (0.59,2.14)	0.725
Low plus High RH	447	23 (5.1)	1.07 (0.65,1.77)	0.788

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-5. Analysis of Chronic Liver Disease and Cirrhosis (Alcohol-related)  
(Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,146		
Background RH	358	1.03 (0.56,1.90)	0.914
Low RH	225	0.95 (0.48,1.91)	0.894
High RH	219	0.88 (0.43,1.81)	0.734
Low plus High RH	444	0.92 (0.54,1.57)	0.755

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	273	12 (4.4)	1.10 (0.89,1.37)	0.368
Medium	269	15 (5.6)		
High	266	12 (4.5)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
802	1.09 (0.84,1.41)		0.506

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

### 13.2.2.1.5 Chronic Liver Disease and Cirrhosis (Non-alcohol-related)

All results from analysis of non-alcohol-related chronic liver disease and cirrhosis were nonsignificant (Table 13-6(a–h): p>0.21 for all analyses).

**Table 13-6. Analysis of Chronic Liver Disease and Cirrhosis (Non-alcohol-related)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	870	14 (1.6)	1.44 (0.68,3.04)	0.336
	<i>Comparison</i>	1,250	14 (1.1)		
Officer	Ranch Hand	341	5 (1.5)	2.43 (0.58,10.18)	0.226
	Comparison	493	3 (0.6)		
Enlisted Flyer	Ranch Hand	151	2 (1.3)	0.82 (0.14,4.99)	0.832
	Comparison	187	3 (1.6)		
Enlisted Groundcrew	Ranch Hand	378	7 (1.9)	1.33 (0.48,3.69)	0.589
	Comparison	570	8 (1.4)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	1.43 (0.68,3.03)	0.348
Officer	2.47 (0.58,10.52)	0.219
Enlisted Flyer	0.77 (0.13,4.71)	0.777
Enlisted Groundcrew	1.32 (0.47,3.69)	0.598

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	160	2 (1.3)	1.02 (0.61,1.70)	0.949
Medium	162	4 (2.5)		
High	160	2 (1.3)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
479	1.04 (0.61,1.76)	0.897

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race because of the sparse number of Ranch Hands with a history of non-alcohol-related chronic liver disease and cirrhosis.

**Table 13-6. Analysis of Chronic Liver Disease and Cirrhosis (Non-alcohol-related)  
(Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,212	14 (1.2)		
Background RH	381	6 (1.6)	1.64 (0.62,4.34)	0.321
Low RH	239	3 (1.3)	1.01 (0.29,3.58)	0.986
High RH	243	5 (2.1)	1.52 (0.53,4.32)	0.433
Low plus High RH	482	8 (1.7)	1.24 (0.50,3.06)	0.639

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,211		
Background RH	378	1.89 (0.68,5.25)	0.223
Low RH	238	1.15 (0.32,4.12)	0.829
High RH	241	1.37 (0.47,4.00)	0.568
Low plus High RH	479	1.26 (0.51,3.12)	0.625

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	288	4 (1.4)	1.05 (0.73,1.49)	0.803
Medium	287	4 (1.4)		
High	288	6 (2.1)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-6. Analysis of Chronic Liver Disease and Cirrhosis (Non-alcohol-related)  
(Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
857	1.02 (0.68,1.54)	0.920

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

**13.2.2.1.6 Liver Abscess and Sequelae of Chronic Liver Disease**

A sparse number of abnormalities restricted the analysis of liver abscess and sequelae of chronic liver disease. One non-Black, Ranch Hand enlisted groundcrew and one non-Black, Comparison officer were noted to have a liver abscess and sequelae of chronic liver disease. No significant relations with dioxin were noted in any of the Models 1 through 4 analyses (Table 13-7(a–h): p>0.16 for all analyses performed).

**Table 13-7. Analysis of Liver Abscess and Sequelae of Chronic Liver Disease**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>870</i>	<i>1 (0.1)</i>	<i>1.44 (0.09,23.03)</i>	<i>0.798</i>
	<i>Comparison</i>	<i>1,251</i>	<i>1 (0.1)</i>		
Officer	Ranch Hand	341	0 (0.0)	--	0.999 <sup>a</sup>
	Comparison	494	1 (0.2)		
Enlisted Flyer	Ranch Hand	151	0 (0.0)	--	--
	Comparison	187	0 (0.0)		
Enlisted Groundcrew	Ranch Hand	378	1 (0.3)	--	0.836 <sup>a</sup>
	Comparison	570	0 (0.0)		

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a history of a liver abscess and sequelae of chronic liver disease.

--: Results not presented because of the sparse number of participants with a liver abscess and sequelae of chronic liver disease.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.45 (0.09,23.24)</i>	<i>0.795</i>
Officer	--	--
Enlisted Flyer	--	--
Enlisted Groundcrew	--	--

--: Results not presented because of the sparse number of participants with a liver abscess and sequelae of chronic liver disease.

Note: Results are not adjusted for race and occupation because of the sparse number of participants with a liver abscess and sequelae of chronic liver disease.

**Table 13-7. Analysis of Liver Abscess and Sequelae of Chronic Liver Disease (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	160	0 (0.0)	1.99 (0.64,6.25)	0.277
Medium	162	0 (0.0)		
High	160	1 (0.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.)	p-Value
479	2.09 (0.61,7.19)	0.277

Note: Results are adjusted only for percent body fat at the time of the blood measurement of dioxin, age, and lifetime alcohol history because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,213	1 (0.1)		
Background RH	381	0 (0.0)	--	0.999 <sup>c</sup>
Low RH	239	0 (0.0)	--	0.999 <sup>c</sup>
High RH	243	1 (0.4)	5.44 (0.33,89.44)	0.236
Low plus High RH	482	1 (0.2)	--	0.999 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

--: Results not presented because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-7. Analysis of Liver Abscess and Sequelae of Chronic Liver Disease (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
Comparison	1,212		
Background RH	378	--	--
Low RH	238	--	--
High RH	241	7.76 (0.38,158.28)	0.183
Low plus High RH	479	--	--

--: Analyses not performed because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for race and occupation because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	288	0 (0.0)	2.30 (0.71,7.43)	0.162
Medium	287	0 (0.0)		
High	288	1 (0.3)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)</b>		<b>p-Value</b>
857	2.05 (0.68,6.15)		0.212

Note: Results are adjusted only for age and lifetime alcohol history because of the sparse number of Ranch Hands with a liver abscess and sequelae of chronic liver disease.

### 13.2.2.1.7 Enlarged Liver (Hepatomegaly)

The unadjusted and adjusted Model 1 analyses of the prevalence of enlarged liver revealed no group differences when combining all occupations (Table 13-8(a,b):  $p > 0.33$  for each analysis). After stratifying by occupation, a marginally significant difference was seen between Ranch Hand and Comparison enlisted groundcrew (Table 13-8(a,b): Est. RR=0.30,  $p=0.056$ ; Adj. RR=0.29,  $p=0.057$ , respectively). Among the enlisted groundcrew, 0.8 percent of the Ranch Hands had an enlarged liver versus 2.6 percent of the Comparisons. No significant results were seen in the Model 2, Model 3, or Model 4 analyses (Table 13-8(c-h):  $p > 0.15$  for all analyses).

**Table 13-8. Analysis of Enlarged Liver (Hepatomegaly)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>869</i>	<i>14 (1.6)</i>	<i>0.74 (0.39,1.42)</i>	<i>0.361</i>
	<i>Comparison</i>	<i>1,249</i>	<i>27 (2.2)</i>		
Officer	Ranch Hand	341	5 (1.5)	0.80 (0.27,2.40)	0.689
	Comparison	492	9 (1.8)		
Enlisted Flyer	Ranch Hand	151	6 (4.0)	2.54 (0.62,10.32)	0.193
	Comparison	187	3 (1.6)		
Enlisted Groundcrew	Ranch Hand	377	3 (0.8)	0.30 (0.09,1.03)	0.056
	Comparison	570	15 (2.6)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.73 (0.38,1.41)</i>	<i>0.339</i>
Officer	0.78 (0.26,2.36)	0.662
Enlisted Flyer	2.53 (0.62,10.38)	0.198
Enlisted Groundcrew	0.29 (0.08,1.03)	0.057

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	160	2 (1.3)	0.96 (0.56,1.65)	0.880
Medium	162	4 (2.5)		
High	159	2 (1.3)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
478	0.91 (0.46,1.80)	0.790

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race because of the sparse number of Ranch Hands with a history of an enlarged liver.

**Table 13-8. Analysis of Enlarged Liver (Hepatomegaly) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,211	26 (2.1)		
Background RH	381	6 (1.6)	0.75 (0.31,1.86)	0.540
Low RH	239	2 (0.8)	0.38 (0.09,1.62)	0.191
High RH	242	6 (2.5)	1.12 (0.46,2.78)	0.798
Low plus High RH	481	8 (1.7)	0.66 (0.27,1.61)	0.357

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,210		
Background RH	378	0.80 (0.32,2.01)	0.630
Low RH	238	0.35 (0.08,1.51)	0.159
High RH	240	1.09 (0.42,2.79)	0.864
Low plus High RH	478	0.62 (0.25,1.54)	0.302

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	288	4 (1.4)	0.94 (0.65,1.35)	0.731
Medium	287	4 (1.4)		
High	287	6 (2.1)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-8. Analysis of Enlarged Liver (Hepatomegaly) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
856	0.93 (0.60,1.46)	0.753

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

**13.2.2.1.8 Other Liver Disorders**

Both the unadjusted and adjusted Model 1 analyses revealed marginally significant differences between Ranch Hands and Comparisons over all occupations (Table 13-9(a,b): Est. RR=1.20, p=0.067; Adj. RR=1.19, p=0.090, respectively). The percentage of Ranch Hands with other liver disorders was 28.8 versus 25.2 for Comparisons. Stratifying by occupation revealed a marginally significant difference between Ranch Hands and Comparisons within the enlisted groundcrew stratum for both the unadjusted and adjusted analyses (Table 13-9(a,b): Est. RR=1.32, p=0.062; Adj. RR=1.31, p=0.073, respectively). Of the enlisted groundcrew Ranch Hands, 30.8 percent had other liver disorders versus 25.2 percent of the Comparisons.

**Table 13-9. Analysis of Other Liver Disorders**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	866	249 (28.8)	<i>1.20 (0.99,1.46)</i>	<i>0.067</i>
	<i>Comparison</i>	1,240	312 (25.2)		
Officer	Ranch Hand	338	93 (27.5)	1.15 (0.84,1.57)	0.399
	Comparison	486	121 (24.9)		
Enlisted Flyer	Ranch Hand	151	40 (26.5)	1.04 (0.64,1.70)	0.864
	Comparison	187	48 (25.7)		
Enlisted Groundcrew	Ranch Hand	377	116 (30.8)	1.32 (0.99,1.76)	0.062
	Comparison	567	143 (25.2)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.19 (0.97,1.45)</i>	<i>0.090</i>
Officer	1.15 (0.83,1.57)	0.400
Enlisted Flyer	0.98 (0.60,1.61)	0.933
Enlisted Groundcrew	1.31 (0.98,1.75)	0.073

**Table 13-9. Analysis of Other Liver Disorders (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	159	39 (24.5)	1.12 (0.97,1.30)	0.119
Medium	162	53 (32.7)		
High	160	55 (34.4)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
478	1.23 (1.03,1.47)	0.022

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,202	299 (24.9)		
Background RH	378	99 (26.2)	1.15 (0.88,1.50)	0.318
Low RH	238	64 (26.9)	1.09 (0.80,1.50)	0.578
High RH	243	83 (34.2)	1.49 (1.10,2.00)	0.009
Low plus High RH	481	147 (30.6)	1.28 (1.01,1.62)	0.042

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

Background (Ranch Hand): Current Dioxin ≤ 10 ppt.

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,201		
Background RH	375	1.13 (0.86,1.49)	0.371
Low RH	237	1.05 (0.76,1.45)	0.757
High RH	241	1.52 (1.11,2.08)	0.009
Low plus High RH	478	1.27 (1.00,1.62)	0.055

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

Background (Ranch Hand): Current Dioxin ≤ 10 ppt.

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-9. Analysis of Other Liver Disorders (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	286	73 (25.5)	1.10 (1.00,1.22)	0.055
Medium	285	76 (26.7)		
High	288	97 (33.7)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤ 7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
853	1.11 (0.99,1.25)		0.077

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The unadjusted Model 2 analysis did not reveal a significant association between initial dioxin and other liver disorders (Table 13-9(c):  $p=0.119$ ). After adjusting for covariates, the results became significant (Table 13-9(d): Adj. RR=1.23,  $p=0.022$ ). The percentages of other liver disorders in the low, medium, and high initial dioxin categories were 24.5, 32.7, and 34.4, respectively.

The unadjusted Model 3 analysis of other liver disorders revealed significant differences between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-9(e): Est. RR=1.49,  $p=0.009$ ; Est. RR=1.28,  $p=0.042$ , respectively). The same contrasts were significant after adjusting for covariates (Table 13-9(f): Adj. RR=1.52,  $p=0.009$ , for Ranch Hands in the high dioxin category versus Comparisons; Adj. RR=1.27,  $p=0.055$ , for Ranch Hands in the low and high dioxin categories combined versus Comparisons). The percentages of other liver disorders among Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 34.2, 30.6, and 24.9, respectively.

Both the unadjusted and adjusted Model 4 analyses revealed marginally significant positive associations between 1987 dioxin and other liver disorders (Table 13-9(g,h): Est. RR=1.10,  $p=0.055$ ; Adj. RR=1.11,  $p=0.077$ , respectively). The percentages of other liver disorders in the low, medium, and high 1987 dioxin categories were 25.5, 26.7, and 33.7, respectively.

### 13.2.2.2 Physical Examination Variables

#### 13.2.2.2.1 Current Hepatomegaly

All unadjusted and adjusted analyses of current hepatomegaly, as assessed by a physician at the 1997 physical examination, were nonsignificant for Models 1 through 4 (Table 13-10:  $p>0.10$  for each analysis).

**Table 13-10. Analysis of Current Hepatomegaly**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>860</i>	<i>10 (1.2)</i>	<i>2.06 (0.78,5.43)</i>	<i>0.141</i>
	<i>Comparison</i>	<i>1,231</i>	<i>7 (0.6)</i>		
Officer	Ranch Hand	340	4 (1.2)	2.90 (0.53,15.95)	0.220
	Comparison	490	2 (0.4)		
Enlisted Flyer	Ranch Hand	150	2 (1.3)	--	0.389 <sup>a</sup>
	Comparison	185	0 (0.0)		
Enlisted Groundcrew	Ranch Hand	370	4 (1.1)	1.20 (0.32,4.51)	0.783
	Comparison	556	5 (0.9)		

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with current hepatomegaly.

--: Results not presented because of the sparse number of participants with current hepatomegaly.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
<i>All</i>	<i>2.13 (0.80,5.67)</i>	<i>0.127</i>
Officer	3.17 (0.57,17.56)	0.187
Enlisted Flyer	--	--
Enlisted Groundcrew	1.18 (0.31,4.51)	0.805

--: Results not presented because of the sparse number of participants with current hepatomegaly.

Note: Results are not adjusted for race because of the sparse number of participants with current hepatomegaly.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	3 (1.9)	0.69 (0.36,1.31)	0.223
Medium	159	3 (1.9)		
High	160	1 (0.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
474	0.66 (0.30,1.45)	0.279

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race because of the sparse number of participants with current hepatomegaly.

**Table 13-10. Analysis of Current Hepatomegaly (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	7 (0.6)		
Background RH	376	3 (0.8)	1.53 (0.39,5.99)	0.543
Low RH	236	3 (1.3)	2.10 (0.54,8.23)	0.284
High RH	241	4 (1.7)	2.58 (0.74,8.97)	0.136
Low plus High RH	477	7 (1.5)	2.33 (0.80,6.76)	0.119

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	1.64 (0.40,6.69)	0.489
Low RH	235	2.26 (0.57,9.01)	0.247
High RH	239	2.62 (0.70,9.84)	0.154
Low plus High RH	474	2.44 (0.82,7.24)	0.109

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for race because of the sparse number of participants with current hepatomegaly.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	3 (1.1)	1.04 (0.69,1.58)	0.853
Medium	285	3 (1.1)		
High	285	4 (1.4)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-10. Analysis of Current Hepatomegaly (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
848	1.05 (0.64,1.74)	0.838

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race because of the sparse number of participants with current hepatomegaly.

### 13.2.2.3 Laboratory Examination Variables

#### 13.2.2.3.1 AST (Continuous)

Model 1 showed no significant difference in mean AST levels between Ranch Hands and Comparisons in either the unadjusted or adjusted analysis (Table 13-11(a,b):  $p > 0.44$  for all contrasts). The unadjusted and adjusted analyses for Model 2 did not reveal any significant relations between initial dioxin and AST levels (Table 13-11(c,d):  $p > 0.49$  in both analyses).

**Table 13-11. Analysis of AST (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	859	23.01	0.13 --	0.705
	<i>Comparison</i>	1,231	22.88		
Officer	Ranch Hand	340	23.40	0.06 --	0.914
	Comparison	490	23.34		
Enlisted Flyer	Ranch Hand	150	22.17	-0.32 --	0.696
	Comparison	185	22.48		
Enlisted Groundcrew	Ranch Hand	369	22.99	0.39 --	0.447
	Comparison	556	22.60		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-11. Analysis of AST (U/I) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	23.36	0.18 --	0.597
	<i>Comparison</i>	1,229	23.17		
Officer	Ranch Hand	340	23.88	0.08 --	0.885
	Comparison	489	23.80		
Enlisted Flyer	Ranch Hand	148	22.79	-0.09 --	0.916
	Comparison	184	22.87		
Enlisted Groundcrew	Ranch Hand	366	23.32	0.37 --	0.470
	Comparison	556	22.95		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	23.39	23.50	0.011	0.003 (0.012)	0.813
Medium	159	23.71	23.72			
High	159	23.43	23.32			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of AST versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>				
Low	158	24.76		0.057	0.010 (0.014)	0.493
Medium	158	25.53				
High	157	24.99				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of AST versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-11. Analysis of AST (U/I) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	22.85	22.84		
Background RH	376	22.34	22.54	-0.30 --	0.501
Low RH	236	23.45	23.39	0.55 --	0.306
High RH	240	23.56	23.36	0.52 --	0.334
Low plus High RH	476	23.51	23.37	0.53 --	0.193

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>					
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>	
Comparison	1,193	23.23			
Background RH	374	22.76	-0.47 --	0.305	
Low RH	235	23.93	0.70 --	0.207	
High RH	238	24.17	0.94 --	0.100	
Low plus High RH	473	24.05	0.82 --	0.055	

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	283	22.29	0.005	0.017 (0.008)	0.033
Medium	285	23.30			
High	284	23.38			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of AST versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-11. Analysis of AST (U/l) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	22.72	0.036	0.028 (0.009)	0.002
Medium	283	24.06			
High	281	24.66			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of AST versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The Model 3 unadjusted analysis of AST showed no significant difference between any of the Ranch Hand categories and the Comparison group (Table 13-11(e):  $p > 0.19$  for all contrasts). After covariate adjustment, a marginally significant difference between the mean AST of Ranch Hands in the high dioxin category and the Comparison mean was revealed (Table 13-11(f): difference of adjusted means = 0.94 U/l,  $p = 0.100$ ). The adjusted mean levels of AST for Ranch Hands in the high dioxin category and the Comparison group were 24.17 U/l and 23.23 U/l, respectively. A marginally significant difference between Ranch Hands in the low and high dioxin categories combined and the Comparisons also was seen after covariate adjustment (Table 13-11(f): difference of adjusted means = 0.82 U/l,  $p = 0.055$ ). The adjusted mean levels of AST for Ranch Hands in the low and high dioxin categories combined and the Comparison group were 24.05 U/l and 23.23 U/l, respectively.

In Model 4, the unadjusted analysis found a significant positive association between AST in its continuous form and 1987 dioxin levels (Table 13-11(g): slope = 0.017,  $p = 0.033$ ). The adjusted Model 4 analysis revealed a significant association between AST levels and 1987 dioxin levels (Table 13-11(h): adjusted slope = 0.028,  $p = 0.002$ ). The adjusted mean AST levels in the low, medium, and high 1987 dioxin categories were 22.72 U/l, 24.06 U/l, and 24.66 U/l, respectively.

#### 13.2.2.3.2 AST (Discrete)

The unadjusted and adjusted Model 1 analyses did not show a significant group difference in the percentage of individuals with high AST levels (Table 13-12(a,b):  $p > 0.25$  for all contrasts).

**Table 13-12. Analysis of AST (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	859	63 (7.3)	<i>1.11 (0.79,1.56)</i>	<i>0.552</i>
	<i>Comparison</i>	1,231	82 (6.7)		
Officer	Ranch Hand	340	24 (7.1)	1.09 (0.63,1.88)	0.765
	Comparison	490	32 (6.5)		
Enlisted Flyer	Ranch Hand	150	10 (6.7)	0.75 (0.33,1.72)	0.501
	Comparison	185	16 (8.6)		
Enlisted Groundcrew	Ranch Hand	369	29 (7.9)	1.31 (0.78,2.19)	0.304
	Comparison	556	34 (6.1)		

**Table 13-12. Analysis of AST (Discrete) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.14 (0.81,1.61)</i>	<i>0.448</i>
Officer	1.09 (0.63,1.89)	0.763
Enlisted Flyer	0.84 (0.36,1.92)	0.671
Enlisted Groundcrew	1.35 (0.81,2.28)	0.252

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	158	11 (7.0)	1.08 (0.86,1.36)	0.498
Medium	159	20 (12.6)		
High	159	14 (8.8)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
473	1.13 (0.86,1.50)	0.380

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	79 (6.6)		
Background RH	376	17 (4.5)	0.72 (0.42,1.24)	0.241
Low RH	236	19 (8.1)	1.21 (0.72,2.04)	0.476
High RH	240	26 (10.8)	1.60 (1.00,2.56)	0.051
Low plus High RH	476	45 (9.5)	1.39 (0.95,2.05)	0.094

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-12. Analysis of AST (Discrete) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	0.70 (0.40,1.22)	0.212
Low RH	235	1.28 (0.75,2.18)	0.360
High RH	238	1.79 (1.08,2.96)	0.024
Low plus High RH	473	1.51 (1.02,2.26)	0.041

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	11 (3.9)	1.26 (1.06,1.48)	0.008
Medium	285	23 (8.1)		
High	284	28 (9.9)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
847	1.38 (1.12,1.71)		0.002

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

In Model 2, neither the unadjusted nor adjusted analyses showed significant associations between AST and initial dioxin (Table 13-12(c,d):  $p \geq 0.38$  for both analyses).

The unadjusted Model 3 analysis of AST in its discrete form revealed two marginally significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-12(e): Est. RR=1.60,  $p=0.051$ ; Est. RR=1.39,  $p=0.094$ , respectively). Similarly, the adjusted analysis showed a significant difference between Ranch Hands in the high dioxin category and Comparisons (Table 13-12(f): Adj. RR=1.79,  $p=0.024$ ), as well as between the Ranch Hands in the low and high dioxin categories combined and Comparisons (Adj. RR=1.51,  $p=0.041$ ). The percentages of individuals with high levels of AST among the Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 10.8, 9.5, and 6.6, respectively.

The unadjusted analysis for Model 4 showed a significant association between AST in its discrete form and 1987 dioxin (Table 13-12(g): Est. RR=1.26, p=0.008). Similarly, the adjusted analysis revealed significant results (Adj. RR=1.38, p=0.002). The percentages of participants with high AST levels in the low, medium, and high 1987 dioxin categories were 3.9, 8.1, and 9.9, respectively.

### 13.2.2.3.3 ALT (Continuous)

All Model 1 and 2 analyses of ALT in its continuous form showed nonsignificant results (Table 13-13(a–d): p>0.19 for each analysis).

**Table 13-13. Analysis of ALT (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>42.58</i>	<i>0.13 --</i>	<i>0.803</i>
	<i>Comparison</i>	<i>1,231</i>	<i>42.45</i>		
Officer	Ranch Hand	340	42.21	0.42 --	0.613
	Comparison	490	41.79		
Enlisted Flyer	Ranch Hand	150	41.21	-1.38 --	0.290
	Comparison	185	42.59		
Enlisted Groundcrew	Ranch Hand	369	43.50	0.51 --	0.537
	Comparison	556	42.99		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>42.29</i>	<i>0.20 --</i>	<i>0.707</i>
	<i>Comparison</i>	<i>1,229</i>	<i>42.09</i>		
Officer	Ranch Hand	340	42.75	0.61 --	0.460
	Comparison	489	42.14		
Enlisted Flyer	Ranch Hand	148	41.72	-1.12 --	0.386
	Comparison	184	42.84		
Enlisted Groundcrew	Ranch Hand	366	41.96	0.30 --	0.698
	Comparison	556	41.66		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-13. Analysis of ALT (U/l) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	42.39	42.65	0.036	0.013 (0.010)	0.199
Medium	159	44.97	45.00			
High	159	45.02	44.72			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of ALT versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	44.34	0.094	0.011 (0.012)	0.357
Medium	158	47.03			
High	157	46.08			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of ALT versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	42.41	42.37		
Background RH	376	40.74	41.32	-1.05 --	0.129
Low RH	236	43.32	43.14	0.77 --	0.368
High RH	240	44.91	44.27	1.90 --	0.027
Low plus High RH	476	44.12	43.71	1.34 --	0.041

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-13. Analysis of ALT (U/I) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
Comparison	1,193	42.21		
Background RH	374	41.31	-0.90 --	0.192
Low RH	235	43.65	1.44 --	0.084
High RH	238	43.62	1.41 --	0.098
Low plus High RH	473	43.63	1.42 --	0.026

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	41.17	0.023	0.029 (0.007)	<0.001
Medium	285	41.87			
High	284	44.82			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of ALT versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	40.98	0.079	0.033 (0.007)	<0.001
Medium	283	42.50			
High	281	45.28			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of ALT versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted Model 3 analysis of ALT revealed two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-13(e): difference of means=1.90 U/l, p=0.027; difference of means=1.34 U/l, p=0.041, respectively).

After covariate adjustment, the Model 3 analysis of ALT revealed marginally significant differences between the adjusted mean of Ranch Hands in the low dioxin category and the Comparison adjusted mean (Table 13-13(f): difference of adjusted means=1.44 U/l, p=0.084) and between the adjusted mean of Ranch Hands in the high dioxin category and the Comparison adjusted mean (difference of adjusted means=1.41 U/l, p=0.098). Ranch Hands in the low and high dioxin categories combined also were significantly different from the Comparisons in the adjusted analysis (difference of adjusted means=1.42 U/l, p=0.026). Ranch Hands in the low and high dioxin categories combined had higher mean ALT levels (43.65 U/l and 43.62 U/l) than did the Comparisons (42.21 U/l).

The unadjusted and adjusted analyses for Model 4 each showed significant positive associations between ALT in its continuous form and 1987 dioxin (Table 13-13(g,h): slope=0.029, p<0.001, unadjusted; slope=0.033, p<0.001, adjusted). The adjusted mean ALT levels in the low, medium, and high 1987 dioxin categories were 40.98 U/l, 42.50 U/l, and 45.28 U/l, respectively.

#### 13.2.2.3.4 ALT (Discrete)

The Model 1 analyses of ALT in its discrete form revealed no significant differences between Ranch Hands and Comparisons when examined across all occupations and within each occupation (Table 13-14(a,b): p>0.13 for each contrast).

**Table 13-14. Analysis of ALT (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	68 (7.9)	<i>1.13 (0.81,1.57)</i>	<i>0.468</i>
	<i>Comparison</i>	1,231	87 (7.1)		
Officer	Ranch Hand	340	23 (6.8)	1.54 (0.85,2.82)	0.157
	Comparison	490	22 (4.5)		
Enlisted Flyer	Ranch Hand	150	15 (10.0)	0.97 (0.48,1.98)	0.935
	Comparison	185	19 (10.3)		
Enlisted Groundcrew	Ranch Hand	369	30 (8.1)	0.98 (0.61,1.59)	0.938
	Comparison	556	46 (8.3)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.12 (0.80,1.57)</i>	<i>0.495</i>
Officer	1.58 (0.86,2.89)	0.138
Enlisted Flyer	0.97 (0.46,2.01)	0.927
Enlisted Groundcrew	0.97 (0.60,1.57)	0.889

**Table 13-14. Analysis of ALT (Discrete) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	10 (6.3)	1.17 (0.95,1.45)	0.140
Medium	159	21 (13.2)		
High	159	19 (11.9)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.32 (1.00,1.73)	0.049

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	85 (7.1)		
Background RH	376	17 (4.5)	0.67 (0.39,1.15)	0.145
Low RH	236	20 (8.5)	1.18 (0.71,1.97)	0.522
High RH	240	30 (12.5)	1.74 (1.11,2.71)	0.015
Low plus High RH	476	50 (10.5)	1.43 (0.99,2.08)	0.058

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	0.71 (0.41,1.23)	0.223
Low RH	235	1.30 (0.77,2.18)	0.323
High RH	238	1.53 (0.95,2.45)	0.080
Low plus High RH	473	1.41 (0.96,2.07)	0.079

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-14. Analysis of ALT (Discrete) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>
Low	283	15 (5.3)	1.33 (1.13,1.56) 0.001
Medium	285	18 (6.3)	
High	284	34 (12.0)	

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
847	1.48 (1.20,1.83)	<0.001

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The association between initial dioxin and ALT examined in the unadjusted Model 2 analysis revealed nonsignificant results (Table 13-14(c):  $p=0.140$ ). After covariate adjustment, a significant association was revealed (Table 13-14(d): Adj. RR=1.32,  $p=0.049$ ). The percentages of high ALT levels in the low, medium, and high initial dioxin categories were 6.3, 13.2, and 11.9, respectively.

The unadjusted Model 3 analysis of ALT in its discrete form revealed two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-14(e): Est. RR=1.74,  $p=0.015$ ; Est. RR=1.43,  $p=0.058$ , respectively). The percentages of individuals with high ALT levels among Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 12.5, 10.5, and 7.1, respectively. The same two contrasts were marginally significant after adjusting for covariates (Table 13-14(f): Adj. RR=1.53,  $p=0.080$ ; Adj. RR=1.41,  $p=0.079$ ).

The Model 4 unadjusted and adjusted analyses each revealed a significant association between 1987 dioxin and ALT in its discrete form (Table 13-14(g,h): Est. RR=1.33,  $p=0.001$ ; Adj. RR=1.48,  $p<0.001$ ). The percentages of participants with high ALT values in the low, medium, and high 1987 dioxin categories were 5.3, 6.3, and 12.0, respectively.

#### 13.2.2.3.5 GGT (Continuous)

All analysis results from Models 1 and 2 of GGT were nonsignificant (Table 13-15(a–d):  $p>0.22$  for each analysis). The unadjusted Model 3 analysis of GGT revealed significant differences between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-15(e): difference of means=5.17 U/l,  $p=0.003$ ; difference of means=3.46 U/l,  $p=0.007$ , respectively). The same contrasts were significant after adjusting for covariates (Table 13-15(f): difference of adjusted means=5.00 U/l,  $p=0.006$ , for Ranch Hands in the high dioxin category versus Comparisons; difference of adjusted means=3.71 U/l,  $p=0.006$ , for Ranch Hands in the low and high dioxin categories combined versus Comparisons). The adjusted mean GGT levels for Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 50.40 U/l, 49.11 U/l, and 45.40 U/l, respectively.

A significant association was revealed between GGT and 1987 dioxin in the Model 4 unadjusted analysis (Table 13-15(g): slope=0.040, p=0.002). Similarly, the adjusted analysis found a significant association between GGT levels and 1987 dioxin (Table 13-15(h): adjusted slope=0.042, p=0.003). The adjusted mean GGT levels were 42.89 U/l for the low dioxin category, 45.65 U/l for the medium dioxin category, and 50.85 U/l for the high dioxin category.

**Table 13-15. Analysis of GGT (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>43.62</i>	<i>1.01 --</i>	<i>0.340</i>
	<i>Comparison</i>	<i>1,231</i>	<i>42.61</i>		
Officer	Ranch Hand	340	42.32	1.57 --	0.332
	Comparison	490	40.74		
Enlisted Flyer	Ranch Hand	150	44.45	-0.84 --	0.758
	Comparison	185	45.29		
Enlisted Groundcrew	Ranch Hand	369	44.52	1.09 --	0.506
	Comparison	556	43.44		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>46.80</i>	<i>1.33 --</i>	<i>0.223</i>
	<i>Comparison</i>	<i>1,229</i>	<i>45.47</i>		
Officer	Ranch Hand	340	45.24	1.62 --	0.331
	Comparison	489	43.62		
Enlisted Flyer	Ranch Hand	148	48.28	0.62 --	0.826
	Comparison	184	47.66		
Enlisted Groundcrew	Ranch Hand	366	46.67	1.28 --	0.439
	Comparison	556	45.39		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-15. Analysis of GGT (U/I) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	43.87	44.19	0.013	0.004 (0.019)	0.823
Medium	159	48.89	48.92			
High	159	46.22	45.86			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of GGT versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	48.46	0.097	0.008 (0.022)	0.709
Medium	158	52.52			
High	157	50.18			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of GGT versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	42.26	42.21		
Background RH	376	39.99	40.81	-1.40 --	0.296
Low RH	236	44.27	43.99	1.78 --	0.283
High RH	240	48.36	47.38	5.17 --	0.003
Low plus High RH	476	46.29	45.67	3.46 --	0.007

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-15. Analysis of GGT (U/I) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
Comparison	1,193	45.40		
Background RH	374	44.67	-0.73 --	0.606
Low RH	235	47.84	2.43 --	0.159
High RH	238	50.40	5.00 --	0.006
Low plus High RH	473	49.11	3.71 --	0.006

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	40.35	0.012	0.040 (0.013)	0.002
Medium	285	42.53			
High	284	47.59			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of GGT versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	42.89	0.103	0.042 (0.014)	0.003
Medium	283	45.65			
High	281	50.85			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of GGT versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

13.2.2.3.6 GGT (Discrete)

The unadjusted and adjusted analysis results for Models 1 and 2 showed no significant results (Table 13-16(a-d):  $p \geq 0.31$  for each analysis).

A marginally significant difference between Ranch Hands in the low and high dioxin categories combined and Comparisons was revealed in both the unadjusted and adjusted Model 3 analyses (Table 13-16(e,f): Est. RR=1.33,  $p=0.094$ , for the unadjusted analysis; Adj. RR=1.38,  $p=0.065$ , for the adjusted analysis). The percentage of abnormal GGT values among Ranch Hands in the low and high dioxin categories combined was 13.0 versus 9.8 among the Comparisons.

**Table 13-16. Analysis of GGT (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	89 (10.4)	1.03 (0.77,1.38)	0.831
	<i>Comparison</i>	1,231	124 (10.1)		
Officer	Ranch Hand	340	31 (9.1)	1.23 (0.75,2.02)	0.419
	Comparison	490	37 (7.6)		
Enlisted Flyer	Ranch Hand	150	23 (15.3)	1.16 (0.63,2.14)	0.637
	Comparison	185	25 (13.5)		
Enlisted Groundcrew	Ranch Hand	369	35 (9.5)	0.83 (0.54,1.29)	0.419
	Comparison	556	62 (11.2)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	1.08 (0.80,1.45)	0.604
Officer	1.24 (0.75,2.06)	0.399
Enlisted Flyer	1.39 (0.73,2.65)	0.310
Enlisted Groundcrew	0.86 (0.55,1.35)	0.512

  

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	17 (10.8)	1.00 (0.81,1.22)	0.964
Medium	159	28 (17.6)		
High	159	17 (10.7)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-16. Analysis of GGT (Discrete) (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.06 (0.82,1.37)	0.669

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	117 (9.8)		
Background RH	376	25 (6.6)	0.70 (0.45,1.10)	0.122
Low RH	236	29 (12.3)	1.27 (0.82,1.96)	0.283
High RH	240	33 (13.8)	1.38 (0.91,2.10)	0.127
Low plus High RH	476	62 (13.0)	1.33 (0.95,1.84)	0.094

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	0.77 (0.48,1.23)	0.273
Low RH	235	1.42 (0.91,2.22)	0.127
High RH	238	1.35 (0.86,2.11)	0.186
Low plus High RH	473	1.38 (0.98,1.95)	0.065

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	21 (7.4)	1.17 (1.01,1.35)	0.034
Medium	285	27 (9.5)		
High	284	39 (13.7)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-16. Analysis of GGT (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
847	1.27 (1.05,1.53)	0.012

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

In Model 4, both unadjusted and adjusted analyses showed significant positive associations with 1987 dioxin (Table 13-16(g,h): Est. RR=1.17, p=0.034; Adj. RR=1.27, p=0.012, respectively). The percentages of high GGT levels in the low, medium, and high 1987 dioxin categories were 7.4, 9.5, and 13.7, respectively.

*13.2.2.3.7 Alkaline Phosphatase (Continuous)*

Both the unadjusted and adjusted Model 1 analyses of alkaline phosphatase revealed significant overall group differences (Table 13-17(a,b): difference of means=2.16 U/l, p=0.024; difference of adjusted means=2.32 U/l, p=0.016). The overall adjusted mean alkaline phosphatase values were 82.77 U/l and 80.46 U/l for Ranch Hands and Comparisons, respectively. After stratifying by occupation, unadjusted and adjusted analyses revealed group differences within the enlisted groundcrew stratum (unadjusted: difference of means=3.18 U/l, p=0.030; adjusted: difference of adjusted means=3.43 U/l, p=0.021). Within the enlisted groundcrew stratum, the Ranch Hands had an adjusted mean alkaline phosphatase of 85.11 U/l versus 81.68 U/l for the Comparisons.

**Table 13-17. Analysis of Alkaline Phosphatase (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>81.81</i>	<i>2.16 --</i>	<i>0.024</i>
	<i>Comparison</i>	<i>1,231</i>	<i>79.65</i>		
Officer	Ranch Hand	340	78.44	1.70 --	0.241
	Comparison	490	76.74		
Enlisted Flyer	Ranch Hand	150	83.79	0.34 --	0.889
	Comparison	185	83.45		
Enlisted Groundcrew	Ranch Hand	369	84.22	3.18 --	0.030
	Comparison	556	81.04		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-17. Analysis of Alkaline Phosphatase (U/l) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	856	82.77	2.32 --	0.016
	<i>Comparison</i>	1,229	80.46		
Officer	Ranch Hand	340	78.68	1.80 --	0.215
	Comparison	489	76.88		
Enlisted Flyer	Ranch Hand	149	84.06	0.58 --	0.811
	Comparison	184	83.47		
Enlisted Groundcrew	Ranch Hand	367	85.11	3.43 --	0.021
	Comparison	556	81.68		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	81.73	81.97	0.009	-0.004 (0.009)	0.646
Medium	159	83.60	83.63			
High	159	80.51	80.25			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of alkaline phosphatase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>				
Low	158	80.72	0.037	-0.021 (0.011)	0.053	
Medium	158	79.95				
High	158	75.04				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of alkaline phosphatase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-17. Analysis of Alkaline Phosphatase (U/I) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	79.58	79.57		
Background RH	376	81.35	81.50	1.93 --	0.130
Low RH	236	82.39	82.34	2.78 --	0.070
High RH	240	81.50	81.36	1.79 --	0.238
Low plus High RH	476	81.94	81.85	2.28 --	0.051

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	80.38		
Background RH	375	83.86	3.48 --	0.008
Low RH	235	83.18	2.79 --	0.071
High RH	239	80.32	-0.06 --	0.967
Low plus High RH	474	81.72	1.34 --	0.255

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	283	81.36	<0.001	-0.004 (0.006)	0.555
Medium	285	81.39			
High	284	82.29			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of alkaline phosphatase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-17. Analysis of Alkaline Phosphatase (U/l) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	80.95	0.042	-0.021 (0.007)	0.003
Medium	284	80.09			
High	282	77.40			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of alkaline phosphatase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The Model 2 unadjusted analysis of alkaline phosphatase was nonsignificant (Table 13-17(c):  $p=0.646$ ). The adjusted analysis revealed a marginally significant inverse association between alkaline phosphatase and initial dioxin (Table 13-17(d): adjusted slope= $-0.021$ ,  $p=0.053$ ). Mean alkaline phosphatase levels in the low, medium, and high initial dioxin categories were 80.72 U/l, 79.95 U/l, and 75.04 U/l, respectively.

The unadjusted Model 3 analysis of alkaline phosphatase revealed two marginally significant contrasts: Ranch Hands in the low dioxin category versus Comparisons (Table 13-17(e): difference of means= $2.78$  U/l,  $p=0.070$ ) and Ranch Hands in the low and high dioxin categories combined versus Comparisons (difference of means= $2.28$  U/l,  $p=0.051$ ). The adjusted analysis showed significant differences between Ranch Hands in the background dioxin category and Comparisons (Table 13-17(f): difference of adjusted means= $3.48$  U/l,  $p=0.008$ ), as well as a marginally significant difference between Ranch Hands in the low dioxin category and Comparisons (difference of adjusted means= $2.79$  U/l,  $p=0.071$ ). Ranch Hands in the background and low dioxin categories had higher mean alkaline phosphatase levels than the Comparisons ( $83.86$  U/l for the Ranch Hands in the background dioxin category and  $83.18$  U/l for the Ranch Hands in the low dioxin category versus  $80.38$  U/l for Comparisons).

The unadjusted analysis of Model 4 showed no significant association between alkaline phosphatase and 1987 dioxin levels (Table 13-17(g):  $p=0.555$ ). After covariate adjustment, a significant inverse relation was revealed (Table 13-17(h): adjusted slope= $-0.021$ ,  $p=0.003$ ). The adjusted mean alkaline phosphatase values in the low, medium, and high 1987 dioxin categories were 80.95 U/l, 80.09 U/l, and 77.40 U/l, respectively.

### 13.2.2.3.8 Alkaline Phosphatase (Discrete)

The unadjusted and adjusted Model 1 analyses of alkaline phosphatase in its discrete form showed no overall group difference between Ranch Hands and Comparisons (Table 13-18(a,b):  $p>0.33$  for each analysis). Stratifying by occupation revealed a marginally significant group difference within the enlisted groundcrew stratum for both the unadjusted and adjusted analyses (Table 13-18(a,b): Est. RR= $2.30$ ,  $p=0.071$ ; Adj. RR= $2.46$ ,  $p=0.053$ ). The percentage of enlisted groundcrew with high alkaline phosphatase levels among the Ranch Hands was 3.3 percent versus 1.4 percent among the Comparisons. All analyses for Models 2 and 3 were nonsignificant (Table 13-18(c–f):  $p>0.10$  for each analysis).

**Table 13-18. Analysis of Alkaline Phosphatase (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	22 (2.6)	1.32 (0.74,2.37)	0.352
	<i>Comparison</i>	1,231	24 (1.9)		
Officer	Ranch Hand	340	4 (1.2)	0.47 (0.15,1.48)	0.200
	Comparison	490	12 (2.4)		
Enlisted Flyer	Ranch Hand	150	6 (4.0)	1.89 (0.52,6.81)	0.333
	Comparison	185	4 (2.2)		
Enlisted Groundcrew	Ranch Hand	369	12 (3.3)	2.30 (0.93,5.69)	0.071
	Comparison	556	8 (1.4)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	1.34 (0.74,2.42)	0.332
Officer	0.45 (0.14,1.41)	0.172
Enlisted Flyer	2.03 (0.56,7.40)	0.284
Enlisted Groundcrew	2.46 (0.99,6.13)	0.053

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	3 (1.9)	0.99 (0.60,1.65)	0.971
Medium	159	4 (2.5)		
High	159	2 (1.3)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
474	1.04 (0.61,1.76)	0.897

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results not adjusted for occupation because of the sparse number of participants with a high alkaline phosphatase level.

**Table 13-18. Analysis of Alkaline Phosphatase (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	21 (1.8)		
Background RH	376	12 (3.2)	1.76 (0.85,3.63)	0.127
Low RH	236	4 (1.7)	0.97 (0.33,2.86)	0.960
High RH	240	5 (2.1)	1.24 (0.46,3.33)	0.670
Low plus High RH	476	9 (1.9)	1.10 (0.50,2.43)	0.815

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
Comparison	1,193			
Background RH	375	1.85 (0.88,3.90)		0.104
Low RH	235	0.91 (0.31,2.71)		0.871
High RH	239	1.23 (0.44,3.41)		0.688
Low plus High RH	474	1.06 (0.48,2.37)		0.883

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	9 (3.2)	0.79 (0.58,1.09)	0.144
Medium	285	6 (2.1)		
High	284	6 (2.1)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>				
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)				
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value	
849	0.69 (0.50,0.94)		0.020	

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The Model 4 unadjusted analysis did not show significant results (Table 13-18(g):  $p=0.144$ ). The adjusted analysis revealed a significant inverse relation between alkaline phosphatase and 1987 dioxin levels (Table 13-18(h): Adj. RR=0.69,  $p=0.020$ ). The percentages of abnormal alkaline phosphatase values in the low, medium, and high 1987 dioxin categories were 3.2, 2.1, and 2.1, respectively.

### 13.2.2.3.9 Total Bilirubin (Continuous)

All unadjusted and adjusted Model 1 through Model 4 analyses of total bilirubin in its continuous form were nonsignificant (Table 13-19(a–h):  $p>0.36$  for each analysis).

**Table 13-19. Analysis of Total Bilirubin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>0.518</i>	<i>-0.002 --</i>	<i>0.857</i>
	<i>Comparison</i>	<i>1,231</i>	<i>0.520</i>		
Officer	Ranch Hand	340	0.546	0.003 --	0.887
	Comparison	490	0.543		
Enlisted Flyer	Ranch Hand	150	0.489	-0.023 --	0.365
	Comparison	185	0.513		
Enlisted Groundcrew	Ranch Hand	369	0.506	0.003 --	0.869
	Comparison	556	0.503		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>0.511</i>	<i>-0.000 --</i>	<i>0.963</i>
	<i>Comparison</i>	<i>1,229</i>	<i>0.511</i>		
Officer	Ranch Hand	340	0.528	0.000 --	0.993
	Comparison	489	0.528		
Enlisted Flyer	Ranch Hand	148	0.487	-0.018 --	0.482
	Comparison	184	0.505		
Enlisted Groundcrew	Ranch Hand	366	0.512	0.006 --	0.727
	Comparison	556	0.507		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-19. Analysis of Total Bilirubin (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
Low	158	0.524	0.527	0.013	-0.014 (0.016)	0.368
Medium	159	0.503	0.503			
High	159	0.514	0.510			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of total bilirubin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	158	0.522	0.038	0.004 (0.019)	0.822
Medium	158	0.511			
High	157	0.532			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of total bilirubin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>d</sup></b>
Comparison	1,194	0.520	0.520		
Background RH	376	0.523	0.526	0.006 --	0.673
Low RH	236	0.517	0.516	-0.004 --	0.828
High RH	240	0.510	0.506	-0.014 --	0.418
Low plus High RH	476	0.513	0.511	-0.009 --	0.500

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-19. Analysis of Total Bilirubin (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	0.517		
Background RH	374	0.515	-0.002 --	0.901
Low RH	235	0.514	-0.003 --	0.884
High RH	238	0.520	0.003 --	0.861
Low plus High RH	473	0.517	0.000 --	0.981

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	0.526	0.001	-0.007 (0.011)	0.499
Medium	285	0.518			
High	284	0.509			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of total bilirubin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	0.521	0.023	0.008 (0.012)	0.519
Medium	283	0.516			
High	281	0.532			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of total bilirubin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

### 13.2.2.3.10 Total Bilirubin (Discrete)

All analysis results of total bilirubin in its dichotomous form were nonsignificant (Table 13-20(a–h): p>0.11 for each analysis).

**Table 13-20. Analysis of Total Bilirubin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	46 (5.4)	<i>0.86 (0.59,1.25)</i>	<i>0.430</i>
	<i>Comparison</i>	1,231	76 (6.2)		
Officer	Ranch Hand	340	22 (6.5)	0.90 (0.52,1.56)	0.707
	Comparison	490	35 (7.1)		
Enlisted Flyer	Ranch Hand	150	8 (5.3)	1.10 (0.41,2.93)	0.846
	Comparison	185	9 (4.9)		
Enlisted Groundcrew	Ranch Hand	369	16 (4.3)	0.74 (0.40,1.37)	0.342
	Comparison	556	32 (5.8)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.86 (0.58,1.25)</i>	<i>0.420</i>
Officer	0.90 (0.52,1.57)	0.723
Enlisted Flyer	1.15 (0.43,3.08)	0.779
Enlisted Groundcrew	0.71 (0.38,1.33)	0.286

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	12 (7.6)	0.77 (0.54,1.09)	0.118
Medium	159	5 (3.1)		
High	159	7 (4.4)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	0.75 (0.49,1.13)	0.154

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-20. Analysis of Total Bilirubin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	74 (6.2)		
Background RH	376	21 (5.6)	0.91 (0.55,1.51)	0.724
Low RH	236	15 (6.4)	1.02 (0.58,1.81)	0.940
High RH	240	9 (3.8)	0.58 (0.29,1.18)	0.131
Low plus High RH	476	24 (5.0)	0.77 (0.47,1.25)	0.286

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
Comparison	1,193			
Background RH	374	0.88 (0.53,1.47)		0.619
Low RH	235	1.03 (0.58,1.84)		0.919
High RH	238	0.59 (0.27,1.27)		0.175
Low plus High RH	473	0.78 (0.47,1.29)		0.331

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	18 (6.4)	0.89 (0.72,1.10)	0.275
Medium	285	15 (5.3)		
High	284	12 (4.2)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
847	0.94 (0.73,1.21)		0.646

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

13.2.2.3.11 Direct Bilirubin

In each of the unadjusted and adjusted analyses of Models 1 through 4, no significant associations were seen between dioxin and direct bilirubin (Table 13-21(a-h):  $p > 0.19$  for each contrast). Because of a sparse number of participants with a high direct bilirubin level, the analysis was limited in some of the models.

**Table 13-21. Analysis of Direct Bilirubin**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	1 (0.1)	0.29 (0.03,2.45)	0.196
	<i>Comparison</i>	1,231	5 (0.4)		
Officer	Ranch Hand	340	1 (0.3)	0.48 (0.05,4.62)	0.524
	Comparison	490	3 (0.6)		
Enlisted Flyer	Ranch Hand	150	0 (0.0)	--	--
	Comparison	185	0 (0.0)		
Enlisted Groundcrew	Ranch Hand	369	0 (0.0)	--	0.667 <sup>a</sup>
	Comparison	556	2 (0.4)		

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a high direct bilirubin level.

--: Results not presented because of the sparse number of participants with a high direct bilirubin level.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	0.32 (0.04,2.82)	0.254
Officer	0.50 (0.05,4.90)	0.551
Enlisted Flyer	--	--
Enlisted Groundcrew	--	--

--: Results not presented because of the sparse number of participants with a high direct bilirubin level.

Note: Results for analysis across all occupational categories are not adjusted for occupation because of the sparse number of participants with a high direct bilirubin level.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	0 (0.0)	--	--
Medium	159	0 (0.0)		
High	159	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

--: Results not presented because of the sparse number of Ranch Hands with a high direct bilirubin level.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-21. Analysis of Direct Bilirubin (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.)	p-Value
--	--	--

--: Results not presented because of the sparse number of Ranch Hands with a high direct bilirubin level.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	5 (0.4)		
Background RH	376	1 (0.3)	0.88 (0.10,7.75)	0.906
Low RH	236	0 (0.0)	--	0.695 <sup>c</sup>
High RH	240	0 (0.0)	--	0.686 <sup>c</sup>
Low plus High RH	476	0 (0.0)	--	0.359 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of Ranch Hands with a high direct bilirubin level.

--: Results not presented because of the sparse number of Ranch Hands with a high direct bilirubin level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	1.09 (0.12,10.31)	0.937
Low RH	235	--	--
High RH	238	--	--
Low plus High RH	473	--	--

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

--: Results not presented because of the sparse number of Ranch Hands with a high direct bilirubin level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for occupation because of the sparse number of Ranch Hands with a high direct bilirubin level.

**Table 13-21. Analysis of Direct Bilirubin (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	0 (0.0)	0.78 (0.18,3.33)	0.735
Medium	285	1 (0.4)		
High	284	0 (0.0)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
847	0.79 (0.17,3.72)		0.764

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are adjusted only for age and lifetime alcohol history because of the sparse number of Ranch Hands with a high direct bilirubin level.

**13.2.2.3.12 Lactic Dehydrogenase (Continuous)**

The unadjusted and adjusted analyses of Models 1 through 4 showed no significant associations between dioxin and lactic dehydrogenase in its continuous form (Table 13-22(a–h): p>0.18 for each analysis).

**Table 13-22. Analysis of Lactic Dehydrogenase (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>154.0</i>	<i>0.3 --</i>	<i>0.822</i>
	<i>Comparison</i>	<i>1,229</i>	<i>153.8</i>		
Officer	Ranch Hand	340	153.9	–0.5 --	0.799
	Comparison	489	154.4		
Enlisted Flyer	Ranch Hand	150	152.3	–0.3 --	0.927
	Comparison	184	152.5		
Enlisted Groundcrew	Ranch Hand	369	154.9	1.2 --	0.488
	Comparison	556	153.7		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-22. Analysis of Lactic Dehydrogenase (U/l) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	155.3	0.3 --	0.790
	<i>Comparison</i>	1,227	155.0		
Officer	Ranch Hand	340	154.8	-0.6 --	0.768
	Comparison	488	155.3		
Enlisted Flyer	Ranch Hand	148	153.1	-0.8 --	0.787
	Comparison	183	153.9		
Enlisted Groundcrew	Ranch Hand	366	157.8	1.5 --	0.397
	Comparison	556	156.3		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	155.7	156.0	0.009	-0.001 (0.006)	0.908
Medium	159	152.4	152.4			
High	159	156.0	155.6			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of lactic dehydrogenase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin Category Summary Statistics</b>			<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean</b>				
Low	158	159.1	159.1	0.036	0.000 (0.007)	0.979
Medium	158	156.8				
High	157	160.1				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of lactic dehydrogenase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-22. Analysis of Lactic Dehydrogenase (U/l) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,192	153.8	153.7		
Background RH	376	153.1	154.3	0.6 --	0.693
Low RH	236	153.9	153.6	-0.1 --	0.941
High RH	240	155.4	154.1	0.4 --	0.816
Low plus High RH	476	154.7	153.8	0.1 --	0.916

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,192	155.5		
Background RH	374	156.1	0.6 --	0.737
Low RH	235	155.0	-0.5 --	0.774
High RH	238	156.8	1.3 --	0.528
Low plus High RH	473	155.9	0.4 --	0.812

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	283	152.7	0.002	0.005 (0.004)	0.211
Medium	285	155.3			
High	284	153.9			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of lactic dehydrogenase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-22. Analysis of Lactic Dehydrogenase (U/l) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	154.3	0.015	0.006 (0.005)	0.187
Medium	283	156.4			
High	281	155.4			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of lactic dehydrogenase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

### 13.2.2.3.13 Lactic Dehydrogenase (Discrete)

Lactic dehydrogenase in its dichotomized form showed nonsignificant results in all of the Models 1 through 4 unadjusted and adjusted analyses (Table 13-23(a–h): p>0.21 for each analysis).

**Table 13-23. Analysis of Lactic Dehydrogenase (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>81 (9.4)</i>	<i>0.89 (0.66,1.19)</i>	<i>0.424</i>
	<i>Comparison</i>	<i>1,229</i>	<i>129 (10.5)</i>		
Officer	Ranch Hand	340	32 (9.4)	0.85 (0.54,1.36)	0.506
	Comparison	489	53 (10.8)		
Enlisted Flyer	Ranch Hand	150	13 (8.7)	1.07 (0.49,2.32)	0.866
	Comparison	184	15 (8.2)		
Enlisted Groundcrew	Ranch Hand	369	36 (9.8)	0.88 (0.57,1.35)	0.555
	Comparison	556	61 (11.0)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>0.90 (0.67,1.21)</i>	<i>0.479</i>
Officer	0.86 (0.54,1.37)	0.530
Enlisted Flyer	1.03 (0.47,2.24)	0.945
Enlisted Groundcrew	0.90 (0.58,1.39)	0.625

**Table 13-23. Analysis of Lactic Dehydrogenase (Discrete) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	17 (10.8)	0.96 (0.75,1.21)	0.709
Medium	159	10 (6.3)		
High	159	16 (10.1)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	0.98 (0.74,1.30)	0.889

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,192	123 (10.3)		
Background RH	376	36 (9.6)	1.05 (0.71,1.57)	0.794
Low RH	236	21 (8.9)	0.81 (0.50,1.33)	0.406
High RH	240	22 (9.2)	0.77 (0.47,1.25)	0.291
Low plus High RH	476	43 (9.0)	0.79 (0.55,1.15)	0.214

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,191		
Background RH	374	1.07 (0.72,1.61)	0.729
Low RH	235	0.80 (0.48,1.31)	0.366
High RH	238	0.81 (0.49,1.34)	0.416
Low plus High RH	473	0.80 (0.55,1.17)	0.255

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-23. Analysis of Lactic Dehydrogenase (Discrete) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	27 (9.5)	1.00 (0.85,1.17)	0.989
Medium	285	30 (10.5)		
High	284	22 (7.7)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
847	1.01 (0.84,1.21)	0.892

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

**13.2.2.3.14 Cholesterol (Continuous)**

The Model 1 unadjusted and adjusted analyses showed no significant association between group and cholesterol (Table 13-24(a,b): p>0.14 for each analysis).

**Table 13-24. Analysis of Cholesterol (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>211.4</i>	<i>-0.3 --</i>	<i>0.838</i>
	<i>Comparison</i>	<i>1,231</i>	<i>211.7</i>		
Officer	Ranch Hand	340	206.2	-3.8 --	0.149
	Comparison	490	210.0		
Enlisted Flyer	Ranch Hand	150	215.0	-1.3 --	0.760
	Comparison	185	216.3		
Enlisted Groundcrew	Ranch Hand	369	214.7	3.0 --	0.239
	Comparison	556	211.8		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

**Table 13-24. Analysis of Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	212.3	-0.3 --	0.850
	<i>Comparison</i>	1,229	212.6		
Officer	Ranch Hand	340	206.6	-3.8 --	0.141
	Comparison	489	210.4		
Enlisted Flyer	Ranch Hand	148	215.3	-1.2 --	0.781
	Comparison	184	216.4		
Enlisted Groundcrew	Ranch Hand	366	214.6	3.2 --	0.197
	Comparison	556	211.4		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	205.9	205.7	0.017	0.129 (0.046)	0.005
Medium	159	215.1	215.1			
High	159	217.9	218.2			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on square root of cholesterol versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>		R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	209.0		0.044	0.083 (0.054)	0.122
Medium	158	215.9				
High	157	217.4				

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of cholesterol versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-24. Analysis of Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	211.7	211.7		
Background RH	376	209.4	208.8	-2.9 --	0.183
Low RH	236	209.1	209.3	-2.4 --	0.351
High RH	240	216.8	217.4	5.7 --	0.032
Low plus High RH	476	213.0	213.4	1.7 --	0.422

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>d</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	212.9		
Background RH	374	211.0	-1.9 --	0.392
Low RH	235	210.6	-2.3 --	0.389
High RH	238	217.3	4.4 --	0.115
Low plus High RH	473	214.0	1.1 --	0.616

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	283	210.9	0.008	0.077 (0.030)	0.009
Medium	285	206.6			
High	284	216.6			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of cholesterol versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-24. Analysis of Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	214.9	0.023	0.046 (0.034)	0.178
Medium	283	209.6			
High	281	216.8			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of cholesterol versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted Model 2 analysis revealed a significant positive association between initial dioxin and cholesterol (Table 13-24(c): slope=0.129, p=0.005). After covariate adjustment, the relation became nonsignificant (Table 13-24(d): p=0.122).

A significant difference between Ranch Hands in the high dioxin category and Comparisons was found in the unadjusted Model 3 analysis of cholesterol (Table 13-24(e): difference of means=5.7 mg/dl, p=0.032). The adjusted analysis revealed no significant contrasts (Table 13-24(f): p>0.11 for each contrast).

Model 4 unadjusted analysis results showed a significant association between 1987 dioxin and cholesterol in its continuous form (Table 13-24(g): slope=0.077, p=0.009). The adjusted analysis results were nonsignificant (Table 13-24(h): p=0.178).

#### 13.2.2.3.15 Cholesterol (Discrete)

No significant difference between Ranch Hands and Comparisons was revealed in either the unadjusted or adjusted Model 1 analysis of cholesterol (Table 13-25(a,b): p>0.16 for each contrast).

**Table 13-25. Analysis of Cholesterol (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>130 (15.1)</i>	<i>1.03 (0.81,1.31)</i>	<i>0.826</i>
	<i>Comparison</i>	<i>1,231</i>	<i>182 (14.8)</i>		
Officer	Ranch Hand	340	39 (11.5)	0.80 (0.53,1.22)	0.310
	Comparison	490	68 (13.9)		
Enlisted Flyer	Ranch Hand	150	22 (14.7)	0.96 (0.53,1.77)	0.905
	Comparison	185	28 (15.1)		
Enlisted Groundcrew	Ranch Hand	369	69 (18.7)	1.26 (0.89,1.78)	0.198
	Comparison	556	86 (15.5)		

**Table 13-25. Analysis of Cholesterol (Discrete) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.04 (0.82,1.34)</i>	<i>0.726</i>
Officer	0.80 (0.53,1.23)	0.312
Enlisted Flyer	1.00 (0.54,1.83)	0.993
Enlisted Groundcrew	1.28 (0.90,1.82)	0.167

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	158	19 (12.0)	1.21 (1.01,1.45)	0.036
Medium	159	31 (19.5)		
High	159	32 (20.1)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
473	1.23 (0.99,1.52)		0.062

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	177 (14.8)		
Background RH	376	48 (12.8)	0.80 (0.56,1.12)	0.195
Low RH	236	34 (14.4)	0.98 (0.66,1.46)	0.915
High RH	240	48 (20.0)	1.51 (1.06,2.16)	0.023
Low plus High RH	476	82 (17.2)	1.22 (0.91,1.63)	0.183

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-25. Analysis of Cholesterol (Discrete) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	0.85 (0.60,1.21)	0.379
Low RH	235	1.01 (0.68,1.51)	0.964
High RH	238	1.41 (0.97,2.04)	0.071
Low plus High RH	473	1.19 (0.89,1.60)	0.240

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	40 (14.1)	1.15 (1.02,1.30)	0.025
Medium	285	32 (11.2)		
High	284	58 (20.4)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
847	1.08 (0.93,1.24)		0.312

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The unadjusted Model 2 analysis found a significant association between cholesterol and initial dioxin (Table 13-25(c): Est. RR=1.21, p=0.036). Similarly, the adjusted Model 2 analysis was marginally significant (Table 13-25(d): Adj. RR=1.23, p=0.062). The percentages of participants with high cholesterol levels in the low, medium, and high initial dioxin categories were 12.0, 19.5, and 20.1, respectively.

The Model 3 unadjusted analysis of cholesterol revealed a significant difference between Ranch Hands in the high dioxin category and Comparisons (Table 13-25(e): Est. RR=1.51, p=0.023) and a marginally significant difference in the adjusted analysis (Table 13-25(f): Adj. RR=1.41, p=0.071). The percentage of Ranch Hands in the high dioxin category was 20.0 versus 14.8 in the Comparison category.

The Model 4 unadjusted analysis showed a significant relation between 1987 dioxin and cholesterol level (Table 13-25(g): Est. RR=1.15, p=0.025). After adjusting for covariates, the results became nonsignificant (Table 13-25(h): p=0.312).

13.2.2.3.16 HDL Cholesterol (Continuous)

The unadjusted Model 1 analysis of HDL cholesterol showed no group difference between Ranch Hands and Comparisons (Table 13-26(a):  $p \geq 0.24$  for each analysis). Although the adjusted analysis showed no overall group difference, stratifying by occupation revealed a marginally significant difference between Ranch Hands and Comparisons among the enlisted flyer stratum (Table 13-26(b): difference of means=2.29 mg/dl,  $p=0.078$ ). The adjusted mean HDL cholesterol level for enlisted flyers in the Ranch Hand group was 47.56 mg/dl versus 45.28 mg/dl for the enlisted flyers in the Comparison group. Models 2 and 3 unadjusted and adjusted analyses showed no significant relations between dioxin and HDL cholesterol (Table 13-26(c-f):  $p \geq 0.13$  for each analysis).

The unadjusted Model 4 analysis revealed a significant association between 1987 dioxin and HDL cholesterol (Table 13-26(g): slope=-0.023,  $p < 0.001$ ). Similarly, the adjusted Model 4 analysis results were significant (Table 13-26(h): adjusted slope=-0.014,  $p=0.037$ ). Both analyses showed a decrease in HDL cholesterol levels as 1987 dioxin increased. The adjusted mean HDL cholesterol levels were 49.22 mg/dl, 46.80 mg/dl, and 46.31 mg/dl in the low, medium, and high 1987 dioxin categories, respectively.

**Table 13-26. Analysis of HDL Cholesterol (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	858	44.97	0.13 --	0.805
	<i>Comparison</i>	1,230	44.84		
Officer	Ranch Hand	340	46.64	-0.04 --	0.965
	Comparison	489	46.68		
Enlisted Flyer	Ranch Hand	149	45.07	1.49 --	0.240
	Comparison	185	43.58		
Enlisted Groundcrew	Ranch Hand	369	43.44	-0.25 --	0.739
	Comparison	556	43.69		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	853	47.08	0.28 --	0.600
	<i>Comparison</i>	1,228	46.81		
Officer	Ranch Hand	340	48.76	-0.10 --	0.907
	Comparison	488	48.86		
Enlisted Flyer	Ranch Hand	147	47.56	2.29 --	0.078
	Comparison	184	45.28		
Enlisted Groundcrew	Ranch Hand	366	45.68	-0.13 --	0.866
	Comparison	556	45.81		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-26. Analysis of HDL Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	157	45.03	44.73	0.053	-0.009 (0.009)	0.312
Medium	159	43.33	43.30			
High	159	43.32	43.64			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of HDL cholesterol versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	157	46.09	0.132	0.005 (0.010)	0.625
Medium	158	44.96			
High	157	46.38			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of HDL cholesterol versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,193	44.75	44.79		
Background RH	376	46.34	45.54	0.75 --	0.269
Low RH	235	44.98	45.23	0.44 --	0.585
High RH	240	42.83	43.58	-1.21 --	0.130
Low plus High RH	475	43.88	44.39	-0.40 --	0.519

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-26. Analysis of HDL Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
Comparison	1,192	46.77		
Background RH	374	47.11	0.34 --	0.628
Low RH	234	47.10	0.33 --	0.687
High RH	238	46.77	0.00 --	0.999
Low plus High RH	472	46.93	0.16 --	0.795

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	47.12	0.016	-0.023 (0.006)	<0.001
Medium	284	44.60			
High	284	43.23			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of HDL cholesterol versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	49.22	0.081	-0.014 (0.007)	0.037
Medium	282	46.80			
High	281	46.31			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of HDL cholesterol versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

### 13.2.2.3.17 HDL Cholesterol (Discrete)

All Model 1 analyses of HDL cholesterol in its discrete form were nonsignificant (Table 13-27(a,b): p>0.42 for each analysis).

The association between initial dioxin and HDL cholesterol examined in the unadjusted Model 2 analysis revealed nonsignificant results (Table 13-27(c):  $p=0.249$ ). After adjusting for covariates, a significant association was shown (Table 13-27(d): Adj. RR=0.72,  $p=0.029$ ). The percentages of low HDL cholesterol levels in the low, medium, and high initial dioxin categories were 8.3, 10.1, and 5.7, respectively.

**Table 13-27. Analysis of HDL Cholesterol (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Low	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	858	71 (8.3)	<i>1.14 (0.83,1.58)</i>	<i>0.421</i>
	<i>Comparison</i>	1,230	90 (7.3)		
Officer	Ranch Hand	340	19 (5.6)	1.15 (0.62,2.13)	0.664
	Comparison	489	24 (4.9)		
Enlisted Flyer	Ranch Hand	149	16 (10.7)	1.12 (0.55,2.27)	0.762
	Comparison	185	18 (9.7)		
Enlisted Groundcrew	Ranch Hand	369	36 (9.8)	1.14 (0.73,1.80)	0.561
	Comparison	556	48 (8.7)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.13 (0.81,1.57)</i>	<i>0.473</i>
Officer	1.15 (0.62,2.15)	0.650
Enlisted Flyer	0.98 (0.47,2.04)	0.957
Enlisted Groundcrew	1.18 (0.74,1.87)	0.483

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	157	13 (8.3)	0.86 (0.66,1.12)	0.249
Medium	159	16 (10.1)		
High	159	9 (5.7)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
472	0.72 (0.53,0.98)	0.029

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-27. Analysis of HDL Cholesterol (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,193	88 (7.4)		
Background RH	376	33 (8.8)	1.35 (0.88,2.05)	0.170
Low RH	235	19 (8.1)	1.07 (0.64,1.80)	0.798
High RH	240	19 (7.9)	0.98 (0.58,1.65)	0.937
Low plus High RH	475	38 (8.0)	1.02 (0.69,1.53)	0.910

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
Comparison	1,192			
Background RH	374	1.57 (1.00,2.45)		0.049
Low RH	234	1.09 (0.64,1.84)		0.761
High RH	238	0.80 (0.47,1.37)		0.416
Low plus High RH	472	0.93 (0.62,1.40)		0.731

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	23 (8.1)	0.92 (0.78,1.09)	0.349
Medium	284	27 (9.5)		
High	284	21 (7.4)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>				
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>				
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>	
846	0.82 (0.68,0.98)		0.029	

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The unadjusted Model 3 analysis of HDL cholesterol did not show any of the Ranch Hand categories to be significantly different from the Comparison group (Table 13-27(e):  $p \geq 0.17$  for all contrasts). In the adjusted analysis, a significant difference between Comparisons and Ranch Hands in the background dioxin category was revealed (Table 13-27(f): Adj. RR=1.57,  $p=0.049$ ). The percentage of low HDL cholesterol values among Ranch Hands in the background dioxin category was 8.8 percent versus 7.4 percent for Comparisons.

The unadjusted Model 4 analysis showed nonsignificant results (Table 13-27(g):  $p=0.349$ ). After covariate adjustment, a significant inverse relation between HDL cholesterol and 1987 dioxin level was shown (Table 13-27(h): Adj. RR=0.82,  $p=0.029$ ). The percentages of low HDL cholesterol values in the low, medium, and high 1987 dioxin categories were 8.1, 9.5, and 7.4, respectively.

#### 13.2.2.3.18 Cholesterol-HDL Ratio (Continuous)

The unadjusted Model 1 analysis of the cholesterol-HDL ratio did not disclose a significant difference between Ranch Hands and Comparisons (Table 13-28(a):  $p > 0.15$  for all contrasts). The adjusted analysis showed no significant difference between Ranch Hands and Comparisons combined across all occupations. Stratifying the analysis by occupation revealed a marginally significant group difference for the enlisted flyers (Table 13-28(b): difference of adjusted means =  $-0.27$ ,  $p=0.051$ ). Within the enlisted flyer stratum, the mean cholesterol-HDL ratio was lower for the Ranch Hands than for the Comparisons (4.49 versus 4.76).

**Table 13-28. Analysis of Cholesterol-HDL Ratio (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	858	4.66	-0.02 --	0.723
	<i>Comparison</i>	1,230	4.68		
Officer	Ranch Hand	340	4.39	-0.07 --	0.425
	Comparison	489	4.46		
Enlisted Flyer	Ranch Hand	149	4.72	-0.21 --	0.155
	Comparison	185	4.93		
Enlisted Groundcrew	Ranch Hand	369	4.90	0.10 --	0.282
	Comparison	556	4.81		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-28. Analysis of Cholesterol-HDL Ratio (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	853	4.48	-0.03 --	0.546
	<i>Comparison</i>	1,228	4.51		
Officer	Ranch Hand	340	4.21	-0.06 --	0.446
	Comparison	488	4.27		
Enlisted Flyer	Ranch Hand	147	4.49	-0.27 --	0.051
	Comparison	184	4.76		
Enlisted Groundcrew	Ranch Hand	366	4.67	0.08 --	0.316
	Comparison	556	4.58		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>			
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	157	4.52	4.55	0.055	0.028 (0.009)	0.003
Medium	159	4.92	4.93			
High	159	4.99	4.96			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of cholesterol-HDL ratio versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	157	4.49	0.118	0.007 (0.011)	0.499
Medium	158	4.77			
High	157	4.66			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of cholesterol-HDL ratio versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-28. Analysis of Cholesterol-HDL Ratio (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,193	4.69	4.69		
Background RH	376	4.49	4.55	-0.14 --	0.068
Low RH	235	4.60	4.58	-0.11 --	0.220
High RH	240	5.02	4.95	0.26 --	0.005
Low plus High RH	475	4.81	4.76	0.07 --	0.282

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,192	4.52		
Background RH	374	4.45	-0.07 --	0.352
Low RH	234	4.43	-0.09 --	0.289
High RH	238	4.61	0.09 --	0.290
Low plus High RH	472	4.52	0.00 --	0.978

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	4.44	0.030	0.033 (0.007)	<0.001
Medium	284	4.59			
High	284	4.97			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of cholesterol-HDL ratio versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-28. Analysis of Cholesterol-HDL Ratio (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	4.34	0.074	0.021 (0.007)	0.006
Medium	282	4.44			
High	281	4.65			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of cholesterol-HDL ratio versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

A significant association between initial dioxin and the cholesterol-HDL ratio was seen in the Model 2 unadjusted analysis (Table 13-28(c): slope=0.028, p=0.003). The adjusted analysis results were nonsignificant (Table 13-28(d): p=0.499).

The unadjusted Model 3 analysis revealed significant differences between Ranch Hands in the background category and Comparisons, as well as between Ranch Hands in the high dioxin category and Comparisons (Table 13-28(e): difference of means=-0.14, p=0.068; difference of means=0.26, p=0.005, respectively). The adjusted Model 3 analysis did not show any of the Ranch Hand categories to be significantly different from the Comparison group (Table 13-28(f): p>0.28 for each analysis).

Both the unadjusted and adjusted Model 4 analyses revealed significant positive associations between 1987 dioxin and the cholesterol-HDL ratio (Table 13-28(g,h): slope=0.033, p<0.001, for unadjusted analysis; adjusted slope=0.021, p=0.006, for adjusted analysis). The mean cholesterol-HDL ratio values after covariate adjustment in the low, medium, and high 1987 dioxin categories were 4.34, 4.44, and 4.65, respectively.

#### 13.2.2.3.19 Cholesterol-HDL Ratio (Discrete)

The unadjusted Model 1 analysis of the cholesterol-HDL ratio in its dichotomized form did not reveal a significant difference between Ranch Hands and Comparisons overall or stratified by occupation (Table 13-29(a): p>0.13 for all unadjusted contrasts). No significant overall group difference was found between all Ranch Hands and Comparisons in the adjusted analysis. After stratifying the adjusted analysis by occupation, a marginally significant group difference among the enlisted flyers was revealed (Table 13-29(b): Adj. RR=0.67, p=0.075). The percentage of Ranch Hand enlisted flyers with high cholesterol-HDL ratios was 38.9 percent versus 47.0 percent for Comparison enlisted flyers.

**Table 13-29. Analysis of Cholesterol-HDL Ratio (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	858	356 (41.5)	<i>1.02 (0.85,1.22)</i>	<i>0.843</i>
	<i>Comparison</i>	1,230	505 (41.1)		
Officer	Ranch Hand	340	114 (33.5)	1.08 (0.80,1.45)	0.623
	Comparison	489	156 (31.9)		
Enlisted Flyer	Ranch Hand	149	58 (38.9)	0.72 (0.46,1.11)	0.138
	Comparison	185	87 (47.0)		
Enlisted Groundcrew	Ranch Hand	369	184 (49.9)	1.12 (0.86,1.45)	0.414
	Comparison	556	262 (47.1)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.01 (0.85,1.22)</i>	<i>0.878</i>
Officer	1.09 (0.81,1.47)	0.563
Enlisted Flyer	0.67 (0.43,1.04)	0.075
Enlisted Groundcrew	1.11 (0.85,1.45)	0.436

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	157	54 (34.4)	1.25 (1.09,1.45)	0.002
Medium	159	77 (48.4)		
High	159	85 (53.5)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
472	1.08 (0.91,1.28)	0.378

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-29. Analysis of Cholesterol-HDL Ratio (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,193	492 (41.2)		
Background RH	376	136 (36.2)	0.88 (0.69,1.13)	0.321
Low RH	235	86 (36.6)	0.80 (0.60,1.07)	0.135
High RH	240	130 (54.2)	1.57 (1.18,2.08)	0.002
Low plus High RH	475	216 (45.5)	1.12 (0.90,1.40)	0.295

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,192		
Background RH	374	1.00 (0.77,1.28)	0.982
Low RH	234	0.83 (0.61,1.12)	0.221
High RH	238	1.26 (0.93,1.69)	0.133
Low plus High RH	472	1.02 (0.82,1.28)	0.849

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	104 (36.7)	1.22 (1.11,1.34)	<0.001
Medium	284	98 (34.5)		
High	284	150 (52.8)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-29. Analysis of Cholesterol-HDL Ratio (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
846	1.13 (1.01,1.26)	0.025

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

A significant positive association between the cholesterol-HDL ratio and initial dioxin was shown in the unadjusted Model 2 analysis (Table 13-29(c): Est. RR=1.25, p=0.002). After adjustment for covariates, the analysis results were nonsignificant (Table 13-29(d): p=0.378).

The Model 3 unadjusted analysis of the cholesterol-HDL ratio revealed a significant difference between Ranch Hands in the high dioxin category and Comparisons (Table 13-29(e): Est. RR=1.57, p=0.002). All contrasts between the Ranch Hand categories and Comparisons were nonsignificant in the adjusted analysis (Table 13-29(f): p>0.13 for each contrast).

The unadjusted and adjusted Model 4 analyses each revealed a significant relation between 1987 dioxin and cholesterol-HDL ratio (Table 13-29(g,h): Est. RR=1.22, p<0.001, for the unadjusted analysis; Adj. RR=1.13, p=0.025, for the adjusted analysis). The percentages of participants with high cholesterol-HDL ratios in the low, medium, and high 1987 dioxin categories were 36.7, 34.5, and 52.8, respectively.

#### 13.2.2.3.20 Triglycerides (Continuous)

No significant associations with dioxin were shown in all Model 1 and 2 analyses (Table 13-30(a–d): p>0.10 for each analysis).

The unadjusted Model 3 analysis showed a significant difference between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-30(e): difference of means=20.1 mg/dl, p<0.001; difference of means=9.4 mg/dl, p=0.023, respectively).

**Table 13-30. Analysis of Triglycerides (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	858	122.8	2.1 --	0.539
	<i>Comparison</i>	1,231	120.7		
Officer	Ranch Hand	339	114.9	3.2 --	0.523
	Comparison	490	111.7		
Enlisted Flyer	Ranch Hand	150	123.9	-13.8 --	0.122
	Comparison	185	137.7		
Enlisted Groundcrew	Ranch Hand	369	130.0	6.4 --	0.230
	Comparison	556	123.6		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-30. Analysis of Triglycerides (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	853	107.4	1.8 --	0.546
	<i>Comparison</i>	1,229	105.6		
Officer	Ranch Hand	339	100.3	3.2 --	0.458
	Comparison	489	97.1		
Enlisted Flyer	Ranch Hand	148	107.0	-12.4 --	0.109
	Comparison	184	119.5		
Enlisted Groundcrew	Ranch Hand	366	110.5	5.3 --	0.239
	Comparison	556	105.2		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	117.3	118.6	0.025	0.033 (0.023)	0.140
Medium	159	141.9	142.0			
High	159	141.0	139.4			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of triglycerides versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	106.9	0.055	0.006 (0.027)	0.830
Medium	158	123.9			
High	157	118.4			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of triglycerides versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-30. Analysis of Triglycerides (mg/dl) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	120.6	120.3		
Background RH	375	110.3	114.5	-5.8 --	0.172
Low RH	236	121.0	119.7	-0.6 --	0.897
High RH	240	145.8	140.4	20.1 --	<0.001
Low plus High RH	476	132.9	129.7	9.4 --	0.023

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	105.9		
Background RH	373	103.2	-2.7 --	0.483
Low RH	235	107.0	1.1 --	0.820
High RH	238	118.2	12.3 --	0.013
Low plus High RH	473	112.5	6.6 --	0.070

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	282	109.2	0.028	0.072 (0.015)	<0.001
Medium	285	118.3			
High	284	141.9			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of triglycerides versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-30. Analysis of Triglycerides (mg/dl) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	282	96.3	0.041	0.063 (0.017)	<0.001
Medium	283	105.7			
High	281	122.9			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of triglycerides versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The adjusted Model 3 analysis of triglycerides revealed the same two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons (Table 13-30(f): difference of adjusted means=12.3 mg/dl, p=0.013) and Ranch Hands in the low and high dioxin categories combined versus Comparisons (difference of adjusted means=6.6 mg/dl, p=0.070). The adjusted mean levels of triglycerides for Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 118.2 mg/dl, 112.5 mg/dl, and 105.9 mg/dl, respectively.

The Model 4 unadjusted and adjusted analyses both showed significant relations between 1987 dioxin and triglycerides (Table 13-30(g,h): slope=0.072, p<0.001, for the unadjusted analysis; adjusted slope=0.063, p<0.001, for the adjusted analysis). The adjusted mean triglyceride levels in the low, medium, and high 1987 dioxin categories were 96.3 mg/dl, 105.7 mg/dl, and 122.9 mg/dl, respectively.

#### 13.2.2.3.21 Triglycerides (Discrete)

The unadjusted and adjusted Model 1 analyses of triglycerides in their discrete form showed no overall group differences (Table 13-31(a,b): p>0.31 for each analysis). After stratifying by occupation, significant group differences were noted within the enlisted groundcrew stratum for both the unadjusted and adjusted analyses (Table 13-31(a,b): Est. RR=1.36, p=0.052; Adj. RR=1.37, p=0.047, respectively). Among the enlisted groundcrew, 26.6 percent of the Ranch Hands had high triglyceride levels versus 21.0 percent of the Comparisons.

**Table 13-31. Analysis of Triglycerides (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	858	188 (21.9)	1.10 (0.89,1.36)	0.377
	<i>Comparison</i>	1,231	250 (20.3)		
Officer	Ranch Hand	339	60 (17.7)	1.07 (0.74,1.54)	0.717
	Comparison	490	82 (16.7)		
Enlisted Flyer	Ranch Hand	150	30 (20.0)	0.66 (0.39,1.10)	0.109
	Comparison	185	51 (27.6)		
Enlisted Groundcrew	Ranch Hand	369	98 (26.6)	1.36 (1.00,1.85)	0.052
	Comparison	556	117 (21.0)		

**Table 13-31. Analysis of Triglycerides (Discrete) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.12 (0.90,1.39)</i>	<i>0.318</i>
Officer	1.10 (0.76,1.58)	0.628
Enlisted Flyer	0.66 (0.39,1.12)	0.123
Enlisted Groundcrew	1.37 (1.00,1.88)	0.047

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	158	37 (23.4)	1.09 (0.94,1.27)	0.275
Medium	159	45 (28.3)		
High	159	49 (30.8)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
473	0.96 (0.80,1.15)		0.690

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	240 (20.1)		
Background RH	375	53 (14.1)	0.72 (0.52,1.00)	0.051
Low RH	236	54 (22.9)	1.15 (0.82,1.62)	0.411
High RH	240	77 (32.1)	1.74 (1.27,2.37)	<0.001
Low plus High RH	476	131 (27.5)	1.42 (1.10,1.82)	0.006

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-31. Analysis of Triglycerides (Discrete) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	373	0.79 (0.56,1.10)	0.161
Low RH	235	1.24 (0.88,1.76)	0.215
High RH	238	1.55 (1.12,2.15)	0.009
Low plus High RH	473	1.39 (1.07,1.80)	0.012

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	282	41 (14.5)	1.29 (1.16,1.44)	<0.001
Medium	285	58 (20.4)		
High	284	85 (29.9)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
846	1.23 (1.09,1.40)		0.001

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The Model 2 unadjusted and adjusted analyses showed no significant association between initial dioxin and triglycerides (Table 13-31(c,d):  $p > 0.27$  for each analysis). The unadjusted Model 3 analysis of triglycerides revealed Ranch Hands in the background dioxin category, Ranch Hands in the high dioxin category, and Ranch Hands in the low and high dioxin categories combined each to be significantly different from the Comparisons (Table 13-31(e): Est. RR=0.72,  $p=0.051$ , for the background dioxin category contrast; Est. RR=1.74,  $p < 0.001$ , for the high dioxin category contrast; and Est. RR=1.42,  $p=0.006$ , for the low and high dioxin categories combined contrast). The adjusted Model 3 analysis showed a significant difference between Ranch Hands in the high dioxin category and Comparisons (Table 13-31(f): Adj. RR=1.55,  $p=0.009$ ), as well as a significant difference between Ranch Hands in the low and high dioxin categories combined and Comparisons (Adj. RR=1.39,  $p=0.012$ ). The percentages of individuals with high triglyceride levels among Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 32.1, 27.5, and 20.1, respectively.

The unadjusted and adjusted Model 4 analyses each revealed a significant association between triglycerides and 1987 dioxin levels (Table 13-31(g,h): Est. RR=1.29, p<0.001, for the unadjusted analysis; Adj. RR=1.23, p=0.001, for the adjusted analysis). The percentages of participants with high levels of triglycerides in the low, medium, and high 1987 dioxin categories were 14.5, 20.4, and 29.9, respectively.

#### 13.2.2.3.22 Creatine Phosphokinase (Continuous)

All unadjusted and adjusted analyses in Models 1 through 3 showed no significant associations between dioxin and creatine phosphokinase (Table 13-32(a-f): p>0.50 for each analysis).

**Table 13-32. Analysis of Creatine Phosphokinase (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>106.3</i>	<i>0.8 --</i>	<i>0.791</i>
	<i>Comparison</i>	<i>1,231</i>	<i>105.5</i>		
Officer	Ranch Hand	340	105.8	1.4 --	0.748
	Comparison	490	104.3		
Enlisted Flyer	Ranch Hand	150	97.2	-3.8 --	0.562
	Comparison	185	101.0		
Enlisted Groundcrew	Ranch Hand	369	110.8	2.6 --	0.565
	Comparison	556	108.2		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>140.3</i>	<i>0.9 --</i>	<i>0.809</i>
	<i>Comparison</i>	<i>1,229</i>	<i>139.4</i>		
Officer	Ranch Hand	340	147.7	2.4 --	0.696
	Comparison	489	145.3		
Enlisted Flyer	Ranch Hand	148	131.5	-4.9 --	0.568
	Comparison	184	136.4		
Enlisted Groundcrew	Ranch Hand	366	140.2	1.8 --	0.736
	Comparison	556	138.3		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-32. Analysis of Creatine Phosphokinase (U/l) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	111.8	112.7	0.013	0.005 (0.021)	0.800
Medium	159	104.0	104.1			
High	159	112.0	111.1			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of creatine phosphokinase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>		R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	149.8		0.121	-0.004 (0.023)	0.871
Medium	158	139.9				
High	157	143.6				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of creatine phosphokinase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>						
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>		p-Value <sup>d</sup>
Comparison	1,194	105.6	105.4			
Background RH	376	102.7	105.6	0.2	--	0.961
Low RH	236	109.1	108.2	2.8	--	0.547
High RH	240	109.3	106.3	0.9	--	0.843
Low plus High RH	476	109.2	107.2	1.8	--	0.602

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-32. Analysis of Creatine Phosphokinase (U/l) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	140.2		
Background RH	374	139.5	-0.7 --	0.889
Low RH	235	142.6	2.4 --	0.679
High RH	238	143.8	3.6 --	0.549
Low plus High RH	473	143.2	3.0 --	0.503

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	99.8	0.004	0.024 (0.014)	0.084
Medium	285	110.6			
High	284	108.7			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of creatine phosphokinase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	126.6	0.091	0.039 (0.015)	0.011
Medium	283	141.1			
High	281	143.2			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of creatine phosphokinase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted and adjusted Model 4 analyses each showed a positive relation between 1987 dioxin and creatine phosphokinase, with the unadjusted slope marginally significant and the adjusted slope significant (Table 13-32(g,h): slope=0.024, p=0.084; adjusted slope=0.039, p=0.011). The adjusted mean creatine phosphokinase levels in the low, medium, and high 1987 dioxin categories were 126.6 U/l, 141.1 U/l, and 143.2 U/l, respectively.

13.2.2.3.23 Creatine Phosphokinase (Discrete)

All analyses of high creatine phosphokinase levels in Models 1 through 3 were nonsignificant (Table 13-33(a-f):  $p \geq 0.21$  for each analysis).

**Table 13-33. Analysis of Creatine Phosphokinase (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	72 (8.4)	<i>0.89 (0.65,1.21)</i>	<i>0.448</i>
	<i>Comparison</i>	1,231	115 (9.3)		
Officer	Ranch Hand	340	26 (7.6)	0.84 (0.51,1.39)	0.497
	Comparison	490	44 (9.0)		
Enlisted Flyer	Ranch Hand	150	7 (4.7)	0.55 (0.22,1.40)	0.212
	Comparison	185	15 (8.1)		
Enlisted Groundcrew	Ranch Hand	369	39 (10.6)	1.06 (0.69,1.62)	0.807
	Comparison	556	56 (10.1)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.87 (0.63,1.20)</i>	<i>0.390</i>
Officer	0.84 (0.50,1.41)	0.519
Enlisted Flyer	0.55 (0.21,1.41)	0.210
Enlisted Groundcrew	1.00 (0.63,1.58)	0.998

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	16 (10.1)	1.05 (0.83,1.32)	0.698
Medium	159	12 (7.5)		
High	159	17 (10.7)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.09 (0.82,1.45)	0.542

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-33. Analysis of Creatine Phosphokinase (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	111 (9.3)		
Background RH	376	26 (6.9)	0.81 (0.51,1.26)	0.345
Low RH	236	20 (8.5)	0.87 (0.53,1.44)	0.599
High RH	240	25 (10.4)	1.03 (0.65,1.64)	0.905
Low plus High RH	476	45 (9.5)	0.95 (0.66,1.37)	0.781

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
Comparison	1,193			
Background RH	374	0.75 (0.46,1.20)		0.227
Low RH	235	0.80 (0.47,1.35)		0.402
High RH	238	1.20 (0.73,1.98)		0.465
Low plus High RH	473	0.98 (0.67,1.45)		0.923

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	17 (6.0)	1.14 (0.97,1.33)	0.123
Medium	285	26 (9.1)		
High	284	28 (9.9)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>				
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)				
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value	
847	1.22 (1.00,1.49)		0.043	

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The unadjusted Model 4 analysis results were nonsignificant (Table 13-33(g):  $p=0.123$ ). After adjusting for covariates, a significant relation between creatine phosphokinase in its dichotomous form and 1987 dioxin was revealed (Table 13-33(h): Adj. RR=1.22,  $p=0.043$ ). The percentages of participants with high levels of creatine phosphokinase in the low, medium, and high 1987 dioxin categories were 6.0, 9.1, and 9.9, respectively.

#### 13.2.2.3.24 Serum Amylase (Continuous)

The unadjusted and adjusted Model 1 analyses of serum amylase did not show a significant overall group difference between Ranch Hands and Comparisons (Table 13-34(a,b):  $p>0.92$  for each analysis). Stratifying the analyses by occupation revealed a significant group difference among the officers in both the unadjusted and adjusted analyses (Table 13-34(a,b): difference of means=-2.98 U/l,  $p=0.048$ , for the unadjusted analysis; difference of adjusted means=-3.50 U/l,  $p=0.037$ , for the adjusted analysis). The adjusted mean serum amylase level among the officers in the Ranch Hand group was 61.86 U/l versus 65.36 U/l among the officers in the Comparison group.

The results from the unadjusted Model 2 analysis revealed a marginally significant inverse association between serum amylase and initial dioxin (Table 13-34(c): slope=-0.024,  $p=0.070$ ). Similarly, after covariate adjustment, a marginally significant inverse association between serum amylase and initial dioxin was present (Table 13-34(d): adjusted slope=-0.029,  $p=0.060$ ). The adjusted mean serum amylase levels in the low, medium, and high initial dioxin categories were 67.45 U/l, 64.22 U/l, and 64.25 U/l, respectively.

**Table 13-34. Analysis of Serum Amylase (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>56.92</i>	<i>0.07 --</i>	<i>0.942</i>
	<i>Comparison</i>	<i>1,231</i>	<i>56.85</i>		
Officer	Ranch Hand	340	54.88	-2.98 --	0.048
	Comparison	490	57.86		
Enlisted Flyer	Ranch Hand	150	58.46	2.55 --	0.284
	Comparison	185	55.91		
Enlisted Groundcrew	Ranch Hand	369	58.23	1.95 --	0.182
	Comparison	556	56.29		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-34. Analysis of Serum Amylase (U/l) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	63.65	-0.09 --	0.929
	<i>Comparison</i>	1,229	63.74		
Officer	Ranch Hand	340	61.86	-3.50 --	0.037
	Comparison	489	65.36		
Enlisted Flyer	Ranch Hand	148	65.17	2.73 --	0.301
	Comparison	184	62.44		
Enlisted Groundcrew	Ranch Hand	366	64.84	1.98 --	0.218
	Comparison	556	62.86		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	59.22	58.66	0.052	-0.024 (0.013)	0.070
Medium	159	55.89	55.83			
High	159	55.54	56.13			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of serum amylase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>		R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	67.45		0.125	-0.029 (0.015)	0.060
Medium	158	64.22				
High	157	64.25				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of serum amylase versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-34. Analysis of Serum Amylase (U/l) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>d</sup></b>
Comparison	1,194	56.82	56.88		
Background RH	376	57.03	55.87	-1.01 --	0.419
Low RH	236	60.17	60.54	3.66 --	0.019
High RH	240	53.78	54.89	-1.99 --	0.178
Low plus High RH	476	56.86	57.63	0.75 --	0.523

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>	
Comparison	1,193	63.45			
Background RH	374	62.33	-1.12 --	0.427	
Low RH	235	66.45	3.00 --	0.078	
High RH	238	61.31	-2.14 --	0.205	
Low plus High RH	473	63.82	0.37 --	0.774	

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-34. Analysis of Serum Amylase (U/l) (Continuous) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	57.84	0.005	-0.019 (0.009)	0.035
Medium	285	57.77			
High	284	55.23			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of serum amylase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	68.24	0.063	-0.030 (0.010)	0.003
Medium	283	66.40			
High	281	62.16			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of serum amylase versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted Model 3 analysis revealed a significant difference in mean serum amylase levels between Ranch Hands in the low dioxin category and Comparisons (Table 13-34(e): difference of means=3.66 U/l, p=0.019). The adjusted results showed a marginally significant difference between Ranch Hands in the low dioxin category and Comparisons (Table 13-34(f): difference of adjusted means=3.00 U/l, p=0.078). The adjusted mean serum amylase level for Ranch Hands in the low dioxin category was 66.45 U/l versus 63.45 U/l for Comparisons.

Both the unadjusted and adjusted Model 4 analyses showed serum amylase to be significantly inversely associated with 1987 dioxin (Table 13-34(g,h): slope=-0.019, p=0.035; adjusted slope=-0.030, p=0.003). The adjusted mean serum amylase levels in the low, medium, and high 1987 dioxin categories were 68.24 U/l, 66.40 U/l, and 62.16 U/l, respectively.

#### 13.2.2.3.25 Serum Amylase (Discrete)

The unadjusted and adjusted Model 1 analyses revealed no significant overall group difference in the percentage of individuals with high serum amylase levels (Table 13-35(a,b): p>0.73 for each analysis). In both the unadjusted and adjusted analyses, stratifying by occupation revealed marginally significant reduction in risk among the Ranch Hand officers (Table 13-35(a,b): Est. RR=0.45, p=0.067, for the unadjusted analysis; Adj. RR=0.43, p=0.058, for the adjusted analysis). Among the officers in the Ranch Hand group, 2.1 percent had high serum amylase levels versus 4.5 percent of officers in the Comparison group. All analyses of Models 2, 3, and 4 showed no significant associations between serum amylase and dioxin (Table 13-35(c–h): p>0.11 for each analysis).

**Table 13-35. Analysis of Serum Amylase (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	25 (2.9)	<i>0.94 (0.56,1.57)</i>	<i>0.816</i>
	<i>Comparison</i>	1,231	38 (3.1)		
Officer	Ranch Hand	340	7 (2.1)	0.45 (0.19,1.06)	0.067
	Comparison	490	22 (4.5)		
Enlisted Flyer	Ranch Hand	150	4 (2.7)	1.66 (0.37,7.54)	0.510
	Comparison	185	3 (1.6)		
Enlisted Groundcrew	Ranch Hand	369	14 (3.8)	1.65 (0.77,3.55)	0.202
	Comparison	556	13 (2.3)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.91 (0.54,1.54)</i>	<i>0.733</i>
Officer	0.43 (0.18,1.03)	0.058
Enlisted Flyer	1.66 (0.36,7.69)	0.514
Enlisted Groundcrew	1.60 (0.73,3.50)	0.240

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	7 (4.4)	0.86 (0.58,1.29)	0.458
Medium	159	5 (3.1)		
High	159	5 (3.1)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.04 (0.63,1.71)	0.884

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-35. Analysis of Serum Amylase (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	38 (3.2)		
Background RH	376	8 (2.1)	0.61 (0.28,1.32)	0.210
Low RH	236	11 (4.7)	1.51 (0.76,3.01)	0.236
High RH	240	6 (2.5)	0.84 (0.35,2.02)	0.697
Low plus High RH	476	17 (3.6)	1.13 (0.62,2.06)	0.701

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	0.53 (0.24,1.16)	0.112
Low RH	235	1.37 (0.67,2.77)	0.387
High RH	238	1.02 (0.41,2.59)	0.959
Low plus High RH	473	1.18 (0.63,2.21)	0.602

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	7 (2.5)	0.93 (0.70,1.22)	0.590
Medium	285	10 (3.5)		
High	284	8 (2.8)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-35. Analysis of Serum Amylase (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
847	0.93 (0.68,1.26)	0.623

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

**13.2.2.3.26 Antibodies for Hepatitis A**

All unadjusted and adjusted analyses in Models 1 through 4 showed no significant associations between dioxin and the presence of antibodies for hepatitis A (Table 13-36(a–h):  $p > 0.12$  for each analysis).

**Table 13-36. Analysis of Antibodies for Hepatitis A**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	870	283 (32.5)	<i>0.95 (0.79,1.14)</i>	<i>0.580</i>
	<i>Comparison</i>	1,250	421 (33.7)		
Officer	Ranch Hand	341	92 (27.0)	1.00 (0.73,1.36)	0.999
	Comparison	493	133 (27.0)		
Enlisted Flyer	Ranch Hand	151	74 (49.0)	1.13 (0.73,1.73)	0.581
	Comparison	187	86 (46.0)		
Enlisted Groundcrew	Ranch Hand	378	117 (31.0)	0.82 (0.62,1.08)	0.153
	Comparison	570	202 (35.4)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>			
Occupational Category	Adjusted Relative Risk (95% C.I.)		p-Value
<i>All</i>	<i>0.93 (0.76,1.12)</i>		<i>0.434</i>
Officer	0.95 (0.68,1.31)		0.739
Enlisted Flyer	1.07 (0.69,1.68)		0.754
Enlisted Groundcrew	0.85 (0.64,1.14)		0.285

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>		
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>		p-Value
Low	160	57 (35.6)	0.98 (0.85,1.14)		0.830
Medium	162	54 (33.3)			
High	160	57 (35.6)			

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-36. Analysis of Antibodies for Hepatitis A (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
479	1.02 (0.86,1.22)	0.813

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,212	405 (33.4)		
Background RH	381	112 (29.4)	0.84 (0.65,1.08)	0.175
Low RH	239	84 (35.1)	1.08 (0.80,1.44)	0.619
High RH	243	84 (34.6)	1.04 (0.78,1.39)	0.784
Low plus High RH	482	168 (34.9)	1.06 (0.85,1.32)	0.615

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,211		
Background RH	378	0.92 (0.70,1.21)	0.561
Low RH	238	0.92 (0.67,1.25)	0.577
High RH	241	0.96 (0.70,1.32)	0.787
Low plus High RH	479	0.94 (0.74,1.19)	0.588

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin Category Summary Statistics			Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
1987 Dioxin	n	Number (%) Yes		
Low	288	81 (28.1)	1.08 (0.98,1.19)	0.125
Medium	287	103 (35.9)		
High	288	96 (33.3)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-36. Analysis of Antibodies for Hepatitis A (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
857	1.06 (0.94,1.19)	0.346

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

*13.2.2.3.27 Evidence of Prior Hepatitis B*

The unadjusted Model 1 analysis of serological evidence of prior hepatitis B revealed a significant overall group difference between Ranch Hands and Comparisons (Table 13-37(a): Est. RR=0.62, p=0.001). After stratifying by occupation, a significant difference between Ranch Hands and Comparisons was seen within each occupational stratum (Table 13-37(a): Est. RR=0.49, p=0.031, for officers; Est. RR=0.58, p=0.079, for enlisted flyers; and Est. RR=0.66, p=0.035, for enlisted groundcrew). In each stratum, the percentage of participants with evidence of prior hepatitis B was greater for Comparisons than for Ranch Hands.

**Table 13-37. Analysis of Evidence of Prior Hepatitis B**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	869	77 (8.9)	<i>0.62 (0.46,0.82)</i>	<i>0.001</i>
	<i>Comparison</i>	1,249	170 (13.6)		
Officer	Ranch Hand	340	13 (3.8)	0.49 (0.26,0.94)	0.031
	Comparison	494	37 (7.5)		
Enlisted Flyer	Ranch Hand	151	19 (12.6)	0.58 (0.32,1.06)	0.079
	Comparison	187	37 (19.8)		
Enlisted Groundcrew	Ranch Hand	378	45 (11.9)	0.66 (0.45,0.97)	0.035
	Comparison	568	96 (16.9)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>0.59 (0.44,0.80)</i>	<i>&lt;0.001</i>
Officer	0.47 (0.25,0.91)	0.024
Enlisted Flyer	0.58 (0.31,1.07)	0.079
Enlisted Groundcrew	0.66 (0.44,0.97)	0.035

**Table 13-37. Analysis of Evidence of Prior Hepatitis B (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	159	17 (10.7)	1.06 (0.86,1.31)	0.588
Medium	162	14 (8.6)		
High	160	22 (13.8)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
478	0.95 (0.74,1.22)	0.669

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,211	166 (13.7)		
Background RH	381	23 (6.0)	0.42 (0.27,0.66)	<0.001
Low RH	238	26 (10.9)	0.76 (0.49,1.18)	0.229
High RH	243	27 (11.1)	0.76 (0.49,1.17)	0.214
Low plus High RH	481	53 (11.0)	0.76 (0.55,1.06)	0.105

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,210		
Background RH	378	0.50 (0.31,0.80)	0.004
Low RH	237	0.71 (0.45,1.12)	0.143
High RH	241	0.59 (0.37,0.92)	0.021
Low plus High RH	478	0.65 (0.46,0.91)	0.012

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-37. Analysis of Evidence of Prior Hepatitis B (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	288	14 (4.9)	1.20 (1.03,1.40)	0.023
Medium	286	27 (9.4)		
High	288	35 (12.2)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
856	1.06 (0.89,1.25)		0.531

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

The adjusted Model 1 analysis mirrored the unadjusted analysis. Significant differences were seen between all Ranch Hands and Comparisons (Table 13-37(b): Adj. RR=0.59, p<0.001) and within each occupational stratum (Table 13-37(b): Adj. RR=0.47, p=0.024, for officers; Adj. RR=0.58, p=0.079, for enlisted flyers; and Adj. RR=0.66, p=0.035, for enlisted groundcrew). Both the unadjusted and adjusted Model 2 analyses revealed no relation between prior hepatitis B and initial dioxin (Table 13-37(c,d): p>0.58 for each analysis).

The unadjusted Model 3 analysis revealed a significant difference in prior hepatitis B between Ranch Hands in the background dioxin category and Comparisons (Table 13-37(e): Est. RR=0.42, p<0.001). The adjusted results showed a significant difference between Ranch Hands in the background dioxin category and Comparisons (Table 13-37(f): Adj. RR=0.50, p=0.004), as well as differences between Ranch Hands in the high dioxin category and Comparisons and Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-37(f): Adj. RR=0.59, p=0.021; Adj. RR=0.65, p=0.012, respectively). The percentages of participants with evidence of prior hepatitis B were 6.0 in the background dioxin category, 11.1 in the high dioxin category, 11.0 in the low and high dioxin categories combined, and 13.7 in the Comparison category.

The unadjusted Model 4 analysis revealed a significant relation between evidence of prior hepatitis B and 1987 dioxin (Table 13-37(g): Est. RR=1.20, p=0.023). After adjusting for covariates, the relation became nonsignificant (Table 13-37(h): p=0.531).

#### 13.2.2.3.28 Current Hepatitis B

All unadjusted and adjusted analyses of current hepatitis B for Models 1 through 4 were nonsignificant (Table 13-38(a,b): p>0.45 for each analysis).

**Table 13-38. Analysis of Current Hepatitis B**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	870	1 (0.1)	0.72 (0.07,7.94)	0.784
	<i>Comparison</i>	1,251	2 (0.2)		
Officer	Ranch Hand	341	0 (0.0)	--	--
	Comparison	494	0 (0.0)		
Enlisted Flyer	Ranch Hand	151	0 (0.0)	--	--
	Comparison	187	0 (0.0)		
Enlisted Groundcrew	Ranch Hand	378	1 (0.3)	0.75 (0.07,8.34)	0.817
	Comparison	570	2 (0.4)		

--: Results not presented because of the sparse number of participants with current hepatitis B.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	0.56 (0.05,6.93)	0.646
Officer	--	--
Enlisted Flyer	--	--
Enlisted Groundcrew	0.68 (0.06,8.27)	0.762

--: Results not presented because of the sparse number of participants with current hepatitis B.

Note: Results for analysis across all occupational categories are not adjusted for occupation because of the sparse number of participants with current hepatitis B.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	160	0 (0.0)	0.99 (0.17,5.76)	0.987
Medium	162	1 (0.6)		
High	160	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
479	0.39 (0.02,9.42)	0.497

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are adjusted only for percent body fat at the time of the blood measurement of dioxin, age, and lifetime alcohol history because of the sparse number of Ranch Hands with current hepatitis B.

**Table 13-38. Analysis of Current Hepatitis B (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,213	2 (0.2)		
Background RH	381	0 (0.0)	--	0.999 <sup>c</sup>
Low RH	239	1 (0.4)	2.52 (0.23,27.92)	0.453
High RH	243	0 (0.0)	--	0.999 <sup>c</sup>
Low plus High RH	482	1 (0.2)	--	0.999 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of Ranch Hands with current hepatitis B.

--: Results not presented because of the sparse number of Ranch Hands with current hepatitis B.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
Comparison	1,212			
Background RH	378	--	--	--
Low RH	238	1.94 (0.14,26.64)		0.622
High RH	241	--	--	--
Low plus High RH	479	--	--	--

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

--: Results not presented because of the sparse number of Ranch Hands with current hepatitis B.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for occupation because of the sparse number of Ranch Hands with current hepatitis B.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	288	0 (0.0)	1.37 (0.41,4.55)	0.617
Medium	287	0 (0.0)		
High	288	1 (0.3)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-38. Analysis of Current Hepatitis B (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
857	1.33 (0.27,6.59) <sup>b</sup>	0.719

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race, occupation, industrial chemical exposure, and degreasing chemical exposure because of the sparse number of Ranch Hands with current hepatitis B.

### 13.2.2.3.29 Antibodies for Hepatitis C

No significant associations were seen between dioxin and hepatitis C for all unadjusted and adjusted analyses in Models 1 through 4 (Table 13-39(a–h)):  $p > 0.13$ .

**Table 13-39. Analysis of Antibodies for Hepatitis C**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	870	9 (1.0)	0.72 (0.32,1.60)	0.408
	<i>Comparison</i>	1,251	18 (1.4)		
Officer	Ranch Hand	341	1 (0.3)	0.36 (0.04,3.24)	0.362
	Comparison	494	4 (0.8)		
Enlisted Flyer	Ranch Hand	151	1 (0.7)	0.62 (0.06,6.87)	0.694
	Comparison	187	2 (1.1)		
Enlisted Groundcrew	Ranch Hand	378	7 (1.9)	0.88 (0.34,2.25)	0.785
	Comparison	570	12 (2.1)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	0.63 (0.27,1.47)	0.274
Officer	0.36 (0.04,3.27)	0.367
Enlisted Flyer	0.61 (0.05,6.87)	0.690
Enlisted Groundcrew	0.73 (0.27,1.98)	0.532

**Table 13-39. Analysis of Antibodies for Hepatitis C (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	160	2 (1.3)	0.61 (0.24,1.60)	0.271
Medium	162	2 (1.2)		
High	160	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
479	0.63 (0.23,1.75)	0.344

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for occupation, industrial chemical exposure, and degreasing chemical exposure because of the sparse number of Ranch Hands with antibodies for hepatitis C.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,213	17 (1.4)		
Background RH	381	5 (1.3)	0.89 (0.32,2.44)	0.819
Low RH	239	2 (0.8)	0.60 (0.14,2.62)	0.497
High RH	243	2 (0.8)	0.61 (0.14,2.67)	0.512
Low plus High RH	482	4 (0.8)	0.61 (0.20,1.81)	0.369

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-39. Analysis of Antibodies for Hepatitis C (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,212		
Background RH	378	0.87 (0.28,2.73)	0.816
Low RH	238	0.54 (0.12,2.40)	0.415
High RH	241	0.50 (0.11,2.23)	0.359
Low plus High RH	479	0.52 (0.17,1.57)	0.243

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	288	5 (1.7)	0.69 (0.42,1.14)	0.139
Medium	287	2 (0.7)		
High	288	2 (0.7)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
857	0.67 (0.40,1.14)		0.141

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

### 13.2.2.3.30 Antibodies for Hepatitis D

Only one participant had positive results for hepatitis D antibodies. He was a Black Ranch Hand in the enlisted groundcrew occupational stratum. No further analyses were performed.

### 13.2.2.3.31 Stool Hemocult

All unadjusted and adjusted analyses of stool hemocult for Models 1 through 4 were nonsignificant (Table 13-40(a–h): p>0.17 for each analysis).

**Table 13-40. Analysis of Stool Hemocult**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Yes	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>834</i>	<i>29 (3.5)</i>	<i>0.78 (0.49,1.23)</i>	<i>0.279</i>
	<i>Comparison</i>	<i>1,196</i>	<i>53 (4.4)</i>		
Officer	Ranch Hand	332	14 (4.2)	0.92 (0.46,1.83)	0.818
	Comparison	483	22 (4.6)		
Enlisted Flyer	Ranch Hand	147	2 (1.4)	0.34 (0.07,1.65)	0.179
	Comparison	178	7 (3.9)		
Enlisted Groundcrew	Ranch Hand	355	13 (3.7)	0.81 (0.41,1.61)	0.547
	Comparison	535	24 (4.5)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.78 (0.49,1.25)</i>	<i>0.301</i>
Officer	0.90 (0.45,1.80)	0.774
Enlisted Flyer	0.34 (0.07,1.70)	0.191
Enlisted Groundcrew	0.82 (0.41,1.64)	0.574

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	156	4 (2.6)	0.85 (0.59,1.24)	0.390
Medium	156	11 (7.1)		
High	152	4 (2.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
461	0.97 (0.62,1.51)	0.880

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-40. Analysis of Stool Hemocult (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Yes	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,162	50 (4.3)		
Background RH	365	10 (2.7)	0.68 (0.34,1.35)	0.270
Low RH	232	11 (4.7)	1.08 (0.55,2.12)	0.814
High RH	232	8 (3.4)	0.74 (0.35,1.59)	0.443
Low plus High RH	464	19 (4.1)	0.90 (0.52,1.55)	0.696

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,161		
Background RH	363	0.63 (0.31,1.28)	0.201
Low RH	231	1.08 (0.55,2.13)	0.822
High RH	230	0.86 (0.39,1.90)	0.705
Low plus High RH	461	0.96 (0.55,1.68)	0.895

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Yes	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	275	8 (2.9)	1.04 (0.81,1.34)	0.760
Medium	280	9 (3.2)		
High	274	12 (4.4)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-40. Analysis of Stool Hemocult (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
824	1.13 (0.83,1.53)	0.448

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

**13.2.2.3.32 Prealbumin (Continuous)**

The unadjusted and adjusted analyses of prealbumin in its continuous form displayed no significant associations with dioxin in any of Models 1 through 4 (Table 13-41(a–h): p>0.38 for each analysis).

**Table 13-41. Analysis of Prealbumin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean	Difference of Means (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	29.54	-0.07 (-0.50,0.37)	0.766
	<i>Comparison</i>	1,231	29.61		
Officer	Ranch Hand	340	29.65	-0.22 (-0.92,0.47)	0.532
	Comparison	490	29.87		
Enlisted Flyer	Ranch Hand	150	29.56	0.23 (-0.85,1.31)	0.679
	Comparison	185	29.33		
Enlisted Groundcrew	Ranch Hand	369	29.44	-0.03 (-0.70,0.63)	0.922
	Comparison	556	29.48		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean	Difference of Adj. Means (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	854	29.66	-0.04 (-0.47,0.39)	0.861
	<i>Comparison</i>	1,229	29.70		
Officer	Ranch Hand	340	30.03	-0.17 (-0.86,0.51)	0.621
	Comparison	489	30.20		
Enlisted Flyer	Ranch Hand	148	30.03	0.48 (-0.59,1.55)	0.382
	Comparison	184	29.55		
Enlisted Groundcrew	Ranch Hand	366	29.10	-0.11 (-0.76,0.54)	0.746
	Comparison	556	29.21		

**Table 13-41. Analysis of Prealbumin (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)</b>	<b>p-Value</b>
Low	158	29.72	29.61	0.030	-0.041 (0.178)	0.818
Medium	159	28.77	28.76			
High	159	29.83	29.95			

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean</b>		<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)</b>	<b>p-Value</b>
Low	158	29.69		0.072	-0.127 (0.207)	0.538
Medium	158	28.68				
High	157	29.77				

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>						
<b>Dioxin Category</b>	<b>n</b>	<b>Mean</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)</b>		<b>p-Value</b>
Comparison	1,194	29.61	29.62			
Background RH	376	29.72	29.53	-0.09 (-0.67,0.49)		0.760
Low RH	236	29.41	29.47	-0.15 (-0.85,0.54)		0.665
High RH	240	29.47	29.65	0.03 (-0.66,0.73)		0.927
Low plus High RH	476	29.44	29.56	-0.06 (-0.59,0.47)		0.825

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-41. Analysis of Prealbumin (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean</b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)</b>	<b>p-Value</b>
Comparison	1,193	29.65		
Background RH	374	29.51	-0.15 (-0.73,0.44)	0.626
Low RH	235	29.69	0.04 (-0.65,0.73)	0.908
High RH	238	29.72	0.06 (-0.64,0.77)	0.860
Low plus High RH	473	29.71	0.05 (-0.48,0.58)	0.847

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean</b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)</b>	<b>p-Value</b>
Low	283	30.00	<0.001	-0.047 (0.124)	0.704
Medium	285	29.28			
High	284	29.41			

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean</b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)</b>	<b>p-Value</b>
Low	283	29.90	0.053	-0.007 (0.140)	0.961
Medium	283	29.43			
High	281	29.35			

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

### 13.2.2.3.33 Prealbumin (Discrete)

The unadjusted and adjusted Model 1 analyses did not disclose a significant overall difference in prealbumin levels between Ranch Hands and Comparisons (Table 13-42(a,b):  $p > 0.13$  for each analysis). After stratifying the unadjusted analysis by occupation, a marginally significant difference between Ranch Hands and Comparisons was noted among enlisted groundcrew (Table 13-42(a): Est. RR=3.56,  $p=0.067$ ). Similarly, the stratified adjusted analysis revealed a significant difference between enlisted groundcrew Ranch Hands and enlisted groundcrew Comparisons (Table 13-42(b): Adj. RR=4.27,  $p=0.043$ ). The percentage of Ranch Hand enlisted groundcrew with low prealbumin levels was 1.9 percent versus 0.5 percent of Comparison enlisted groundcrew.

**Table 13-42. Analysis of Prealbumin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Low	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>13 (1.5)</i>	<i>1.70 (0.76,3.82)</i>	<i>0.195</i>
	<i>Comparison</i>	<i>1,231</i>	<i>11 (0.9)</i>		
Officer	Ranch Hand	340	5 (1.5)	1.03 (0.32,3.27)	0.960
	Comparison	490	7 (1.4)		
Enlisted Flyer	Ranch Hand	150	1 (0.7)	1.23 (0.08,19.91)	0.882
	Comparison	185	1 (0.5)		
Enlisted Groundcrew	Ranch Hand	369	7 (1.9)	3.56 (0.92,13.87)	0.067
	Comparison	556	3 (0.5)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.87 (0.82,4.26)</i>	<i>0.136</i>
Officer	1.03 (0.32,3.29)	0.962
Enlisted Flyer	1.64 (0.09,28.94)	0.736
Enlisted Groundcrew	4.27 (1.05,17.39)	0.043

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	1 (0.6)	1.44 (0.84,2.47)	0.203
Medium	159	3 (1.9)		
High	159	2 (1.3)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.76 (0.94,3.30)	0.081

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for occupation because of the sparse number of Ranch Hands with low prealbumin levels.

**Table 13-42. Analysis of Prealbumin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Low	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	10 (0.8)		
Background RH	376	6 (1.6)	1.94 (0.69,5.41)	0.207
Low RH	236	1 (0.4)	0.50 (0.06,3.95)	0.513
High RH	240	5 (2.1)	2.50 (0.84,7.42)	0.099
Low plus High RH	476	6 (1.3)	1.13 (0.33,3.90)	0.849

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	1.74 (0.61,5.01)	0.302
Low RH	235	0.49 (0.06,3.93)	0.506
High RH	238	4.34 (1.25,15.05)	0.021
Low plus High RH	473	1.48 (0.41,5.32)	0.552

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	4 (1.4)	1.02 (0.69,1.49)	0.931
Medium	285	3 (1.1)		
High	284	5 (1.8)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-42. Analysis of Prealbumin (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
847	1.00 (0.63,1.60)	0.993

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

No significant relation between prealbumin and initial dioxin was found in the unadjusted Model 2 analysis (Table 13-42(c): p=0.203). A marginally significant relation was found in the adjusted analysis (Table 13-42(d): Adj. RR=1.76, p=0.081), indicating an increased prevalence of low prealbumin levels as initial dioxin increased. In the Model 3 unadjusted analysis of prealbumin, a marginally significant difference was revealed between Ranch Hands in the high dioxin category and the Comparison group (Table 13-42(e): Est. RR=2.50, p=0.099). The same contrast was significant in the adjusted analysis (Table 13-42(f): Adj. RR=4.34, p=0.021). Of the Ranch Hands in the high dioxin category, 2.1 percent had low prealbumin levels versus 0.8 percent of the Comparisons. The Model 4 unadjusted and adjusted analyses were nonsignificant (Table 13-42(g,h): p>0.93 for each analysis).

*13.2.2.3.34 Albumin (Continuous)*

All unadjusted and adjusted Model 1 and 2 analyses were nonsignificant (Table 13-43(a–d): p>0.18 for each analysis).

**Table 13-43. Analysis of Albumin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean</b>	<b>Difference of Means (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	859	4,195.6	-5.6 (-34.9,23.8)	<i>0.709</i>
	<i>Comparison</i>	1,231	4,201.2		
Officer	Ranch Hand	340	4,172.9	-31.8 (-78.3,14.8)	0.181
	Comparison	490	4,204.6		
Enlisted Flyer	Ranch Hand	150	4,190.0	30.1 (-42.4,102.5)	0.416
	Comparison	185	4,159.9		
Enlisted Groundcrew	Ranch Hand	369	4,218.8	7.0 (-37.3,51.2)	0.758
	Comparison	556	4,211.9		

**Table 13-43. Analysis of Albumin (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean	Difference of Adj. Means (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	854	4,180.8	-3.0 (-32.1,26.0)	0.837
	<i>Comparison</i>	1,229	4,183.8		
Officer	Ranch Hand	340	4,163.1	-28.9 (-74.9,17.1)	0.218
	Comparison	489	4,192.1		
Enlisted Flyer	Ranch Hand	148	4,201.9	37.0 (-35.0,109.0)	0.314
	Comparison	184	4,164.9		
Enlisted Groundcrew	Ranch Hand	366	4,190.5	5.8 (-38.1,49.6)	0.797
	Comparison	556	4,184.7		

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Mean	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Slope (Std. Error)	p-Value
Low	158	4,170.0	4,164.4	0.023	13.830 (10.970)	0.208
Medium	159	4,163.0	4,162.4			
High	159	4,221.3	4,227.5			

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean	R <sup>2</sup>	Adj. Slope (Std. Error)	p-Value
Low	158	4,148.8	0.054	-1.264 (12.791)	0.921
Medium	158	4,133.0			
High	157	4,169.0			

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.)	p-Value
Comparison	1,194	4,199.1	4,199.7		
Background RH	376	4,212.2	4,200.6	0.9 (-37.7,39.6)	0.962
Low RH	236	4,151.7	4,155.3	-44.5 (-90.8,1.8)	0.060
High RH	240	4,217.3	4,228.9	29.2 (-16.9,75.3)	0.215
Low plus High RH	476	4,184.8	4,192.4	-7.3 (-42.6,28.0)	0.685

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-43. Analysis of Albumin (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean</b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)</b>	<b>p-Value</b>
Comparison	1,193	4,183.0		
Background RH	374	4,187.9	5.0 (–34.0,43.9)	0.803
Low RH	235	4,154.2	–28.7 (–74.7,17.3)	0.221
High RH	238	4,200.2	17.2 (–30.0,64.4)	0.476
Low plus High RH	473	4,177.3	–5.6 (–41.0,29.8)	0.755

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean</b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)</b>	<b>p-Value</b>
Low	283	4,227.5	<0.001	–2.471 (7.678)	0.748
Medium	285	4,153.4			
High	284	4,210.1			

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean</b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)</b>	<b>p-Value</b>
Low	283	4,223.1	0.040	–11.121 (8.711)	0.202
Medium	283	4,157.9			
High	281	4,181.3			

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted Model 3 analysis showed a marginally significant difference between Ranch Hands in the low dioxin category and Comparisons (Table 13-43(e): difference of means=–44.5 mg/dl, p=0.060). No significant differences were noted in the adjusted Model 3 analysis of albumin (Table 13-43(f): p>0.22 for each contrast). In the Model 4 unadjusted and adjusted analyses of albumin, no significant associations with 1987 dioxin were found (Table 13-43(g,h): p>0.20 for each analysis).

#### 13.2.2.3.35 Albumin (Discrete)

Because of a sparse number of low albumin values among the participants, some analyses were not possible. Table 13-44 contains the results of these analyses. Unadjusted chi-square tests of association in Model 3 revealed a significantly smaller percentage of Ranch Hands in the low and high dioxin categories combined with a low albumin level than Comparisons (Table 13-44(e): p=0.099). All other analyses in Models 1 through 4 were nonsignificant (Table 13-44(a–h): p≥0.17 for all other analyses).

**Table 13-44. Analysis of Albumin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Low	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	3 (0.3)	<i>0.43 (0.12,1.56)</i>	<i>0.170</i>
	<i>Comparison</i>	1,231	10 (0.8)		
Officer	Ranch Hand	340	3 (0.9)	1.08 (0.24,4.86)	0.919
	Comparison	490	4 (0.8)		
Enlisted Flyer	Ranch Hand	150	0 (0.0)	--	0.999 <sup>a</sup>
	Comparison	185	1 (0.5)		
Enlisted Groundcrew	Ranch Hand	369	0 (0.0)	--	0.171 <sup>a</sup>
	Comparison	556	5 (0.9)		

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a low albumin level.

--: Results not presented because of the sparse number of participants with a low albumin level.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.45 (0.12,1.65)</i>	<i>0.200</i>
Officer	1.08 (0.24,4.91)	0.918
Enlisted Flyer	--	--
Enlisted Groundcrew	--	--

--: Results not presented because of the sparse number of participants with a low albumin level.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	0 (0.0)	--	--
Medium	159	0 (0.0)		
High	159	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

--: Results not presented because of the sparse number of Ranch Hands with a low albumin level.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
--	--	--

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

--: Results not presented because of the sparse number of Ranch Hands with a low albumin level.

**Table 13-44. Analysis of Albumin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	10 (0.8)		
Background RH	376	2 (0.5)	0.68 (0.15,3.14)	0.618
Low RH	236	0 (0.0)	--	0.325 <sup>c</sup>
High RH	240	0 (0.0)	--	0.318 <sup>c</sup>
Low plus High RH	476	0 (0.0)	--	0.099 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of Ranch Hands with a low albumin level.

--: Results not presented because of the sparse number of Ranch Hands with a low albumin level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	0.67 (0.14,3.20)	0.611
Low RH	235	--	--
High RH	238	--	--
Low plus High RH	473	--	--

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

--: Results not presented because of the sparse number of Ranch Hands with a low albumin level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	1 (0.4)	0.68 (0.24,1.96)	0.465
Medium	285	1 (0.4)		
High	284	0 (0.0)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-44. Analysis of Albumin (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
847	0.52 (0.09,3.01)	0.442

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race, occupation, and industrial chemical exposure because of the sparse number of participants with a low albumin level.

**13.2.2.3.36 α-1-Acid Glycoprotein (Continuous)**

The Model 1 unadjusted and adjusted analyses of α-1-acid glycoprotein revealed no overall difference between Ranch Hands and Comparisons (Table 13-45(a,b): p>0.46 for each analysis). After stratifying by occupation, a significant difference between Ranch Hands and Comparisons was discovered among the enlisted groundcrew for both the unadjusted and adjusted analyses (Table 13-45(a,b): difference of means=2.61 mg/dl, p=0.044, for the unadjusted analysis; difference of adjusted means=2.76 mg/dl, p=0.030, for the adjusted analysis). The adjusted mean α-1-acid glycoprotein level among the Ranch Hand enlisted groundcrew was 86.86 mg/dl versus 84.10 mg/dl among the Comparison enlisted groundcrew.

The unadjusted Model 2 analysis was not significant (Table 13-45(c): p=0.992). After covariate adjustment, a marginally significant inverse relation between α-1-acid glycoprotein and initial dioxin was detected (Table 13-45(d): adjusted slope=-0.016, p=0.086). The adjusted mean α-1-acid glycoprotein levels in the low, medium, and high initial dioxin categories were 82.09 mg/dl, 83.12 mg/dl, and 79.32 mg/dl, respectively.

**Table 13-45. Analysis of α-1-Acid Glycoprotein (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>84.65</i>	<i>0.50 --</i>	<i>0.550</i>
	<i>Comparison</i>	<i>1,231</i>	<i>84.15</i>		
Officer	Ranch Hand	340	80.89	-1.33 --	0.298
	Comparison	490	82.22		
Enlisted Flyer	Ranch Hand	150	85.49	-0.38 --	0.855
	Comparison	185	85.88		
Enlisted Groundcrew	Ranch Hand	369	87.92	2.61 --	0.044
	Comparison	556	85.31		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-45. Analysis of  $\alpha$ -1-Acid Glycoprotein (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	83.11	0.60 --	0.464
	<i>Comparison</i>	1,229	82.51		
Officer	Ranch Hand	340	78.64	-1.43 --	0.248
	Comparison	489	80.08		
Enlisted Flyer	Ranch Hand	148	83.83	0.15 --	0.942
	Comparison	184	83.68		
Enlisted Groundcrew	Ranch Hand	366	86.86	2.76 --	0.030
	Comparison	556	84.10		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	84.39	84.41	<0.001	0.000 (0.008)	0.992
Medium	159	87.88	87.88			
High	159	85.33	85.32			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of  $\alpha$ -1-acid glycoprotein versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>		R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	82.09		0.046	-0.016 (0.009)	0.086
Medium	158	83.12				
High	157	79.32				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -1-acid glycoprotein versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-45. Analysis of  $\alpha$ -1-Acid Glycoprotein (mg/dl) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	84.28	84.29		
Background RH	376	83.12	83.02	-1.27 --	0.256
Low RH	236	84.79	84.82	0.53 --	0.692
High RH	240	86.92	87.02	2.73 --	0.045
Low plus High RH	476	85.86	85.92	1.63 --	0.114

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	82.72		
Background RH	374	82.67	-0.05 --	0.961
Low RH	235	83.42	0.70 --	0.600
High RH	238	83.78	1.06 --	0.436
Low plus High RH	473	83.60	0.88 --	0.389

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>			
Low	283	83.77	0.001	0.005 (0.005)	0.336
Medium	285	83.02			
High	284	87.18			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -1-acid glycoprotein versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq$ 7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-45. Analysis of  $\alpha$ -1-Acid Glycoprotein (mg/dl) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	82.64	0.056	-0.012 (0.006)	0.049
Medium	283	80.92			
High	281	81.52			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -1-acid glycoprotein versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq 7.9$  ppt; Medium =  $>7.9$ – $19.6$  ppt; High =  $>19.6$  ppt.

In the Model 3 unadjusted analysis of  $\alpha$ -1-acid glycoprotein, a significant difference between Ranch Hands in the high dioxin category and Comparisons was found (Table 13-45(e): difference of means=2.73 mg/dl, p=0.045). The adjusted analysis showed no significant contrasts between each of the dioxin categories and Comparisons (Table 13-45(f): p>0.38 for each contrast).

No significant association between  $\alpha$ -1-acid glycoprotein and 1987 dioxin was revealed in the unadjusted Model 4 analysis (Table 13-45(g): p=0.336). After covariate adjustment, a significant inverse relation was found (Table 13-45(h): adjusted slope=-0.012, p=0.049). The mean  $\alpha$ -1-acid glycoprotein levels in the low, medium, and high 1987 dioxin categories were 82.64 mg/dl, 80.92 mg/dl, and 81.52 mg/dl, respectively.

### 13.2.2.3.37 $\alpha$ -1-Acid Glycoprotein (Discrete)

The unadjusted analysis of  $\alpha$ -1-acid glycoprotein in Model 1 did not show a significant group difference between Ranch Hands and Comparisons overall or after stratifying by occupation (Table 13-46(a): p>0.10 for each contrast). The adjusted analysis revealed a marginally significant difference between Ranch Hands and Comparisons among the enlisted groundcrew stratum (Table 13-46(b): Adj. RR=1.86, p=0.066). The percentage of Ranch Hand enlisted groundcrew with high  $\alpha$ -1-acid glycoprotein levels was 5.4 versus 3.2 of Comparison enlisted groundcrew.

**Table 13-46. Analysis of  $\alpha$ -1-Acid Glycoprotein (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>37 (4.3)</i>	<i>1.34 (0.85,2.11)</i>	<i>0.209</i>
	<i>Comparison</i>	<i>1,231</i>	<i>40 (3.2)</i>		
Officer	Ranch Hand	340	8 (2.4)	0.76 (0.32,1.82)	0.542
	Comparison	490	15 (3.1)		
Enlisted Flyer	Ranch Hand	150	9 (6.0)	1.62 (0.59,4.47)	0.348
	Comparison	185	7 (3.8)		
Enlisted Groundcrew	Ranch Hand	369	20 (5.4)	1.71 (0.89,3.28)	0.105
	Comparison	556	18 (3.2)		

**Table 13-46. Analysis of  $\alpha$ -1-Acid Glycoprotein (Discrete) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>1.39 (0.88,2.21)</i>	<i>0.163</i>
Officer	0.73 (0.31,1.76)	0.487
Enlisted Flyer	1.78 (0.64,4.95)	0.270
Enlisted Groundcrew	1.86 (0.96,3.60)	0.066

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) High</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	158	6 (3.8)	1.00 (0.72,1.38)	0.991
Medium	159	10 (6.3)		
High	159	7 (4.4)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
473	0.92 (0.63,1.35)		0.684

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) High</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	39 (3.3)		
Background RH	376	13 (3.5)	1.00 (0.52,1.90)	0.992
Low RH	236	11 (4.7)	1.47 (0.74,2.91)	0.272
High RH	240	12 (5.0)	1.65 (0.85,3.21)	0.141
Low plus High RH	476	23 (4.8)	1.56 (0.92,2.64)	0.101

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-46. Analysis of  $\alpha$ -1-Acid Glycoprotein (Discrete) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	1.12 (0.58,2.16)	0.745
Low RH	235	1.47 (0.73,2.94)	0.279
High RH	238	1.54 (0.77,3.08)	0.222
Low plus High RH	473	1.50 (0.88,2.58)	0.138

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	11 (3.9)	1.00 (0.80,1.25)	0.986
Medium	285	9 (3.2)		
High	284	16 (5.6)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low =  $\leq$ 7.9 ppt; Medium =  $>$ 7.9–19.6 ppt; High =  $>$ 19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
847	0.87 (0.68,1.11)		0.261

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

All unadjusted and adjusted analyses in Models 2 through 4 showed no significant relation between dioxin and dichotomized  $\alpha$ -1-acid glycoprotein (Table 13-46(c–h):  $p > 0.10$  for each analysis).

### 13.2.2.3.38 $\alpha$ -1-Antitrypsin (Continuous)

Both the unadjusted and adjusted Model 1 analyses of  $\alpha$ -1-antitrypsin revealed significant overall group differences (Table 13-47(a,b): difference of means=3.5 mg/dl,  $p=0.002$ ; difference of adjusted means=3.6 mg/dl,  $p=0.001$ , respectively). The adjusted mean  $\alpha$ -1-antitrypsin level was 146.7 mg/dl for all Ranch Hands and 143.1 mg/dl for all Comparisons. After stratifying by occupation, the unadjusted and adjusted analyses each showed a significant difference between Ranch Hands and Comparisons among the enlisted groundcrew (Table 13-47(a,b): difference of means=5.5 mg/dl,  $p=0.001$ , unadjusted; difference of adjusted means=5.9 mg/dl,  $p < 0.001$ , adjusted). In addition, stratifying by occupation in the adjusted analysis revealed a marginally significant difference between Ranch Hands and Comparisons within the

enlisted flyer stratum (Table 13-47(b): difference of adjusted means=4.7 mg/dl, p=0.086). The adjusted mean  $\alpha$ -1-antitrypsin levels for Ranch Hands and Comparisons in the enlisted flyer stratum were 150.5 mg/dl and 145.9 mg/dl, respectively. Within the enlisted groundcrew stratum, the adjusted mean  $\alpha$ -1-antitrypsin levels were 151.5 mg/dl and 145.6 mg/dl for Ranch Hands and Comparisons, respectively.

**Table 13-47. Analysis of  $\alpha$ -1-Antitrypsin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>150.0</i>	3.5 --	<i>0.002</i>
	<i>Comparison</i>	<i>1,231</i>	<i>146.5</i>		
Officer	Ranch Hand	340	143.9	0.9 --	0.609
	Comparison	490	143.0		
Enlisted Flyer	Ranch Hand	150	155.3	4.2 --	0.136
	Comparison	185	151.1		
Enlisted Groundcrew	Ranch Hand	369	153.5	5.5 --	0.001
	Comparison	556	148.0		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>146.7</i>	3.6 --	<i>0.001</i>
	<i>Comparison</i>	<i>1,229</i>	<i>143.1</i>		
Officer	Ranch Hand	340	138.6	0.7 --	0.693
	Comparison	489	137.9		
Enlisted Flyer	Ranch Hand	148	150.5	4.7 --	0.086
	Comparison	184	145.9		
Enlisted Groundcrew	Ranch Hand	366	151.5	5.9 --	<0.001
	Comparison	556	145.6		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

**Table 13-47. Analysis of  $\alpha$ -1-Antitrypsin (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	148.4	148.2	0.013	0.066 (0.036)	0.071
Medium	159	153.8	153.7			
High	159	151.8	152.1			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on square root of  $\alpha$ -1-antitrypsin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	145.0	0.101	0.023 (0.041)	0.582
Medium	158	148.8			
High	157	145.6			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of  $\alpha$ -1-antitrypsin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	146.8	146.8		
Background RH	376	148.0	147.9	1.1 --	0.470
Low RH	236	148.8	148.9	2.1 --	0.244
High RH	240	153.8	154.0	7.2 --	<0.001
Low plus High RH	476	151.3	151.4	4.6 --	0.001

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>d</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-47. Analysis of  $\alpha$ -1-Antitrypsin (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	143.8		
Background RH	374	147.2	3.4 --	0.024
Low RH	235	145.5	1.7 --	0.339
High RH	238	148.4	4.6 --	0.011
Low plus High RH	473	147.0	3.2 --	0.020

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
1987 Dioxin	n	Mean <sup>a</sup>			
Low	283	148.3	0.003	0.040 (0.025)	0.109
Medium	285	148.2			
High	284	153.1			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of  $\alpha$ -1-antitrypsin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq$ 7.9 ppt; Medium =  $>$ 7.9–19.6 ppt; High =  $>$ 19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
1987 Dioxin	n	Adj. Mean <sup>a</sup>			
Low	283	147.2	0.102	-0.047 (0.027)	0.089
Medium	283	145.2			
High	281	145.0			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of  $\alpha$ -1-antitrypsin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq$ 7.9 ppt; Medium =  $>$ 7.9–19.6 ppt; High =  $>$ 19.6 ppt.

The unadjusted Model 2 analysis revealed a marginally significant positive association between  $\alpha$ -1-antitrypsin and initial dioxin (Table 13-47(c): slope=0.066, p=0.071). After adjusting for covariates, the relation became nonsignificant (Table 13-47(d): p=0.582).

The unadjusted Model 3 analysis revealed a marginally significant difference in mean  $\alpha$ -1-antitrypsin levels between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-47(e): difference of means=7.2 mg/dl,  $p<0.001$ ; difference of means=4.6 mg/dl,  $p=0.001$ , respectively).

Three significant contrasts were found in the adjusted Model 3 analysis of  $\alpha$ -1-antitrypsin: Ranch Hands in the background dioxin category versus Comparisons (Table 13-47(f): difference of adjusted means=3.4 mg/dl,  $p=0.024$ ), Ranch Hands in the high dioxin category versus Comparisons (difference of adjusted means=4.6 mg/dl,  $p=0.011$ ), and Ranch Hands in the low and high dioxin categories combined versus Comparisons (difference of adjusted means=3.2 mg/dl,  $p=0.020$ ). The adjusted mean  $\alpha$ -1-antitrypsin levels for Ranch Hands in the background dioxin category, Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 147.2 mg/dl, 148.4 mg/dl, 147.0 mg/dl, and 143.8 mg/dl, respectively.

The unadjusted Model 4 analysis results were nonsignificant (Table 13-47(g):  $p=0.109$ ). After adjusting for covariates, a marginally significant inverse relation between  $\alpha$ -1-antitrypsin and 1987 dioxin was seen (Table 13-47(g): adjusted slope=-0.047,  $p=0.089$ ). The adjusted mean  $\alpha$ -1-antitrypsin levels in the low, medium, and high 1987 dioxin categories were 147.2 mg/dl, 145.2 mg/dl, and 145.0 mg/dl, respectively.

#### *13.2.2.3.39 $\alpha$ -1-Antitrypsin (Discrete)*

All unadjusted and adjusted results for Models 1 through 4 did not reveal a significant association between the percentage of individuals with low  $\alpha$ -1-antitrypsin levels and dioxin or between the percentage of individuals with high  $\alpha$ -1-antitrypsin levels and dioxin (Table 13-48(a-h):  $p>0.11$  for all analyses).

**Table 13-48. Analysis of  $\alpha$ -1-Antitrypsin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>									
Occupational Category	Group	n	Number (%)			Abnormal Low vs. Normal		Abnormal High vs. Normal	
			Abnormal Low	Normal	Abnormal High	Est. Relative Risk (95% C.I.)	p-Value	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>11 (1.3)</i>	<i>840 (97.8)</i>	<i>8 (0.9)</i>	<i>0.88 (0.41,1.87)</i>	<i>0.737</i>	<i>2.30 (0.75,7.06)</i>	<i>0.145</i>
	<i>Comparison</i>	<i>1,231</i>	<i>18 (1.5)</i>	<i>1,208 (98.1)</i>	<i>5 (0.4)</i>				
Officer	Ranch Hand	340	8 (2.4)	330 (97.1)	2 (0.6)	1.06 (0.42,2.65)	0.908	--	0.327 <sup>a</sup>
	Comparison	490	11 (2.2)	479 (97.8)	0 (0.0)				
Enlisted Flyer	Ranch Hand	150	1 (0.7)	148 (98.7)	1 (0.7)	1.23 (0.08,19.83)	0.884	0.61 (0.07,5.25)	0.657
	Comparison	185	1 (0.5)	182 (98.4)	2 (1.1)				
Enlisted Groundcrew	Ranch Hand	369	2 (0.5)	362 (98.1)	5 (1.4)	0.50 (0.10,2.51)	0.403	2.52 (0.61,10.42)	0.202
	Comparison	556	6 (1.1)	547 (98.4)	3 (0.5)				

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with abnormal high  $\alpha$ -1-antitrypsin levels.

--: Results not presented because of the sparse number of participants with abnormal high  $\alpha$ -1-antitrypsin levels.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>				
Occupational Category	Abnormal Low vs. Normal		Abnormal High vs. Normal	
	Adj. Relative Risk (95% C.I.)	p-Value	Adj. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.81 (0.37,1.78)</i>	<i>0.606</i>	<i>2.51 (0.80,7.90)</i>	<i>0.116</i>
Officer	1.10 (0.44,2.78)	0.834	--	--
Enlisted Flyer	--	--	0.73 (0.08,6.49)	0.778
Enlisted Groundcrew	0.47 (0.10,2.34)	0.358	2.69 (0.63,11.58)	0.183

--: Results not presented because of the sparse number of participants with abnormal  $\alpha$ -1-antitrypsin levels.

Note: Results are not adjusted for race because of the sparse number of participants with abnormal  $\alpha$ -1-antitrypsin levels.

**Table 13-48. Analysis of  $\alpha$ -1-Antitrypsin (Discrete) (Continued)**

<b>(c) MODEL 2: RANCH HANDS — INITIAL DIOXIN — UNADJUSTED</b>								
Initial Dioxin Category Summary Statistics					Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>			
Initial Dioxin Category	n	Number (%)			Abnormal Low vs. Normal		Abnormal High vs. Normal	
		Abnormal Low	Normal	Abnormal High	Est. Relative Risk (95% C.I.) <sup>b</sup>	p-Value	Est. Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	1 (0.6)	156 (98.7)	1 (0.6)	0.83 (0.37,1.90)	0.667	1.05 (0.39,2.80)	0.925
Medium	159	2 (1.3)	156 (98.1)	1 (0.6)				
High	159	1 (0.6)	157 (98.7)	1 (0.6)				

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS — INITIAL DIOXIN — ADJUSTED</b>				
Analysis Results for Log <sub>2</sub> (Initial Dioxin)				
n	Abnormal Low vs. Normal		Abnormal High vs. Normal	
	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	0.75 (0.30,1.84)	0.526	0.80 (0.21,3.00)	0.735

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race, occupation, current wine consumption, and degreasing chemical exposure because of the sparse number of participants with abnormal  $\alpha$ -1-antitrypsin levels.

**Table 13-48. Analysis of  $\alpha$ -1-Antitrypsin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>								
Dioxin Category	n	Number (%)			Abnormal Low vs. Normal		Abnormal High vs. Normal	
		Abnormal Low	Normal	Abnormal High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	17 (1.4)	1,172 (98.2)	5 (0.4)				
Background RH	376	7 (1.9)	364 (96.8)	5 (1.3)	1.14 (0.47,2.79)	0.772	2.48 (0.70,8.77)	0.158
Low RH	236	2 (0.8)	233 (98.7)	1 (0.4)	0.61 (0.14,2.67)	0.513	1.03 (0.11,9.33)	0.976
High RH	240	2 (0.8)	236 (98.3)	2 (0.8)	0.68 (0.16,2.98)	0.610	3.49 (0.64,19.06)	0.149
Low plus High RH	476	4 (0.8)	469 (98.5)	3 (0.6)	0.65 (0.22,1.93)	0.434	1.91 (0.42,8.72)	0.404

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>					
Dioxin Category	n	Abnormal Low vs. Normal		Abnormal High vs. Normal	
		Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193				
Background RH	374	0.78 (0.30,2.01)	0.602	2.76 (0.74,10.35)	0.131
Low RH	235	0.76 (0.17,3.35)	0.712	1.16 (0.13,10.62)	0.895
High RH	238	1.41 (0.28,7.06)	0.677	2.64 (0.43,16.23)	0.295
Low plus High RH	473	1.03 (0.32,3.31)	0.955	1.75 (0.36,8.53)	0.486

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

Results are not adjusted for race because of the sparse number of participants with abnormal  $\alpha$ -1-antitrypsin levels.

**Table 13-48. Analysis of  $\alpha$ -1-Antitrypsin (Discrete) (Continued)**

<b>(g) MODEL 4: RANCH HANDS — 1987 DIOXIN — UNADJUSTED</b>								
1987 Dioxin Category Summary Statistics					Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
1987 Dioxin Category	n	Number (%)			Abnormal Low vs. Normal		Abnormal High vs. Normal	
		Abnormal Low	Normal	Abnormal High	Est. Relative Risk (95% C.I.) <sup>a</sup>	p-Value	Est. Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	5 (1.8)	274 (96.8)	4 (1.4)	0.76 (0.49,1.19)	0.229	0.80 (0.48,1.33)	0.393
Medium	285	3 (1.1)	280 (98.2)	2 (0.7)				
High	284	3 (1.1)	279 (98.2)	2 (0.7)				

<sup>a</sup>Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9-19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS — 1987 DIOXIN — ADJUSTED</b>				
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)				
n	Abnormal Low vs. Normal		Abnormal High vs. Normal	
	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value
847	0.84 (0.52,1.37)	0.486	0.75 (0.44,1.29)	0.302

<sup>a</sup>Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race and occupation because of the sparse number of participants with abnormal  $\alpha$ -1-antitrypsin levels.

13.2.2.3.40  $\alpha$ -2-Macroglobulin (Continuous)

All unadjusted and adjusted analyses of Models 1 through 4 showed no significant associations between dioxin and  $\alpha$ -2-macroglobulin in its continuous form (Table 13-49(a-h):  $p > 0.23$  for each analysis).

**Table 13-49. Analysis of  $\alpha$ -2-Macroglobulin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	859	170.6	-0.7 --	0.726
	<i>Comparison</i>	1,231	171.3		
Officer	Ranch Hand	340	170.6	-0.4 --	0.901
	Comparison	490	171.0		
Enlisted Flyer	Ranch Hand	150	177.0	-0.4 --	0.935
	Comparison	185	177.4		
Enlisted Groundcrew	Ranch Hand	369	168.1	-1.5 --	0.608
	Comparison	556	169.6		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	161.9	-0.9 --	0.610
	<i>Comparison</i>	1,229	162.8		
Officer	Ranch Hand	340	154.5	-1.2 --	0.643
	Comparison	489	155.7		
Enlisted Flyer	Ranch Hand	148	163.8	-1.9 --	0.664
	Comparison	184	165.7		
Enlisted Groundcrew	Ranch Hand	366	167.4	-0.2 --	0.951
	Comparison	556	167.6		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-49. Analysis of  $\alpha$ -2-Macroglobulin (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	R <sup>2</sup>	Slope (Std. Error) <sup>c</sup>	p-Value
Low	158	168.1	168.1	<0.001	-0.004 (0.009)	0.698
Medium	159	175.3	175.3			
High	159	167.4	167.4			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of  $\alpha$ -2-macroglobulin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
Initial Dioxin Category Summary Statistics				Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>		R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	154.2		0.135	0.009 (0.010)	0.368
Medium	158	163.5				
High	157	161.3				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -2-macroglobulin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>						
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>		p-Value <sup>d</sup>
Comparison	1,194	171.2	171.2			
Background RH	376	170.2	170.2	-1.0	--	0.706
Low RH	236	170.2	170.2	-1.0	--	0.747
High RH	240	170.2	170.2	-1.0	--	0.741
Low plus High RH	476	170.2	170.2	-1.0	--	0.669

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-49. Analysis of  $\alpha$ -2-Macroglobulin (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	ADJ. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	163.2		
Background RH	374	162.2	-1.0 --	0.683
Low RH	235	159.9	-3.3 --	0.232
High RH	238	163.3	0.1 --	0.959
Low plus High RH	473	161.6	-1.6 --	0.461

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	169.9	<0.001	-0.004 (0.006)	0.522
Medium	285	170.6			
High	284	170.2			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -2-macroglobulin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq$ 7.9 ppt; Medium =  $>$ 7.9–19.6 ppt; High =  $>$ 19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
1987 Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	162.9	0.131	-0.005 (0.006)	0.390
Medium	283	161.1			
High	281	162.8			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of  $\alpha$ -2-macroglobulin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low =  $\leq$ 7.9 ppt; Medium =  $>$ 7.9–19.6 ppt; High =  $>$ 19.6 ppt.

### 13.2.2.3.41 $\alpha$ -2-Macroglobulin (Discrete)

The unadjusted and adjusted Model 1 analyses of  $\alpha$ -2-macroglobulin were nonsignificant (Table 13-50(a,b):  $p > 0.15$  for each analysis). The unadjusted Model 2 analysis was not significant (Table 13-50(c):  $p = 0.254$ ), but the adjusted analysis was marginally significant (Table 13-50(d): Adj. RR=1.48,  $p = 0.072$ ).

The unadjusted Model 3 analysis revealed a marginally significant difference in high  $\alpha$ -2-macroglobulin levels between Ranch Hands in the background dioxin category and Comparisons (Table 13-50(e): Est. RR=0.46,  $p = 0.080$ ). The percentage of Ranch Hands in the background category with high  $\alpha$ -2-macroglobulin levels was 1.6 versus 3.8 for Comparisons. The same contrast was marginally significant in the adjusted Model 3 analysis (Table 13-50(f): Adj. RR=0.45,  $p = 0.079$ ).

**Table 13-50. Analysis of  $\alpha$ -2-Macroglobulin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	24 (2.8)	0.72 (0.44,1.19)	0.199
	<i>Comparison</i>	1,231	47 (3.8)		
Officer	Ranch Hand	340	8 (2.4)	0.63 (0.27,1.47)	0.287
	Comparison	490	18 (3.7)		
Enlisted Flyer	Ranch Hand	150	5 (3.3)	0.55 (0.19,1.61)	0.271
	Comparison	185	11 (5.9)		
Enlisted Groundcrew	Ranch Hand	369	11 (3.0)	0.92 (0.43,1.97)	0.827
	Comparison	556	18 (3.2)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	0.70 (0.42,1.16)	0.157
Officer	0.59 (0.25,1.40)	0.234
Enlisted Flyer	0.46 (0.15,1.39)	0.169
Enlisted Groundcrew	1.01 (0.46,2.19)	0.988

Note: Results are not adjusted for race because of the sparse number of participants with high  $\alpha$ -2-macroglobulin levels.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin Category Summary Statistics</b>			<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) High</b>		
Low	158	2 (1.3)	1.22 (0.87,1.71)	0.254
Medium	159	10 (6.3)		
High	159	5 (3.1)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-50. Analysis of  $\alpha$ -2-Macroglobulin (Discrete) (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.48 (0.96,2.27)	0.072

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race because of the sparse number of Ranch Hands with high  $\alpha$ -2-macroglobulin levels.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	45 (3.8)		
Background RH	376	6 (1.6)	0.46 (0.19,1.10)	0.080
Low RH	236	7 (3.0)	0.75 (0.33,1.69)	0.492
High RH	240	10 (4.2)	1.00 (0.49,2.03)	0.999
Low plus High RH	476	17 (3.6)	0.87 (0.49,1.55)	0.632

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	0.45 (0.19,1.10)	0.079
Low RH	235	0.61 (0.27,1.40)	0.246
High RH	238	1.09 (0.51,2.31)	0.823
Low plus High RH	473	0.82 (0.45,1.49)	0.511

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$  10 ppt, Initial Dioxin  $>$  94 ppt.

Results are not adjusted for race because of the sparse number of participants with high  $\alpha$ -2-macroglobulin levels.

**Table 13-50. Analysis of  $\alpha$ -2-Macroglobulin (Discrete) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	3 (1.1)	1.37 (1.06,1.77)	0.020
Medium	285	8 (2.8)		
High	284	12 (4.2)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low =  $\leq 7.9$  ppt; Medium =  $>7.9$ – $19.6$  ppt; High =  $>19.6$  ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
847	1.50 (1.08,2.08)		0.014

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race because of the sparse number of participants with high  $\alpha$ -2-macroglobulin levels.

Both the unadjusted and adjusted Model 4 analyses revealed significant associations between  $\alpha$ -2-macroglobulin and 1987 dioxin (Table 13-50(g,h): Est. RR=1.37, p=0.020; Adj. RR=1.50, p=0.014, respectively). The percentages of participants with high  $\alpha$ -2-macroglobulin values in the low, medium, and high 1987 dioxin categories were 1.1, 2.8, and 4.2, respectively.

*13.2.2.3.42 Apolipoprotein B (mg/dl) (Continuous)*

The Model 1 analysis of apolipoprotein B did not show a significant overall difference between Ranch Hands and Comparisons in either the unadjusted or adjusted analyses (Table 13-51(a,b):  $p > 0.27$  for each analysis). After stratifying by occupation, a significant difference between Ranch Hands and Comparisons was discovered among the officers in both the unadjusted and adjusted analyses (Table 13-51(a,b): difference of means =  $-3.3$  mg/dl,  $p = 0.053$ , for the unadjusted analysis; difference of adjusted means =  $-3.3$  mg/dl,  $p = 0.048$ , for the adjusted analysis). The adjusted mean apolipoprotein B level among the Ranch Hand officers was 105.9 mg/dl versus 109.2 mg/dl among the Comparison officers.

**Table 13-51. Analysis of Apolipoprotein B (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>110.5</i>	<i>-1.1 --</i>	<i>0.320</i>
	<i>Comparison</i>	<i>1,231</i>	<i>111.5</i>		
Officer	Ranch Hand	340	106.4	-3.3 --	0.053
	Comparison	490	109.6		
Enlisted Flyer	Ranch Hand	150	113.2	-2.0 --	0.463
	Comparison	185	115.2		
Enlisted Groundcrew	Ranch Hand	369	113.1	1.2 --	0.479
	Comparison	556	112.0		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>110.6</i>	<i>-1.2 --</i>	<i>0.275</i>
	<i>Comparison</i>	<i>1,229</i>	<i>111.8</i>		
Officer	Ranch Hand	340	105.9	-3.3 --	0.048
	Comparison	489	109.2		
Enlisted Flyer	Ranch Hand	148	112.9	-2.2 --	0.413
	Comparison	184	115.1		
Enlisted Groundcrew	Ranch Hand	366	112.6	1.2 --	0.457
	Comparison	556	111.4		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	107.1	107.0	0.014	0.107 (0.041)	0.009
Medium	159	113.9	113.9			
High	159	114.5	114.6			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on square root of apolipoprotein B versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-51. Analysis of Apolipoprotein B (mg/dl) (Continuous) (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	108.5	0.033	0.061 (0.048)	0.209
Medium	158	113.8			
High	157	113.2			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of apolipoprotein B versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	111.5	111.5		
Background RH	376	108.8	108.8	-2.7 --	0.057
Low RH	236	108.9	108.9	-2.6 --	0.131
High RH	240	114.7	114.6	3.1 --	0.073
Low plus High RH	476	111.8	111.8	0.3 --	0.843

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>d</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>					
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>	
Comparison	1,193	112.0			
Background RH	374	110.0	-2.0 --	0.170	
Low RH	235	109.5	-2.5 --	0.154	
High RH	238	113.6	1.6 --	0.358	
Low plus High RH	473	111.6	-0.4 --	0.761	

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-51. Analysis of Apolipoprotein B (mg/dl) (Continuous) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	109.2	0.011	0.083 (0.027)	0.002
Medium	285	108.0			
High	284	114.2			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of apolipoprotein B versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	111.0	0.023	0.046 (0.031)	0.142
Medium	283	109.0			
High	281	112.9			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of apolipoprotein B versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted Model 2 analysis revealed a significant relation between initial dioxin and apolipoprotein B (Table 13-51(c): slope=0.107, p=0.009). The adjusted analysis results were not significant (Table 13-51(d): p=0.209).

The unadjusted Model 3 analysis revealed two marginally significant contrasts: Ranch Hands in the background dioxin category versus Comparisons and Ranch Hands in the high dioxin category versus Comparisons (Table 13-51(e): difference of means=-2.7 mg/dl, p=0.057; difference of means=3.1 mg/dl, p=0.073, respectively). After adjusting for covariates, no contrasts were significant (Table 13-51(f): p>0.15 for each contrast).

The Model 4 unadjusted analysis of apolipoprotein B revealed a significant association with 1987 dioxin (Table 13-51(g): slope=0.083, p=0.002). The adjusted analysis was nonsignificant (Table 13-51(h): p=0.142).

The reference range between 1992 and 1997 decreased according to the manufacturer’s recommendation. Consequently, the mean levels shown in Table 13-51 are less than the 1992 mean levels.

#### 13.2.2.3.43 Apolipoprotein B (Discrete)

Both the unadjusted and adjusted Model 1 analyses of apolipoprotein B in its dichotomous form revealed marginally significant overall group differences (Table 13-52(a,b): Est. RR=0.86, p=0.087; Adj. RR=0.85, p=0.073, respectively). After stratifying by occupation, unadjusted and adjusted analyses revealed group differences within the enlisted flyer stratum (Table 13-52(a,b): Est. RR=0.55, p=0.007; Adj. RR=0.53, p=0.005, respectively). The percentage of participants in the Ranch Hand group with high

apolipoprotein B values was 49.2 versus 53.0 for Comparisons. Within the enlisted flyer stratum, 48.0 percent of the Ranch Hands had high apolipoprotein B values versus 62.7 percent of the Comparisons. The unadjusted Model 2 analysis revealed a marginally significant association between apolipoprotein B and initial dioxin (Table 13-52(c): Est. RR=1.14, p=0.059). The adjusted analysis showed no significant results (Table 13-52(d): p=0.456).

**Table 13-52. Analysis of Apolipoprotein B (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	423 (49.2)	<i>0.86 (0.72,1.02)</i>	<i>0.087</i>
	<i>Comparison</i>	1,231	653 (53.0)		
Officer	Ranch Hand	340	149 (43.8)	0.80 (0.61,1.06)	0.114
	Comparison	490	242 (49.4)		
Enlisted Flyer	Ranch Hand	150	72 (48.0)	0.55 (0.35,0.85)	0.007
	Comparison	185	116 (62.7)		
Enlisted Groundcrew	Ranch Hand	369	202 (54.7)	1.07 (0.82,1.39)	0.615
	Comparison	556	295 (53.1)		

  

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.85 (0.71,1.02)</i>	<i>0.073</i>
Officer	0.80 (0.61,1.06)	0.115
Enlisted Flyer	0.53 (0.34,0.82)	0.005
Enlisted Groundcrew	1.07 (0.82,1.40)	0.603

  

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	73 (46.2)	1.14 (0.99,1.31)	0.059
Medium	159	84 (52.8)		
High	159	88 (55.3)		

  

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	1.06 (0.90,1.25)	0.456

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-52. Analysis of Apolipoprotein B (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	636 (53.3)		
Background RH	376	174 (46.3)	0.75 (0.60,0.95)	0.017
Low RH	236	113 (47.9)	0.81 (0.61,1.07)	0.132
High RH	240	132 (55.0)	1.08 (0.81,1.42)	0.606
Low plus High RH	476	245 (51.5)	0.93 (0.75,1.16)	0.524

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	0.79 (0.62,1.00)	0.050
Low RH	235	0.82 (0.62,1.09)	0.164
High RH	238	0.97 (0.73,1.30)	0.849
Low plus High RH	473	0.89 (0.72,1.11)	0.305

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	135 (47.7)	1.12 (1.02,1.23)	0.017
Medium	285	130 (45.6)		
High	284	154 (54.2)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-52. Analysis of Apolipoprotein B (Discrete) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)		
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
847	1.07 (0.96,1.18)	0.242

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Model 3 revealed significant relations between Ranch Hands in the background dioxin category and Comparisons for both the unadjusted and adjusted analyses (Table 13-52(e,f): Est. RR=0.75, p=0.017; Adj. RR=0.79, p=0.050, respectively). The percentage of high apolipoprotein B values among the Ranch Hands in the background dioxin category was 46.3 versus 53.3 for Comparisons.

The unadjusted Model 4 analysis of apolipoprotein B showed a significant association with 1987 dioxin (Table 13-52(g): Est. RR=1.12, p=0.017). After adjusting for covariates, the relation became nonsignificant (Table 13-52(h): p=0.242).

The reference range between 1992 and 1997 decreased according to the manufacturer’s recommendation. The change may explain partially the decrease in the percentage of participants with high apolipoprotein B levels between 1992 and 1997.

#### 13.2.2.3.44 C3 Complement (mg/dl) (Continuous)

The unadjusted and adjusted Model 1 analyses of C3 complement in its continuous form revealed no significant group differences (Table 13-53(a,b): p>0.50 for each analysis).

**Table 13-53. Analysis of C3 Complement (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>118.9</i>	<i>0.4 --</i>	<i>0.640</i>
	<i>Comparison</i>	<i>1,231</i>	<i>118.5</i>		
Officer	Ranch Hand	340	114.9	0.3 --	0.814
	Comparison	490	114.6		
Enlisted Flyer	Ranch Hand	150	120.3	-0.4 --	0.862
	Comparison	185	120.7		
Enlisted Groundcrew	Ranch Hand	369	122.1	0.8 --	0.537
	Comparison	556	121.3		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-53. Analysis of C3 Complement (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	120.2	0.2 --	0.837
	<i>Comparison</i>	1,229	120.0		
Officer	Ranch Hand	340	116.5	0.4 --	0.765
	Comparison	489	116.1		
Enlisted Flyer	Ranch Hand	148	120.8	-1.4 --	0.505
	Comparison	184	122.2		
Enlisted Groundcrew	Ranch Hand	366	122.8	0.6 --	0.668
	Comparison	556	122.3		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	118.3	118.8	0.071	0.012 (0.005)	0.023
Medium	159	123.6	123.7			
High	159	124.0	123.4			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of C3 complement versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>				
Low	158	119.1		0.083	0.009 (0.006)	0.145
Medium	158	123.9				
High	157	122.7				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C3 complement versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-53. Analysis of C3 Complement (mg/dl) (Continuous) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	118.5	118.5		
Background RH	376	115.2	116.7	-1.8 --	0.107
Low RH	236	120.0	119.5	1.0 --	0.399
High RH	240	123.9	122.3	3.8 --	0.003
Low plus High RH	476	122.0	120.9	2.4 --	0.013

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>					
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>	
Comparison	1,193	120.1			
Background RH	374	119.5	-0.6 --	0.594	
Low RH	235	121.0	0.9 --	0.518	
High RH	238	121.8	1.7 --	0.217	
Low plus High RH	473	121.4	1.3 --	0.213	

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
1987 Dioxin	n	Mean <sup>a</sup>			
Low	283	115.1	0.040	0.021 (0.004)	<0.001
Medium	285	117.8			
High	284	124.1			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C3 complement versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-53. Analysis of C3 Complement (mg/dl) (Continuous) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	117.6	0.067	0.017 (0.004)	<0.001
Medium	283	119.6			
High	281	124.6			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C3 complement versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

A significant relation was found between initial dioxin and C3 complement in the unadjusted Model 2 analysis (Table 13-53(c): slope=0.012, p=0.023). The adjusted analysis was nonsignificant (Table 13-53(d): p=0.145).

The unadjusted Model 3 analysis revealed a significant difference in mean C3 complement levels between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-53(e): difference of means=3.8 mg/dl, p=0.003; difference of means=2.4 mg/dl, p=0.013, respectively). The adjusted analysis showed no significant differences between any of the Ranch Hand categories and Comparisons (Table 13-53(f): p>0.21 for each contrast).

Both the unadjusted and adjusted Model 4 analyses revealed significant associations between C3 complement and 1987 dioxin (Table 13-53(g,h): slope=0.021, p<0.001; adjusted slope=0.017, p<0.001, respectively). The adjusted mean C3 complement levels in the low, medium, and high 1987 dioxin categories were 117.6 mg/dl, 119.6 mg/dl, 124.6 mg/dl, respectively.

#### 13.2.2.3.45 C3 Complement (Discrete)

The unadjusted and adjusted Model 1 analyses showed no significant difference in the percentage of low C3 complement values between Ranch Hands and Comparisons (Table 13-54(a,b): p>0.19 for each analysis).

**Table 13-54. Analysis of C3 Complement (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>15 (1.7)</i>	<i>0.76 (0.41,1.44)</i>	<i>0.398</i>
	<i>Comparison</i>	<i>1,231</i>	<i>28 (2.3)</i>		
Officer	Ranch Hand	340	6 (1.8)	0.61 (0.23,1.61)	0.317
	Comparison	490	14 (2.9)		
Enlisted Flyer	Ranch Hand	150	1 (0.7)	0.24 (0.03,2.09)	0.197
	Comparison	185	5 (2.7)		
Enlisted Groundcrew	Ranch Hand	369	8 (2.2)	1.35 (0.51,3.52)	0.544
	Comparison	556	9 (1.6)		

**Table 13-54. Analysis of C3 Complement (Discrete) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
<b>Occupational Category</b>	<b>Adjusted Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>0.79 (0.42,1.50)</i>	<i>0.474</i>
Officer	0.62 (0.23,1.63)	0.333
Enlisted Flyer	0.27 (0.03,2.33)	0.233
Enlisted Groundcrew	1.41 (0.54,3.71)	0.487

Note: Results are not adjusted for race because of the sparse number of participants with low C3 complement levels.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	158	1 (0.6)	1.06 (0.45,2.49)	0.898
Medium	159	1 (0.6)		
High	159	1 (0.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
473	1.01 (0.39,2.62)		0.977

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race and occupation because of the sparse number of Ranch Hands with low C3 complement levels.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,194	26 (2.2)		
Background RH	376	12 (3.2)	1.28 (0.63,2.57)	0.495
Low RH	236	1 (0.4)	0.20 (0.03,1.46)	0.111
High RH	240	2 (0.8)	0.44 (0.10,1.86)	0.261
Low plus High RH	476	3 (0.6)	0.29 (0.08,1.04)	0.057

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-54. Analysis of C3 Complement (Discrete) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
<b>Dioxin Category</b>	<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Comparison	1,193		
Background RH	374	1.25 (0.61,2.57)	0.536
Low RH	235	0.21 (0.03,1.57)	0.128
High RH	238	0.49 (0.11,2.17)	0.351
Low plus High RH	473	0.32 (0.09,1.16)	0.083

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for race because of the sparse number of participants with low C3 complement levels.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>	
<b>1987 Dioxin</b>	<b>n</b>	<b>Number (%) Low</b>	<b>Estimated Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value</b>
Low	283	10 (3.5)	0.61 (0.41,0.91)	0.011
Medium	285	3 (1.1)		
High	284	2 (0.7)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>			
<b>n</b>	<b>Adjusted Relative Risk (95% C.I.)<sup>a</sup></b>		<b>p-Value</b>
847	0.57 (0.39,0.84)		0.004

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race because of the sparse number of Ranch Hands with low C3 complement levels.

The Model 2 unadjusted and adjusted analyses results were nonsignificant (Table 13-54(c,d):  $p > 0.89$  for each analysis). Both the unadjusted and adjusted Model 3 analyses revealed marginally significant differences between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-54(e,f): Est. RR=0.29,  $p=0.057$ ; Adj. RR=0.32,  $p=0.083$ , respectively). The percentage of low C3 complement values for Ranch Hands in the low and high dioxin categories combined was 0.6 versus 2.2 in the Comparison category.

The Model 4 unadjusted and adjusted analyses each revealed a significant association between C3 complement and 1987 dioxin (Table 13-54(g,h): Est. RR=0.61,  $p=0.011$ ; Adj. RR=0.57,  $p=0.004$ ,

respectively). The percentages of low C3 complement values in the low, medium, and high 1987 dioxin categories were 3.5, 1.1, and 0.7, respectively.

13.2.2.3.46 C4 Complement (Continuous)

The Model 1 unadjusted analysis of C4 complement showed no overall group differences (Table 13-55(a,b):  $p > 0.33$  for each analysis). Stratifying by occupation revealed a significant difference between Ranch Hand and Comparison officers, as well as enlisted flyers (Table 13-55(a): difference of means =  $-0.81$  mg/dl,  $p = 0.024$ , for the officer stratum; difference of means =  $1.02$  mg/dl,  $p = 0.076$ , for the enlisted flyer stratum). After adjusting for covariates, a significant difference between Ranch Hands and Comparisons was noted only among the officer stratum (Table 13-55(b): difference of adjusted means =  $-0.90$  mg/dl,  $p = 0.017$ ). The adjusted mean C4 complement value for Ranch Hand officers was 26.02 mg/dl versus 26.91 mg/dl for Comparison officers.

**Table 13-55. Analysis of C4 Complement (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	859	25.71	-0.20 --	0.395
	<i>Comparison</i>	1,231	25.91		
Officer	Ranch Hand	340	24.73	-0.81 --	0.024
	Comparison	490	25.54		
Enlisted Flyer	Ranch Hand	150	26.52	1.02 --	0.076
	Comparison	185	25.50		
Enlisted Groundcrew	Ranch Hand	369	26.31	-0.06 --	0.862
	Comparison	556	26.38		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	26.98	-0.23 --	0.333
	<i>Comparison</i>	1,229	27.21		
Officer	Ranch Hand	340	26.02	-0.90 --	0.017
	Comparison	489	26.91		
Enlisted Flyer	Ranch Hand	148	27.74	0.98 --	0.104
	Comparison	184	26.77		
Enlisted Groundcrew	Ranch Hand	366	27.61	-0.06 --	0.876
	Comparison	556	27.67		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-55. Analysis of C4 Complement (mg/dl) (Continuous) (Continued)**

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
Low	158	25.70	25.72	0.002	-0.003 (0.007)	0.701
Medium	159	26.43	26.43			
High	159	26.07	26.05			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of C4 complement versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	158	26.58	0.019	-0.004 (0.008)	0.638
Medium	158	27.31			
High	157	27.01			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C4 complement versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>d</sup></b>
Comparison	1,194	25.91	25.90		
Background RH	376	25.26	25.41	-0.49 --	0.109
Low RH	236	26.07	26.03	0.13 --	0.733
High RH	240	26.06	25.91	0.01 --	0.986
Low plus High RH	476	26.06	25.97	0.07 --	0.816

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-55. Analysis of C4 Complement (mg/dl) (Continuous) (Continued)**

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
Comparison	1,193	27.24		
Background RH	374	26.93	-0.31 --	0.336
Low RH	235	27.27	0.03 --	0.942
High RH	238	26.97	-0.27 --	0.494
Low plus High RH	473	27.12	-0.12 --	0.680

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	25.10	0.004	0.009 (0.005)	0.070
Medium	285	25.85			
High	284	26.19			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C4 complement versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	26.73	0.044	0.001 (0.005)	0.849
Medium	283	27.16			
High	281	27.02			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of C4 complement versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted and adjusted analyses for Models 2 and 3 showed no significant relation between dioxin and C4 complement (Table 13-55(c–f): p>0.10 for each analysis). A marginally significant association between 1987 dioxin and C4 complement was revealed in the unadjusted Model 4 analysis (Table 13-55(g): slope=0.009, p=0.070). After covariate adjustment, the adjusted analysis results became nonsignificant (Table 13-55(h): p=0.849).

13.2.2.3.47 C4 Complement (Discrete)

Because of a sparse number of low C4 complement values among the participants, some analyses were not possible. Table 13-56 contains the results of these analyses.

**Table 13-56. Analysis of C4 Complement (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Low	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	2 (0.2)	<i>1.43 (0.20,10.20)</i>	<i>0.719</i>
	<i>Comparison</i>	1,231	2 (0.2)		
Officer	Ranch Hand	340	2 (0.6)	2.89 (0.26,32.04)	0.386
	Comparison	490	1 (0.2)		
Enlisted Flyer	Ranch Hand	150	0 (0.0)	--	0.999 <sup>a</sup>
	Comparison	185	1 (0.5)		
Enlisted Groundcrew	Ranch Hand	369	0 (0.0)	--	--
	Comparison	556	0 (0.0)		

<sup>a</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a low C4 complement level.

--: Results not presented because of the sparse number of participants with a low C4 complement level.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.46 (0.20,10.59)</i>	<i>0.707</i>
Officer	2.85 (0.26,31.68)	0.394
Enlisted Flyer	--	--
Enlisted Groundcrew	--	--

--: Results not presented because of the sparse number of participants with a low C4 complement level.

Note: Results for analysis across all occupational categories are not adjusted for race, occupation, and degreasing chemical exposure because of the sparse number of participants with a low C4 complement level; results for individual occupational categories are not adjusted for race and degreasing chemical exposure because of the sparse number of participants with a low C4 complement level.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	0 (0.0)	--	--
Medium	159	0 (0.0)		
High	159	0 (0.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

--: Results not presented because of the sparse number of Ranch Hands with a low C4 complement level.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-56. Analysis of C4 Complement (Discrete) (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (Initial Dioxin)			
n	Adjusted Relative Risk (95% C.I.)		p-Value
--	--		--

--: Results not presented because of the sparse number of Ranch Hands with a low C4 complement level.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Low	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	2 (0.2)		
Background RH	376	2 (0.5)	3.46 (0.47,25.38)	0.222
Low RH	236	0 (0.0)	--	0.999 <sup>c</sup>
High RH	240	0 (0.0)	--	0.999 <sup>c</sup>
Low plus High RH	476	0 (0.0)	--	0.913 <sup>c</sup>

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a low C4 complement level.

--: Results not presented because of the sparse number of Ranch Hands with a low C4 complement level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	2.99 (0.40,22.39)	0.286
Low RH	235	--	--
High RH	238	--	--
Low plus High RH	473	--	--

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

--: Results not presented because of the sparse number of Ranch Hands with a low C4 complement level.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for race, occupation, and degreasing chemical exposure because of the sparse number of participants with a low C4 complement level.

**Table 13-56. Analysis of C4 Complement (Discrete) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	2 (0.7)	0.32 (0.12,0.90)	0.033
Medium	285	0 (0.0)		
High	284	0 (0.0)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>		p-Value
847	0.26 (0.08,0.86)		0.024

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race, occupation, industrial chemical exposure, and degreasing chemical exposure because of the sparse number of Ranch Hands with a low C4 complement level.

Unadjusted and adjusted results for Models 1 through 3 revealed no significant associations between C4 complement in its dichotomous form and dioxin (Table 13-56(a–f):  $p > 0.22$  for each contrast). The unadjusted and adjusted Model 4 analyses revealed a significant relation between C4 complement and 1987 dioxin (Table 13-56(g,h): Est. RR=0.32,  $p=0.033$ ; Adj. RR=0.26,  $p=0.024$ , respectively).

#### 13.2.2.3.48 Haptoglobin (Continuous)

The unadjusted and adjusted Model 1 analyses of haptoglobin each revealed a significant overall group difference (Table 13-57(a,b): difference of means=8.7 mg/dl,  $p=0.002$ , for the unadjusted analysis; difference of means=8.0 mg/dl,  $p=0.003$ , for the adjusted analysis). The adjusted mean haptoglobin values for the Ranch Hands were 128.5 mg/dl versus 120.5 mg/dl for the Comparisons. After stratifying by occupation, both the unadjusted and adjusted analyses showed a significant difference in mean haptoglobin levels between Ranch Hands and Comparisons in the enlisted groundcrew stratum (Table 13-57(a,b): difference of means=10.2 mg/dl,  $p=0.016$ , for the unadjusted analysis; difference of adjusted means=9.9 mg/dl,  $p=0.016$ , for the adjusted analysis). The adjusted mean haptoglobin level among Ranch Hand enlisted groundcrew was 137.4 mg/dl versus 127.4 mg/dl among Comparison enlisted groundcrew.

**Table 13-57. Analysis of Haptoglobin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>135.2</i>	8.7 --	<i>0.002</i>
	<i>Comparison</i>	<i>1,231</i>	<i>126.5</i>		
Officer	Ranch Hand	340	122.4	6.1 --	0.140
	Comparison	490	116.3		
Enlisted Flyer	Ranch Hand	150	147.8	10.4 --	0.141
	Comparison	185	137.4		
Enlisted Groundcrew	Ranch Hand	369	142.5	10.2 --	0.016
	Comparison	556	132.3		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>854</i>	<i>128.5</i>	8.0 --	<i>0.003</i>
	<i>Comparison</i>	<i>1,229</i>	<i>120.5</i>		
Officer	Ranch Hand	340	112.2	5.4 --	0.172
	Comparison	489	106.8		
Enlisted Flyer	Ranch Hand	148	137.3	9.5 --	0.160
	Comparison	184	127.8		
Enlisted Groundcrew	Ranch Hand	366	137.4	9.9 --	0.016
	Comparison	556	127.4		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	130.2	130.3	0.002	0.084 (0.097)	0.387
Medium	159	144.4	144.5			
High	159	140.0	139.9			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on square root of haptoglobin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-57. Analysis of Haptoglobin (mg/dl) (Continuous) (Continued)**

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>					
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
Initial Dioxin	n	Adj. Mean <sup>a</sup>	R <sup>2</sup>	Adj. Slope (Std. Error) <sup>b</sup>	p-Value
Low	158	118.8	0.066	-0.087 (0.111)	0.433
Medium	158	124.6			
High	157	116.4			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of haptoglobin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	126.7	126.7		
Background RH	376	131.3	131.4	4.7 --	0.210
Low RH	236	134.6	134.5	7.8 --	0.078
High RH	240	141.8	141.7	15.0 --	0.001
Low plus High RH	476	138.2	138.1	11.4 --	0.001

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>d</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>					
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>	
Comparison	1,193	120.9			
Background RH	374	129.8	8.9 --	0.014	
Low RH	235	127.5	6.6 --	0.118	
High RH	238	128.0	7.1 --	0.105	
Low plus High RH	473	127.7	6.8 --	0.036	

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on square root scale.

<sup>c</sup> P-value is based on difference of means on square root scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

**Table 13-57. Analysis of Haptoglobin (mg/dl) (Continuous) (Continued)**

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin +1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	130.4	0.002	0.074 (0.065)	0.254
Medium	285	132.6			
High	284	142.5			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of haptoglobin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	127.4	0.055	-0.116 (0.073)	0.114
Medium	283	125.1			
High	281	124.4			

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Slope and standard error based on square root of haptoglobin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted and adjusted Model 2 analyses showed no significant relation between initial dioxin and haptoglobin (Table 13-57(c,d):  $p > 0.38$  for each analysis). Three significant contrasts were found in the unadjusted Model 3 analysis of haptoglobin: Ranch Hands in the low dioxin category versus Comparisons (Table 13-57(e): difference of means=7.8 mg/dl,  $p=0.078$ ), Ranch Hands in the high dioxin category versus Comparisons (Table 13-57(e): difference of means=15.0 mg/dl,  $p=0.001$ ), and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-57(e): difference of means=11.4 mg/dl,  $p=0.001$ ).

After adjusting for covariates, two contrasts were found to be significant in the Model 3 analysis: Ranch Hands in the background dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-57(f): difference of adjusted means=8.9 mg/dl,  $p=0.014$ ; difference of adjusted means=6.8 mg/dl,  $p=0.036$ , respectively). The adjusted mean haptoglobin levels for Ranch Hands in the background dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 129.8 mg/dl, 127.7 mg/dl, and 120.9 mg/dl respectively. No significant relation was determined between 1987 dioxin and haptoglobin in either the unadjusted or adjusted Model 4 analysis (Table 13-57(g,h):  $p > 0.11$  for each analysis).

#### 13.2.2.3.49 Haptoglobin (Discrete)

A significant overall group difference was revealed in both the unadjusted and adjusted Model 1 analyses of haptoglobin in its discrete form (Table 13-58(a,b): Est. RR=1.26,  $p=0.017$ ; Adj. RR=1.26,  $p=0.020$ , respectively). The percentage of Ranch Hands with high haptoglobin levels was 32.7 versus 27.9 for Comparisons. After stratifying by occupation, both the unadjusted and adjusted analyses revealed a marginally significant difference between Ranch Hands and Comparisons among the enlisted groundcrew

(Table 13-58(a,b): Est. RR=1.30, p=0.063; Adj. RR=1.31, p=0.061, respectively). The percentage of high haptoglobin levels among the Ranch Hand enlisted groundcrew was 37.4 versus 31.5 among the Comparison enlisted groundcrew.

**Table 13-58. Analysis of Haptoglobin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) High	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	281 (32.7)	<i>1.26 (1.04,1.52)</i>	<i>0.017</i>
	<i>Comparison</i>	1,231	343 (27.9)		
Officer	Ranch Hand	340	84 (24.7)	1.19 (0.86,1.65)	0.300
	Comparison	490	106 (21.6)		
Enlisted Flyer	Ranch Hand	150	59 (39.3)	1.29 (0.82,2.01)	0.271
	Comparison	185	62 (33.5)		
Enlisted Groundcrew	Ranch Hand	369	138 (37.4)	1.30 (0.99,1.72)	0.063
	Comparison	556	175 (31.5)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>1.26 (1.04,1.52)</i>	<i>0.020</i>
Officer	1.18 (0.85,1.64)	0.316
Enlisted Flyer	1.27 (0.81,2.01)	0.295
Enlisted Groundcrew	1.31 (0.99,1.73)	0.061

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	49 (31.0)	1.05 (0.91,1.21)	0.506
Medium	159	57 (35.8)		
High	159	58 (36.5)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	0.98 (0.82,1.16)	0.785

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-58. Analysis of Haptoglobin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) High	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	337 (28.2)		
Background RH	376	115 (30.6)	1.13 (0.88,1.46)	0.338
Low RH	236	78 (33.1)	1.25 (0.93,1.69)	0.140
High RH	240	86 (35.8)	1.41 (1.05,1.89)	0.023
Low plus High RH	476	164 (34.5)	1.33 (1.06,1.67)	0.015

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Comparison	1,193		
Background RH	374	1.32 (1.01,1.72)	0.042
Low RH	235	1.25 (0.92,1.69)	0.160
High RH	238	1.15 (0.84,1.56)	0.382
Low plus High RH	473	1.19 (0.95,1.51)	0.136

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) High	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	86 (30.4)	1.03 (0.94,1.14)	0.509
Medium	285	88 (30.9)		
High	284	105 (37.0)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>			
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value	
847	0.91 (0.82,1.02)	0.107	

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

No significant relation between initial dioxin and haptoglobin in its discrete form was revealed in either the unadjusted or adjusted Model 2 analyses (Table 13-58(c,d):  $p > 0.50$  for each analysis). The unadjusted Model 3 analysis of haptoglobin revealed significant differences between Ranch Hands and Comparisons for Ranch Hands in the high dioxin category and Ranch Hands in the low and high dioxin categories combined (Table 13-58(e): Est. RR=1.41,  $p=0.023$ ; Est. RR=1.33,  $p=0.015$ , respectively). The adjusted Model 3 analysis showed a significant difference between Ranch Hands in the background dioxin category and Comparisons (Table 13-58(f): Adj. RR=1.32,  $p=0.042$ ). The percentages of high haptoglobin values for Ranch Hands in the background dioxin category, Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 30.6, 35.8, 34.5, and 28.2, respectively. The unadjusted and adjusted Model 4 analyses were nonsignificant (Table 13-58(g,h):  $p > 0.10$  for each analysis).

#### 13.2.2.3.50 *Transferrin (Continuous)*

The unadjusted and adjusted Model 1 analyses each revealed a significant overall group difference in the mean levels of transferrin (Table 13-59(a,b): difference of means=3.1 mg/dl,  $p=0.044$ , for the unadjusted analysis; difference of adjusted means=3.1 mg/dl,  $p=0.037$ , for the adjusted analysis). The adjusted mean level of transferrin was higher for the Ranch Hands than for the Comparisons (246.2 mg/dl vs. 243.1 mg/dl). Stratifying by occupation uncovered a marginally significant group difference within the enlisted groundcrew stratum in both the unadjusted and adjusted analyses (Table 13-59(a,b): difference of means=4.5 mg/dl,  $p=0.056$ , for the unadjusted analysis; difference of adjusted means=4.2 mg/dl,  $p=0.063$ , for the adjusted analysis). The adjusted mean level of transferrin among Ranch Hand enlisted groundcrew was 247.1 mg/dl versus 242.9 mg/dl among the Comparison enlisted groundcrew.

**Table 13-59. Analysis of Transferrin (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>859</i>	<i>252.7</i>	<i>3.1 --</i>	<i>0.044</i>
	<i>Comparison</i>	<i>1,231</i>	<i>249.6</i>		
Officer	Ranch Hand	340	250.0	1.6 --	0.510
	Comparison	490	248.4		
Enlisted Flyer	Ranch Hand	150	254.5	3.0 --	0.439
	Comparison	185	251.5		
Enlisted Groundcrew	Ranch Hand	369	254.5	4.5 --	0.056
	Comparison	556	250.0		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

**Table 13-59. Analysis of Transferrin (Continuous) (mg/dl) (Continued)**

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>					
Occupational Category	Group	n	Adj. Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	854	246.2	3.1 --	0.037
	<i>Comparison</i>	1,229	243.1		
Officer	Ranch Hand	340	243.5	1.9 --	0.412
	Comparison	489	241.6		
Enlisted Flyer	Ranch Hand	148	247.9	3.1 --	0.404
	Comparison	184	244.8		
Enlisted Groundcrew	Ranch Hand	366	247.1	4.2 --	0.063
	Comparison	556	242.9		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin Category Summary Statistics</b>				<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>			
Low	158	251.5	251.5	0.001	0.003 (0.005)	0.594
Medium	159	254.8	254.8			
High	159	255.6	255.5			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of transferrin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)</b>		
<b>Initial Dioxin Category Summary Statistics</b>			<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>				
Low	158	247.6	0.014	–0.001 (0.006)	0.798	
Medium	158	249.2				
High	157	249.2				

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of transferrin versus log<sub>2</sub> (initial dioxin).

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

**Table 13-59. Analysis of Transferrin (Continuous) (mg/dl) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>					
Dioxin Category	n	Mean <sup>a</sup>	Adj. Mean <sup>ab</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>c</sup>	p-Value <sup>d</sup>
Comparison	1,194	249.5	249.5		
Background RH	376	250.9	250.9	1.4 --	0.480
Low RH	236	251.9	251.9	2.4 --	0.328
High RH	240	256.0	255.9	6.4 --	0.010
Low plus High RH	476	254.0	253.9	4.4 --	0.019

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>d</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adj. Mean <sup>a</sup>	Difference of Adj. Mean vs. Comparisons (95% C.I.) <sup>b</sup>	p-Value <sup>c</sup>
Comparison	1,193	243.0		
Background RH	374	245.2	2.2 --	0.282
Low RH	235	246.1	3.1 --	0.200
High RH	238	247.9	4.9 --	0.050
Low plus High RH	473	247.0	4.0 --	0.032

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale.

<sup>c</sup> P-value is based on difference of means on natural logarithm scale.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>					
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin +1)		
1987 Dioxin	n	Mean <sup>a</sup>	R <sup>2</sup>	Adjusted Slope (Std. Error) <sup>b</sup>	p-Value
Low	283	251.0	0.004	0.005 (0.003)	0.082
Medium	285	251.4			
High	284	255.3			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of transferrin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

**Table 13-59. Analysis of Transferrin (Continuous) (mg/dl) (Continued)**

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>					
<b>1987 Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (1987 Dioxin + 1)</b>		
<b>1987 Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>a</sup></b>	<b>R<sup>2</sup></b>	<b>Adjusted Slope (Std. Error)<sup>b</sup></b>	<b>p-Value</b>
Low	283	247.6	0.014	0.003 (0.004)	0.385
Medium	283	247.8			
High	281	249.9			

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Slope and standard error based on natural logarithm of transferrin versus log<sub>2</sub> (1987 dioxin + 1).

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

The unadjusted and adjusted Model 2 results were not significant (Table 13-59(c,d):  $p > 0.59$  for each analysis). The unadjusted Model 3 analysis revealed Ranch Hands in the high dioxin category and Ranch Hands in the low and high dioxin categories combined to be significantly different from Comparisons (Table 13-59(e): difference of means=6.4 mg/dl,  $p=0.010$ ; difference of means=4.4 mg/dl,  $p=0.019$ , respectively). The adjusted analysis revealed the same two contrasts to be significant: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-59(f): difference of adjusted means=4.9 mg/dl,  $p=0.050$ ; difference of adjusted means=4.0 mg/dl,  $p=0.032$ , respectively). The adjusted mean levels of transferrin for Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 247.9 mg/dl, 247.0 mg/dl, and 243.0 mg/dl, respectively.

A marginally significant association between 1987 dioxin and transferrin was shown in the unadjusted Model 4 analysis (Table 13-59(g): slope=0.005,  $p=0.082$ ). After covariate adjustment, the results became nonsignificant (Table 13-59(h):  $p=0.385$ ).

#### 13.2.2.3.51 Transferrin (Discrete)

Both the unadjusted and adjusted Model 1 analyses of transferrin revealed a significant overall group difference between Ranch Hands and Comparisons (Table 13-60(a,b): Est. RR=0.73,  $p=0.036$ ; Adj. RR=0.71,  $p=0.027$ , respectively). The percentage of low transferrin values among the Ranch Hands was 8.1 versus 10.9 for Comparisons. After stratifying by occupation, both the unadjusted and adjusted Model 1 analyses showed marginally significant differences between Ranch Hands and Comparisons within the officer stratum (Table 13-60(a,b): Est. RR=0.64,  $p=0.083$ ; Adj. RR=0.63,  $p=0.070$ , respectively). The percentage of low transferrin values among Ranch Hand officers was 7.1 versus 10.6 among Comparison officers.

**Table 13-60. Analysis of Transferrin (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
Occupational Category	Group	n	Number (%) Low	Est. Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>Ranch Hand</i>	859	70 (8.1)	<i>0.73 (0.54,0.98)</i>	<i>0.036</i>
	<i>Comparison</i>	1,231	134 (10.9)		
Officer	Ranch Hand	340	24 (7.1)	0.64 (0.39,1.06)	0.083
	Comparison	490	52 (10.6)		
Enlisted Flyer	Ranch Hand	150	15 (10.0)	0.87 (0.43,1.75)	0.691
	Comparison	185	21 (11.4)		
Enlisted Groundcrew	Ranch Hand	369	31 (8.4)	0.74 (0.47,1.17)	0.202
	Comparison	556	61 (11.0)		

<b>(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
<i>All</i>	<i>0.71 (0.52,0.97)</i>	<i>0.027</i>
Officer	0.63 (0.38,1.04)	0.070
Enlisted Flyer	0.83 (0.41,1.68)	0.601
Enlisted Groundcrew	0.74 (0.47,1.18)	0.208

<b>(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
Initial Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup>	
Initial Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>b</sup>	p-Value
Low	158	15 (9.5)	0.99 (0.77,1.27)	0.931
Medium	159	13 (8.2)		
High	159	11 (6.9)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

<b>(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>		
Analysis Results for Log <sub>2</sub> (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value
473	0.93 (0.69,1.24)	0.615

<sup>a</sup> Relative risk for a twofold increase in initial dioxin.

**Table 13-60. Analysis of Transferrin (Discrete) (Continued)**

<b>(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED</b>				
Dioxin Category	n	Number (%) Low	Est. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value
Comparison	1,194	133 (11.1)		
Background RH	376	31 (8.2)	0.72 (0.48,1.09)	0.121
Low RH	236	23 (9.7)	0.86 (0.54,1.37)	0.526
High RH	240	16 (6.7)	0.57 (0.33,0.97)	0.039
Low plus High RH	476	39 (8.2)	0.70 (0.48,1.02)	0.062

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED</b>				
Dioxin Category	n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value	
Comparison	1,193			
Background RH	374	0.73 (0.48,1.11)	0.142	
Low RH	235	0.78 (0.49,1.26)	0.311	
High RH	238	0.57 (0.32,0.99)	0.045	
Low plus High RH	473	0.66 (0.45,0.98)	0.039	

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

<b>(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED</b>				
1987 Dioxin Category Summary Statistics			Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Low	Estimated Relative Risk (95% C.I.) <sup>a</sup>	p-Value
Low	283	21 (7.4)	1.03 (0.88,1.22)	0.710
Medium	285	26 (9.1)		
High	284	23 (8.1)		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

Note: Low = ≤7.9 ppt; Medium = >7.9–19.6 ppt; High = >19.6 ppt.

<b>(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED</b>				
Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1)				
n	Adjusted Relative Risk (95% C.I.) <sup>a</sup>	p-Value		
847	1.03 (0.85,1.24)	0.785		

<sup>a</sup> Relative risk for a twofold increase in 1987 dioxin.

No significant association between initial dioxin and transferrin was found in the unadjusted or adjusted Model 2 analyses (Table 13-60(c,d):  $p > 0.61$  for each analysis). The unadjusted Model 3 analysis of transferrin revealed significant differences between Ranch Hands in the high dioxin category and Comparisons, as well as between Ranch Hands in the low and high dioxin categories combined and Comparisons (Table 13-60(e): Est. RR=0.57,  $p=0.039$ ; Est. RR=0.70,  $p=0.062$ , respectively). The same contrasts were significant after adjusting for covariates (Table 13-60(f): Adj. RR=0.57,  $p=0.045$ , for Ranch Hands in the high dioxin category versus Comparisons; Adj. RR=0.66,  $p=0.039$ , for Ranch Hands in the low and high dioxin categories combined versus Comparisons). The percentages of low transferrin values among Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 6.7, 8.2, and 11.1, respectively. The unadjusted and adjusted Model 4 analyses were nonsignificant (Table 13-60(g,h):  $p > 0.71$  for each analysis).

### 13.2.3 Longitudinal Analysis

Longitudinal analyses were conducted on AST, ALT, GGT, cholesterol, HDL cholesterol, the cholesterol-HDL ratio, and triglycerides to examine whether changes across time differed with respect to group membership (Model 1), initial dioxin (Model 2), and categorized dioxin (Model 3). Model 4 was not examined in longitudinal analyses because 1987 dioxin, the measure of exposure in these models, changes over time and is not available for all participants for 1982 or 1997.

Discrete and continuous analyses were performed for all variables. The longitudinal analyses for all of these variables investigated the difference between the 1982 and 1997 examinations. These analyses were used to investigate the temporal effects of dioxin during the 15-year period between 1982 and 1997.

The longitudinal analysis for these variables in their continuous form examined the paired difference between the measurements from 1982 and 1997. These paired differences measured the change in these variables over time. Each of the three models used in the longitudinal analysis was adjusted for age and the dependent variable as measured in 1982 (see Chapter 7, Statistical Methods).

Participants who were abnormal in 1982 were not included in the longitudinal analysis of discrete dependent variables. The purpose of the longitudinal analysis was to examine the effects of dioxin exposure across time. Participants who were abnormal in 1982 were not considered to be at risk for developing the condition, because the condition already existed at the time of the first collection of data for the AFHS (1982). Only participants who were normal at the 1982 examination were considered to be at risk for developing the disease; therefore the rate of abnormalities under this restriction approximates an incidence rate between 1982 and 1997. That is, an incidence rate is a measure of the rate at which people without a condition develop the condition during a specified period of time (67). Summary statistics are provided for reference purposes for the 1985, 1987, and 1992 examinations.

The longitudinal analyses of discrete variables examined relative risks at the 1997 examination for participants who were classified as normal at the 1982 examination. The adjusted relative risks estimated from each of the three models were used to investigate the change in the dependent variable over time. All three models were adjusted for age; Models 2 and 3 also were adjusted for the percentage of body fat at the time of the blood measurement of dioxin.

The cutpoints for all of these variables except the cholesterol-HDL ratio differed between examinations. The cutpoints changed between examinations because a different laboratory was used to perform the analysis or because an upgrade in the equipment used caused a change in the reference values. This upgrade in equipment may have affected the mean level or the percent abnormal for the dependent variable between examinations. These cutpoints were used for determining abnormal and normal classifications for each of the respective examinations and are shown in Table 13-61.

**Table 13-61. Normal Ranges from Air Force Health Study Examinations for Dependent Variables Used in Longitudinal Analysis**

Dependent Variable (Units)	Examination				
	1982	1985	1987	1992	1997
AST (U/l)	≤41	≤47	≤47	≤50	≤37
ALT (U/l)	≤45	≤36	≤36	≤55	≤65
GGT (U/l)	≤85	≤85	≤85	≤51	≤85
Cholesterol (mg/dl)	≤240	≤250	≤250	≤250	≤260
	(Age <40)	(Age <45)	(Age <45)	(Age <45)	(Age <50)
	≤265	≤260	≤260	≤260	≤250
	(Age ≥40)	(Age 45–69)	(Age 45–69)	(Age 45–69)	(Age ≥50) <sup>a</sup>
		≤250	≤250	≤250	
		(Age ≥70)	(Age ≥70)	(Age ≥70)	
HDL (mg/dl)	≥25	≥30	≥30	≥30	≥32
	(Age <50)	(Age <40)	(Age <40)	(Age <40)	
	≥32	≥25	≥25	≥25	
	(Age ≥50)	(Age 40–44)	(Age 40–44)	(Age 40–44)	
		≥30	≥30	≥30	
		(Age ≥45)	(Age ≥45)	(Age ≥45)	
Triglycerides (mg/dl)	≤150	≤320	≤320	≤320	≤200
	(Age <40)	(Age <55)	(Age <55)	(Age <55)	
	≤160	≤290	≤290	≤290	
	(Age 40–49)	(Age 55–64)	(Age 55–64)	(Age 55–64)	
	≤190	≤260	≤260	≤260	
	(Age ≥50)	(Age ≥65)	(Age ≥65)	(Age ≥65)	

<sup>a</sup> Cutpoint lower for cholesterol for older participants per manufacturer's recommendation.

### 13.2.3.1 Laboratory Examination Variables

#### 13.2.3.1.1 AST (Continuous)

The analyses in each of Models 1 through 3 did not reveal a significant association between dioxin and the change in mean AST levels between 1982 and 1997 (Table 13-62(a–c):  $p > 0.37$  for each analysis).

**Table 13-62. Longitudinal Analysis of AST (U/I) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>32.61</i> <i>(804)</i>	<i>33.33</i> <i>(787)</i>	<i>25.50</i> <i>(778)</i>	<i>23.03</i> <i>(778)</i>	<i>22.99</i> <i>(804)</i>	<i>-9.62</i>	<i>-0.03</i>	<i>0.859</i>
	<i>Comparison</i>	<i>32.48</i> <i>(956)</i>	<i>33.47</i> <i>(938)</i>	<i>25.34</i> <i>(929)</i>	<i>23.59</i> <i>(933)</i>	<i>22.89</i> <i>(956)</i>	<i>-9.59</i>		
Officer	Ranch Hand	32.69 (309)	34.01 (304)	25.85 (301)	23.69 (300)	23.29 (309)	-9.40	0.15	0.897
	Comparison	32.86 (377)	33.57 (371)	25.76 (363)	24.00 (370)	23.31 (377)	-9.55		
Enlisted Flyer	Ranch Hand	31.89 (146)	32.24 (143)	24.47 (141)	21.14 (143)	22.19 (146)	-9.69	0.47	0.710
	Comparison	33.02 (142)	33.53 (141)	25.10 (140)	23.30 (138)	22.87 (142)	-10.16		
Enlisted Groundcrew	Ranch Hand	32.84 (349)	33.18 (340)	25.63 (336)	23.28 (335)	23.06 (349)	-9.78	-0.34	0.687
	Comparison	31.98 (437)	33.36 (426)	25.08 (426)	23.32 (425)	22.54 (437)	-9.44		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of AST; results adjusted for natural logarithm of AST in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-62. Longitudinal Analysis of AST (U/l) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics						Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>	
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	33.11 (151)	34.06 (147)	25.46 (150)	22.57 (146)	23.39 (151)	-0.004 (0.012)	0.731
Medium	33.39 (156)	34.46 (154)	26.08 (152)	23.18 (152)	23.64 (156)		
High	33.54 (151)	33.33 (148)	25.86 (146)	23.82 (148)	23.56 (151)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 AST and natural logarithm of 1982 AST versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 AST, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	32.46 (929)	33.50 (913)	25.35 (903)	23.54 (907)	22.87 (929)	-9.59		
Background	31.70 (340)	32.54 (333)	25.13 (325)	22.78 (327)	22.22 (340)	-9.48	0.11	0.574
Low RH	32.75 (226)	34.41 (220)	25.59 (222)	23.05 (218)	23.40 (226)	-9.34	0.25	0.373
High RH	33.94 (232)	33.51 (229)	26.00 (226)	23.32 (228)	23.65 (232)	-10.29	-0.70	0.911
Low plus High RH	33.35 (458)	33.95 (449)	25.80 (448)	23.19 (446)	23.53 (458)	9.82	-0.23	0.520

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 AST; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 AST, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.2 AST (Discrete)

All longitudinal analyses of the participants with high AST levels in 1997 that were normal in 1982 were nonsignificant (Table 13-63(a-c):  $p > 0.15$  for each analysis).

**Table 13-63. Longitudinal Analysis of AST (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	<i>99 (12.3)</i> <i>(804)</i>	<i>51 (6.5)</i> <i>(787)</i>	<i>31 (4.0)</i> <i>(778)</i>	<i>21 (2.7)</i> <i>(778)</i>	<i>60 (7.5)</i> <i>(804)</i>
	<i>Comparison</i>	<i>122 (12.8)</i> <i>(956)</i>	<i>70 (7.5)</i> <i>(938)</i>	<i>26 (2.8)</i> <i>(929)</i>	<i>31 (3.3)</i> <i>(933)</i>	<i>60 (6.3)</i> <i>(956)</i>
Officer	Ranch Hand	34 (11.0) (309)	24 (7.9) (304)	14 (4.7) (301)	11 (3.7) (300)	21 (6.8) (309)
	Comparison	52 (13.8) (377)	24 (6.5) (371)	13 (3.6) (363)	14 (3.8) (370)	23 (6.1) (377)
Enlisted Flyer	Ranch Hand	16 (11.0) (146)	7 (4.9) (143)	4 (2.8) (141)	1 (0.7) (143)	10 (6.8) (146)
	Comparison	20 (14.1) (142)	13 (9.2) (141)	5 (3.6) (140)	6 (4.3) (138)	12 (8.5) (142)
Enlisted Groundcrew	Ranch Hand	49 (14.0) (349)	20 (5.9) (340)	13 (3.9) (336)	9 (2.7) (335)	29 (8.3) (349)
	Comparison	50 (11.4) (437)	33 (7.7) (426)	8 (1.9) (426)	11 (2.6) (425)	25 (5.7) (437)

Occupational Category	Group	Normal in 1982			
		n in 1997	Number (%) High in 1997	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>705</i>	<i>35 (5.0)</i>	<i>1.13 (0.70,1.81)</i>	<i>0.614</i>
	<i>Comparison</i>	<i>834</i>	<i>37 (4.4)</i>		
Officer	Ranch Hand	275	11 (4.0)	0.87 (0.39,1.93)	0.735
	Comparison	325	15 (4.6)		
Enlisted Flyer	Ranch Hand	130	6 (4.6)	0.69 (0.23,2.05)	0.506
	Comparison	122	8 (6.6)		
Enlisted Groundcrew	Ranch Hand	300	18 (6.0)	1.68 (0.82,3.45)	0.153
	Comparison	387	14 (3.6)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal AST level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-63. Longitudinal Analysis of AST (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	17 (11.3) (151)	11 (7.5) (147)	6 (4.0) (150)	4 (2.7) (146)	11 (7.3) (151)
Medium	30 (19.2) (156)	11 (7.1) (154)	4 (2.6) (152)	4 (2.6) (152)	20 (12.8) (156)
High	23 (15.2) (151)	11 (7.4) (148)	7 (4.8) (146)	4 (2.7) (148)	14 (9.3) (151)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	134	6 (4.5)	1.18 (0.87,1.59)	0.297
Medium	126	11 (8.7)		
High	128	9 (7.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal AST level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	118 (12.7) (929)	69 (7.6) (913)	25 (2.8) (903)	30 (3.3) (907)	59 (6.4) (929)
Background RH	27 (7.9) (340)	18 (5.4) (333)	14 (4.3) (325)	9 (2.8) (327)	14 (4.1) (340)
Low RH	26 (11.5) (226)	19 (8.6) (220)	9 (4.1) (222)	8 (3.7) (218)	19 (8.4) (226)
High RH	44 (19.0) (232)	14 (6.1) (229)	8 (3.5) (226)	4 (1.8) (228)	26 (11.2) (232)
Low plus High RH	70 (15.3) (458)	33 (7.3) (449)	17 (3.8) (448)	12 (2.7) (446)	45 (9.8) (458)

**Table 13-63. Longitudinal Analysis of AST (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	811	37 (4.6)		
Background RH	313	8 (2.6)	0.59 (0.27,1.30)	0.193
Low RH	200	12 (6.0)	1.34 (0.68,2.63)	0.395
High RH	188	14 (7.4)	1.58 (0.83,3.00)	0.166
Low plus High RH	388	26 (6.7)	1.45 (0.86,2.44)	0.162

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, Initial Dioxin  $>$  94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal AST level in 1982 (see Chapter 7, Statistical Methods).

### 13.2.3.1.3 ALT (Continuous)

Models 1 and 2 of the longitudinal analyses of ALT in its continuous form revealed no significant association between the change in mean AST levels and dioxin (Table 13-64(a,b):  $p > 0.21$ ). Model 3 analysis of the change in mean ALT levels between 1982 and 1997 revealed two marginally significant contrasts: Ranch Hands in the low dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-64(c): difference of examination mean change = 1.02 U/l,  $p = 0.054$ ; difference of examination mean change = 0.72 U/l,  $p = 0.094$ , respectively). The examination mean changes for Ranch Hands in the low dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 22.84 U/l, 22.54 U/l, and 21.82 U/l, respectively.

**Table 13-64. Longitudinal Analysis of ALT (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>19.84</i> <i>(804)</i>	<i>21.66</i> <i>(787)</i>	<i>20.52</i> <i>(778)</i>	<i>27.12</i> <i>(778)</i>	<i>42.55</i> <i>(804)</i>	<i>22.71</i>	<i>0.89</i>	<i>0.214</i>
	<i>Comparison</i>	<i>20.38</i> <i>(956)</i>	<i>22.53</i> <i>(938)</i>	<i>20.49</i> <i>(929)</i>	<i>27.91</i> <i>(933)</i>	<i>42.20</i> <i>(956)</i>	<i>21.82</i>		
Officer	Ranch Hand	19.71 (309)	21.96 (304)	20.53 (301)	27.01 (300)	41.93 (309)	22.22	0.99	0.295
	Comparison	20.32 (377)	21.97 (371)	20.35 (363)	27.39 (370)	41.55 (377)	21.23		
Enlisted Flyer	Ranch Hand	18.69 (146)	20.85 (143)	19.83 (141)	25.15 (143)	41.33 (146)	22.63	0.77	0.910
	Comparison	20.59 (142)	22.01 (141)	19.84 (140)	28.03 (138)	42.45 (142)	21.86		
Enlisted Groundcrew	Ranch Hand	20.46 (349)	21.73 (340)	20.79 (336)	28.10 (335)	43.63 (349)	23.17	0.85	0.377
	Comparison	20.37 (437)	23.20 (426)	20.82 (426)	28.33 (425)	42.69 (437)	22.32		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of ALT; results adjusted for natural logarithm of ALT in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-64. Longitudinal Analysis of ALT (U/l) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics					Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	20.29 (151)	22.08 (147)	20.15 (150)	26.54 (146)	42.36 (151)	-0.007 (0.010)	0.444
Medium	21.76 (156)	24.10 (154)	21.94 (152)	28.72 (152)	44.95 (156)		
High	22.96 (151)	23.82 (148)	23.07 (146)	30.13 (148)	45.27 (151)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 ALT and natural logarithm of 1982 ALT versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 ALT, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	20.34 (929)	22.49 (913)	20.46 (903)	27.87 (907)	42.16 (929)	21.82		
Background RH	17.53 (340)	19.62 (33)	19.01 (325)	25.36 (327)	40.39 (340)	22.87	1.05	0.751
Low RH	20.46 (226)	23.08 (220)	20.50 (222)	27.51 (218)	43.30 (226)	22.84	1.02	0.054
High RH	22.86 (232)	23.57 (229)	22.90 (226)	29.36 (228)	45.07 (232)	22.20	0.38	0.503
Low plus High RH	21.64 (458)	23.33 (449)	21.67 (448)	28.44 (446)	44.18 (458)	22.54	0.72	0.094

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 ALT; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 ALT, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.4 ALT (Discrete)

Examination of Models 1 and 2 of the longitudinal analyses for discretized ALT did not find a significant association between dioxin and the percentage of participants with normal ALT values in 1982 and high ALT values in 1997 (Table 13-65(a,b):  $p > 0.19$  for each analysis).

**Table 13-65. Longitudinal Analysis of ALT (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	<i>59 (7.3)</i> <i>804</i>	<i>107 (13.6)</i> <i>(787)</i>	<i>92 (11.8)</i> <i>(778)</i>	<i>45 (5.8)</i> <i>(778)</i>	<i>65 (8.1)</i> <i>(804)</i>
	<i>Comparison</i>	<i>67 (7.0)</i> <i>(956)</i>	<i>133 (14.2)</i> <i>(938)</i>	<i>92 (9.9)</i> <i>(929)</i>	<i>64 (6.9)</i> <i>(933)</i>	<i>68 (7.1)</i> <i>(956)</i>
Officer	Ranch Hand	23 (7.4) (309)	46 (15.1) (304)	38 (12.6) (301)	19 (6.3) (300)	20 (6.5) (309)
	Comparison	26 (6.9) (377)	45 (12.1) (371)	39 (10.7) (363)	20 (5.4) (370)	16 (4.2) (377)
Enlisted Flyer	Ranch Hand	10 (6.8) (146)	15 (10.5) (143)	14 (9.9) (141)	7 (4.9) (143)	15 (10.3) (146)
	Comparison	11 (7.7) (142)	19 (13.5) (141)	9 (6.4) (140)	11 (8.0) (138)	15 (10.6) (142)
Enlisted Groundcrew	Ranch Hand	26 (7.4) (349)	46 (13.5) (340)	40 (11.9) (336)	19 (5.7) (335)	30 (8.6) (349)
	Comparison	30 (6.9) (437)	69 (16.2) (426)	44 (10.3) (426)	33 (7.8) (425)	37 (8.5) (437)

  

Occupational Category	Group	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
		n in 1997	Number (%) High in 1997		
<i>All</i>	<i>Ranch Hand</i>	<i>745</i>	<i>43 (5.8)</i>	<i>0.92 (0.61,1.39)</i>	<i>0.690</i>
	<i>Comparison</i>	<i>889</i>	<i>56 (6.3)</i>		
Officer	Ranch Hand	286	14 (4.9)	1.53 (0.70,3.39)	0.289
	Comparison	351	12 (3.4)		
Enlisted Flyer	Ranch Hand	136	11 (8.1)	0.87 (0.37,2.06)	0.749
	Comparison	131	12 (9.2)		
Enlisted Groundcrew	Ranch Hand	323	18 (5.6)	0.67 (0.37,1.23)	0.195
	Comparison	407	32 (7.9)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal ALT level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-65. Longitudinal Analysis of ALT (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	12 (7.9) (151)	20 (13.6) (147)	11 (7.3) (150)	4 (2.7) (146)	10 (6.6) (151)
Medium	10 (6.4) (156)	21 (13.6) (154)	22 (14.5) (152)	13 (8.6) (152)	21 (13.5) (156)
High	19 (12.6) (151)	27 (18.2) (148)	22 (15.1) (146)	13 (8.8) (148)	19 (12.6) (151)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	139	8 (5.8)	1.05 (0.78,1.40)	0.750
Medium	146	14 (9.6)		
High	132	10 (7.6)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal ALT level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	65 (7.0) (929)	129 (14.1) (913)	90 (10.0) (903)	60 (6.6) (907)	67 (7.2) (929)
Background RH	17 (5.0) (340)	38 (11.4) (333)	36 (11.1) (325)	14 (4.3) (327)	14 (4.1) (340)
Low RH	17 (7.5) (226)	30 (13.6) (220)	21 (9.5) (222)	10 (4.6) (218)	20 (8.8) (226)
High RH	24 (10.3) (232)	38 (16.6) (229)	34 (15.0) (226)	20 (8.8) (228)	30 (12.9) (232)
Low plus High RH	41 (9.0) (458)	68 (15.1) (449)	55 (12.3) (448)	30 (6.7) (446)	50 (10.9) (458)

**Table 13-65. Longitudinal Analysis of ALT (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	864	56 (6.5)		
Background RH	323	10 (3.1)	0.55 (0.27,1.10)	0.089
Low RH	209	15 (7.2)	1.23 (0.68,2.24)	0.495
High RH	208	17 (8.2)	1.04 (0.59,1.85)	0.889
Low plus High RH	417	32 (7.7)	1.13 (0.72,1.79)	0.591

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, Initial Dioxin  $>$  94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal ALT level in 1982 (see Chapter 7, Statistical Methods).

The Model 3 analysis of the percentage of participants with high ALT levels in 1997 and normal ALT levels in 1982 revealed a marginally significant difference between Ranch Hands in the background dioxin category and Comparisons (Table 13-65(c): Adj. RR=0.55, p=0.089). Of the Comparisons with normal ALT levels in 1982, 6.5 percent had high ALT levels in 1997, whereas 3.1 percent of Ranch Hands in the background dioxin category with normal ALT levels in 1982 had high ALT levels in 1997.

#### 13.2.3.1.5 GGT (Continuous)

The analyses in each of Models 1 through 3 did not reveal a significant association between dioxin and the change in mean GGT levels (Table 13-66(a-c): p $>$ 0.26 for each analysis).

**Table 13-66. Longitudinal Analysis of GGT (U/l) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>38.12</i> <i>(804)</i>	<i>31.57</i> <i>(787)</i>	<i>32.05</i> <i>(778)</i>	<i>32.38</i> <i>(778)</i>	<i>43.70</i> <i>(804)</i>	<i>5.57</i>	<i>0.74</i>	<i>0.266</i>
	<i>Comparison</i>	<i>37.44</i> <i>(955)</i>	<i>31.53</i> <i>(937)</i>	<i>31.30</i> <i>(928)</i>	<i>31.61</i> <i>(932)</i>	<i>42.27</i> <i>(955)</i>	<i>4.83</i>		
Officer	Ranch Hand	36.62 (309)	30.88 (304)	31.40 (301)	31.54 (300)	42.13 (309)	5.51	0.41	0.567
	Comparison	36.09 (377)	30.25 (371)	30.70 (363)	31.24 (370)	41.19 (377)	5.10		
Enlisted Flyer	Ranch Hand	38.58 (146)	31.70 (143)	31.74 (141)	30.77 (143)	44.65 (146)	6.07	1.99	0.698
	Comparison	41.81 (142)	34.81 (141)	33.64 (140)	34.67 (138)	45.89 (142)	4.08		
Enlisted Groundcrew	Ranch Hand	39.31 (349)	32.13 (340)	32.77 (336)	33.88 (335)	44.73 (349)	5.42	0.61	0.442
	Comparison	37.28 (436)	31.63 (425)	31.08 (425)	30.99 (424)	42.09 (436)	4.81		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of GGT; results adjusted for natural logarithm of GGT in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-66. Longitudinal Analysis of GGT (U/l) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
<b>Initial Dioxin Category Summary Statistics</b>						<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>	
<b>Initial Dioxin</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Adjusted Slope (Std. Error)</b>	<b>p-Value</b>
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>		
Low	41.42 (151)	33.83 (147)	32.52 (150)	32.74 (146)	43.50 (151)	-0.009 (0.017)	0.579
Medium	42.17 (156)	35.47 (154)	36.50 (152)	36.72 (152)	48.93 (156)		
High	41.69 (151)	33.53 (148)	34.54 (146)	35.61 (148)	46.45 (151)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 GGT and natural logarithm of 1982 GGT versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 GGT, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
<b>Dioxin Category</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
Comparison	37.10 (928)	31.17 (912)	30.95 (902)	31.19 (906)	41.92 (928)	4.82		
Background RH	33.22 (340)	28.00 (333)	28.71 (325)	28.90 (327)	39.90 (340)	6.69	1.87	0.363
Low RH	40.41 (226)	33.57 (220)	32.97 (222)	33.56 (218)	44.00 (226)	3.58	-1.24	0.686
High RH	43.12 (232)	34.98 (229)	36.05 (226)	36.45 (228)	48.59 (232)	5.48	0.66	0.276
Low plus High RH	41.76 (458)	34.28 (449)	34.49 (448)	35.01 (446)	46.27 (458)	4.51	-0.31	0.330

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 GGT; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 GGT, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.6 GGT (Discrete)

The longitudinal analyses in Models 1 through 3 did not reveal a significant association between the change in discretized GGT values and dioxin (Table 13-67(a-c):  $p > 0.10$ ).

**Table 13-67. Longitudinal Analysis of GGT (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	68 (8.5) (804)	58 (7.4) (787)	57 (7.3) (778)	155 (19.9) (778)	84 (10.4) (804)
	<i>Comparison</i>	81 (8.5) (955)	76 (8.1) (937)	60 (6.5) (928)	163 (17.5) (932)	94 (9.8) (955)
Officer	Ranch Hand	26 (8.4) (309)	21 (6.9) (304)	24 (8.0) (301)	56 (18.7) (300)	27 (8.7) (309)
	Comparison	31 (8.2) (377)	27 (7.3) (371)	23 (6.3) (363)	64 (17.3) (370)	32 (8.5) (377)
Enlisted Flyer	Ranch Hand	15 (10.3) (146)	11 (7.7) (143)	13 (9.2) (141)	25 (17.5) (143)	23 (15.8) (146)
	Comparison	16 (11.3) (142)	17 (12.1) (141)	15 (10.7) (140)	29 (21.0) (138)	21 (14.8) (142)
Enlisted Groundcrew	Ranch Hand	27 (7.7) (349)	26 (7.6) (340)	20 (6.0) (336)	74 (22.1) (335)	34 (9.7) (349)
	Comparison	34 (7.8) (436)	32 (7.5) (425)	22 (5.2) (425)	70 (16.5) (424)	41 (9.4) (436)

  

Occupational Category	Group	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
		n in 1997	Number (%) High in 1997		
<i>All</i>	<i>Ranch Hand</i>	736	48 (6.5)	1.02 (0.69,1.53)	0.909
	<i>Comparison</i>	874	56 (6.4)		
Officer	Ranch Hand	283	13 (4.6)	1.01 (0.48,2.14)	0.982
	Comparison	346	16 (4.6)		
Enlisted Flyer	Ranch Hand	131	16 (12.2)	1.12 (0.52,2.41)	0.768
	Comparison	126	14 (11.1)		
Enlisted Groundcrew	Ranch Hand	322	19 (5.9)	0.90 (0.49,1.66)	0.731
	Comparison	402	26 (6.5)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal GGT level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-67. Longitudinal Analysis of GGT (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	17 (11.3) 151	12 (8.2) (147)	10 (6.7) (150)	26 (17.8) (146)	16 (10.6) (151)
Medium	15 (9.6) (156)	12 (7.8) (154)	14 (9.2) (152)	39 (25.7) (152)	27 (17.3) (156)
High	17 (11.3) (151)	14 (9.5) (148)	13 (8.9) (146)	33 (22.3) (148)	17 (11.3) (151)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	134	8 (6.0)	1.03 (0.78,1.35)	0.860
Medium	141	19 (13.5)		
High	134	8 (6.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal GGT level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	74 (8.0) (928)	71 (7.8) (912)	55 (6.1) (902)	151 (16.7) (906)	89 (9.6) (928)
Background RH	17 (5.0) (340)	19 (5.7) (333)	19 (5.8) (325)	55 (16.8) (327)	22 (6.5) (340)
Low RH	22 (9.7) (226)	16 (7.3) (220)	15 (6.8) (222)	43 (19.7) (218)	27 (11.9) (226)
High RH	27 (11.6) (232)	22 (9.6) (229)	22 (9.7) (226)	55 (24.1) (228)	33 (14.2) (232)
Low plus High RH	49 (10.7) (458)	38 (8.5) (449)	37 (8.3) (448)	98 (22.0) (446)	60 (13.1) (458)

**Table 13-67. Longitudinal Analysis of GGT (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	854	55 (6.4)		
Background RH	323	12 (3.7)	0.58 (0.31,1.11)	0.101
Low RH	204	15 (7.4)	1.19 (0.66,2.16)	0.569
High RH	205	20 (9.8)	1.46 (0.85,2.52)	0.173
Low plus High RH	409	35 (8.6)	1.32 (0.84,2.06)	0.224

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin >10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin >10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal GGT level in 1982 (see Chapter 7, Statistical Methods).

### 13.2.3.1.7 Cholesterol (Continuous)

The Model 1 analysis of the change in mean cholesterol levels did not uncover a significant difference between overall Ranch Hands and Comparisons (Table 13-68(a):  $p=0.877$ ). Stratifying by occupation showed marginally significant group differences in the officers and enlisted groundcrew strata (Table 13-68(a): difference of examination mean change = -3.8 mg/dl,  $p=0.075$ , for officers; difference of examination mean change = 6.5 mg/dl,  $p=0.082$ , for enlisted groundcrew). Among the officers, the Ranch Hand mean decreased by 6.5 mg/dl between 1982 and 1997 versus a mean decrease of 2.7 mg/dl for Comparisons. Among the enlisted groundcrew, the Ranch Hands had a mean increase of 4.0 mg/dl between 1982 and 1997 versus a mean decrease of 2.5 mg/dl for Comparisons. Model 2 and 3 analyses did not show any significant relations between dioxin and the change in mean cholesterol levels (Table 13-68(b,c):  $p>0.12$  for each analysis).

**Table 13-68. Longitudinal Analysis of Cholesterol (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>212.3</i> <i>(804)</i>	<i>214.9</i> <i>(787)</i>	<i>216.0</i> <i>(778)</i>	<i>215.9</i> <i>(778)</i>	<i>210.8</i> <i>(804)</i>	<i>-1.5</i>	<i>2.0</i>	<i>0.877</i>
	<i>Comparison</i>	<i>215.8</i> <i>(956)</i>	<i>217.2</i> <i>(938)</i>	<i>215.8</i> <i>(929)</i>	<i>216.0</i> <i>(933)</i>	<i>212.4</i> <i>(956)</i>	<i>-3.5</i>		
Officer	Ranch Hand	212.2 (309)	215.4 (304)	215.9 (301)	214.3 (300)	205.7 (309)	-6.5	-3.8	0.075
	Comparison	213.6 (377)	215.2 (371)	214.6 (363)	213.0 (370)	210.8 (377)	-2.7		
Enlisted Flyer	Ranch Hand	217.4 (146)	220.0 (143)	218.6 (141)	219.8 (143)	213.5 (146)	-3.9	4.4	0.838
	Comparison	224.7 (142)	222.5 (141)	221.8 (140)	221.8 (138)	216.4 (142)	-8.3		
Enlisted Groundcrew	Ranch Hand	210.3 (349)	212.4 (340)	214.9 (336)	215.8 (335)	214.3 (349)	4.0	6.5	0.082
	Comparison	214.9 (437)	217.3 (426)	214.9 (426)	216.9 (425)	212.4 (437)	-2.5		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of square root of cholesterol; results adjusted for square root of cholesterol in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-68. Longitudinal Analysis of Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics						Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>	
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	213.4 (151)	216.4 (147)	216.9 (150)	215.5 (146)	205.6 (151)	0.063 (0.041)	0.128
Medium	212.5 (156)	215.7 (154)	217.0 (152)	215.8 (152)	213.8 (156)		
High	218.6 (151)	219.0 (148)	219.0 (146)	220.8 (148)	217.9 (151)		

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Results based on difference between square root of 1997 cholesterol and square root of 1982 cholesterol versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, square root of 1982 cholesterol, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	215.5 (929)	217.2 (913)	215.7 (903)	215.8 (907)	212.3 (929)	-3.2		
Background RH	208.9 (340)	212.1 (333)	214.0 (325)	214.1 (327)	208.8 (340)	-0.1	3.1	0.800
Low RH	212.8 (226)	215.8 (220)	215.7 (222)	216.4 (218)	208.0 (226)	-4.8	-1.6	0.410
High RH	216.7 (232)	218.2 (229)	219.5 (226)	218.2 (228)	216.7 (232)	0.0	3.2	0.168
Low plus High RH	214.8 (458)	217.0 (449)	217.6 (448)	217.3 (446)	212.4 (458)	-2.4	0.8	0.704

<sup>a</sup> Transformed from square root scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of square root of 1997 cholesterol; results adjusted for percent body fat at the date of the blood measurement of dioxin, square root of 1982 cholesterol, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.8 Cholesterol (Discrete)

The Model 1 analysis of the percentage of participants with high cholesterol levels in 1997 did not uncover a significant difference between overall Ranch Hands and Comparisons (Table 13-69(a):  $p=0.323$ ). Stratifying by occupation showed a significant group difference in the enlisted groundcrew stratum (Table 13-69(a): Adj. RR=1.68,  $p=0.031$ ). For enlisted groundcrew with normal cholesterol levels in 1982, 15.6 percent of the Ranch Hands and 9.9 percent of the Comparisons had high cholesterol levels in 1997.

**Table 13-69. Longitudinal Analysis of Cholesterol (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	121 (15.0) (804)	127 (16.1) (787)	131 (16.8) (778)	108 (13.9) (778)	121 (15.0) (804)
	<i>Comparison</i>	156 (16.3) (956)	170 (18.1) (938)	135 (14.5) (929)	121 (13.0) (933)	142 (14.9) (956)
Officer	Ranch Hand	34 (11.0) (309)	49 (16.1) (304)	49 (16.3) (301)	35 (11.7) (300)	36 (11.7) (309)
	Comparison	43 (11.4) (377)	53 (14.3) (371)	43 (11.8) (363)	40 (10.8) (370)	53 (14.1) (377)
Enlisted Flyer	Ranch Hand	27 (18.5) (146)	27 (18.9) (143)	30 (21.3) (141)	26 (18.2) (143)	21 (14.4) (146)
	Comparison	29 (20.4) (142)	34 (24.1) (141)	27 (19.3) (140)	19 (13.8) (138)	21 (14.8) (142)
Enlisted Groundcrew	Ranch Hand	60 (17.2) (349)	51 (15.0) (340)	52 (15.5) (336)	47 (14.0) (335)	64 (18.3) (349)
	Comparison	84 (19.2) (437)	83 (19.5) (426)	65 (15.3) (426)	62 (14.6) (425)	68 (15.6) (437)

Occupational Category	Group	Normal in 1982			
		n in 1997	Number (%) High in 1997	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
<i>All</i>	<i>Ranch Hand</i>	683	81 (11.9)	1.18 (0.85,1.63)	0.323
	<i>Comparison</i>	800	82 (10.3)		
Officer	Ranch Hand	275	25 (9.1)	0.83 (0.48,1.41)	0.483
	Comparison	334	36 (10.8)		
Enlisted Flyer	Ranch Hand	119	11 (9.2)	0.94 (0.39,2.27)	0.896
	Comparison	113	11 (9.7)		
Enlisted Groundcrew	Ranch Hand	289	45 (15.6)	1.68 (1.05,2.70)	0.031
	Comparison	353	35 (9.9)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-69. Longitudinal Analysis of Cholesterol (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	18 (11.9) (151)	25 (17.0) (147)	25 (16.7) (150)	19 (13.0) (146)	18 (11.9) (151)
Medium	24 (15.4) (156)	25 (16.2) (154)	23 (15.1) (152)	21 (13.8) (152)	29 (18.6) (156)
High	39 (25.8) (151)	26 (17.6) (148)	23 (15.8) (146)	27 (18.2) (148)	30 (19.9) (151)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	133	14 (10.5)	1.23 (0.98,1.54)	0.072
Medium	132	21 (15.9)		
High	112	20 (17.9)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	150 (16.1) (929)	165 (18.1) (913)	131 (14.5) (903)	115 (12.7) (907)	138 (14.9) (929)
Background RH	40 (11.8) (340)	51 (15.3) (333)	60 (18.5) (325)	40 (12.2) (327)	44 (12.9) (340)
Low RH	29 (12.8) (226)	37 (16.8) (220)	35 (15.8) (222)	31 (14.2) (218)	31 (13.7) (226)
High RH	52 (22.4) (232)	39 (17.0) (229)	36 (15.9) (226)	36 (15.8) (228)	46 (19.8) (232)
Low plus High RH	81 (17.7) (458)	76 (16.9) (449)	71 (15.8) (448)	67 (15.0) (446)	77 (16.8) (458)

**Table 13-69. Longitudinal Analysis of Cholesterol (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	779	80 (10.3)		
Background RH	300	26 (8.7)	0.75 (0.47,1.20)	0.236
Low RH	197	24 (12.2)	1.24 (0.76,2.02)	0.393
High RH	180	31 (17.2)	2.04 (1.29,3.24)	0.002
Low plus High RH	377	55 (14.6)	1.57 (1.08,2.29)	0.018

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin >10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin >10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol level in 1982 (see Chapter 7, Statistical Methods).

The Model 2 longitudinal analysis revealed a marginally significant association between initial dioxin and high cholesterol levels in 1997 (Table 13-69(b): Adj. RR=1.23, p=0.072). The percentages of participants who had normal cholesterol levels in 1982 and high cholesterol levels in 1997 were 10.5, 15.9, and 17.9 in the low, medium, and high initial dioxin categories, respectively.

Model 3 analysis of the change in cholesterol values from normal in 1982 to high in 1997 revealed two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-69(c): Adj. RR=2.04, p=0.002; Adj. RR=1.57, p=0.018, respectively). Of the Comparisons, 10.3 percent had normal cholesterol levels in 1982 and high cholesterol levels in 1997. Of the Ranch Hands, 17.2 percent in the high dioxin category and 14.6 percent in the low and high dioxin categories combined had normal cholesterol levels in 1982 and high cholesterol levels in 1997.

#### 13.2.3.1.9 HDL Cholesterol (Continuous)

The longitudinal analyses in Models 1 through 3 did not reveal a significant association between dioxin and the change in mean HDL cholesterol levels (Table 13-70(a–c): p>0.10 for each analysis).

**Table 13-70. Longitudinal Analysis of HDL Cholesterol (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>44.61</i> (798)	<i>44.66</i> (781)	<i>45.43</i> (772)	<i>40.85</i> (763)	<i>45.03</i> (798)	<i>0.42</i>	<i>0.57</i>	<i>0.235</i>
	<i>Comparison</i>	<i>44.89</i> (955)	<i>44.90</i> (937)	<i>45.45</i> (928)	<i>40.60</i> (926)	<i>44.74</i> (955)	<i>-0.15</i>		
Officer	Ranch Hand	45.96 (306)	46.24 (301)	46.94 (298)	42.59 (293)	46.91 (306)	0.95	0.28	0.844
	Comparison	46.31 (377)	46.43 (371)	47.05 (363)	41.90 (367)	46.98 (377)	0.67		
Enlisted Flyer	Ranch Hand	42.99 (145)	42.99 (142)	44.26 (140)	40.48 (138)	44.86 (145)	1.87	1.49	0.146
	Comparison	43.14 (142)	43.51 (141)	44.41 (140)	40.28 (136)	43.53 (142)	0.38		
Enlisted Groundcrew	Ranch Hand	44.13 (347)	44.00 (338)	44.61 (334)	39.52 (332)	43.50 (347)	-0.63	0.37	0.527
	Comparison	44.27 (436)	44.06 (425)	44.47 (425)	39.60 (423)	43.27 (436)	-1.00		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of HDL cholesterol; results adjusted for natural logarithm of HDL cholesterol in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-70. Longitudinal Analysis of HDL Cholesterol (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics					Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	44.90 (149)	44.49 (145)	45.38 (148)	41.26 (144)	45.14 (149)	0.007 (0.008)	0.382
Medium	43.22 (154)	43.05 (152)	43.71 (150)	39.43 (148)	43.51 (154)		
High	42.38 (150)	42.38 (147)	43.37 (145)	38.86 (144)	43.39 (150)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 HDL cholesterol and natural logarithm of 1982 HDL cholesterol versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 HDL cholesterol, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	44.90 (928)	44.80 (912)	45.37 (902)	40.54 (901)	44.65 (928)	-0.24		
Background RH	46.06 (339)	46.57 (332)	47.32 (324)	42.43 (322)	46.44 (339)	0.38	0.62	0.437
Low RH	44.89 (224)	44.77 (218)	45.54 (220)	41.52 (215)	45.07 (224)	0.18	0.42	0.598
High RH	42.15 (229)	41.91 (226)	42.81 (223)	38.26 (221)	42.97 (229)	0.83	1.07	0.105
Low plus High RH	43.48 (453)	43.29 (444)	44.14 (443)	39.83 (436)	44.00 (453)	0.52	0.76	0.161

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 HDL cholesterol; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 HDL cholesterol, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.10 HDL Cholesterol (Discrete)

Analyses of Models 1 through 3 showed no significant relations between dioxin and the percentage of participants with low HDL cholesterol values in 1997 (Table 13-71(a-c):  $p > 0.19$  for each analysis).

**Table 13-71. Longitudinal Analysis of HDL Cholesterol (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) Low/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	21 (2.6) (798)	30 (3.8) (781)	24 (3.1) (772)	82 (10.7) (763)	67 (8.4) (798)
	<i>Comparison</i>	20 (2.1) (955)	33 (3.5) (937)	22 (2.4) (928)	80 (8.6) (926)	74 (7.7) (955)
Officer	Ranch Hand	9 (2.9) (306)	11 (3.7) (301)	7 (2.3) (298)	31 (10.6) (293)	16 (5.2) (306)
	Comparison	10 (2.7) (377)	13 (3.5) (371)	4 (1.1) (363)	28 (7.6) (367)	19 (5.0) (377)
Enlisted Flyer	Ranch Hand	4 (2.8) (145)	8 (5.6) (142)	8 (5.7) (140)	12 (8.7) (138)	16 (11.0) (145)
	Comparison	4 (2.8) (142)	8 (5.7) (141)	6 (4.3) (140)	14 (10.3) (136)	15 (10.6) (142)
Enlisted Groundcrew	Ranch Hand	8 (2.3) (347)	11 (3.3) (338)	9 (2.7) (334)	39 (11.7) (332)	35 (10.1) (347)
	Comparison	6 (1.4) (436)	12 (2.8) (425)	12 (2.8) (425)	38 (9.0) (423)	40 (9.2) (436)

Occupational Category	Group	Normal in 1982			
		n in 1997	Number (%) Low in 1997	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
<i>All</i>	<i>Ranch Hand</i>	777	57 (7.3)	1.06 (0.73,1.53)	0.760
	<i>Comparison</i>	935	65 (7.0)		
Officer	Ranch Hand	297	13 (4.4)	0.94 (0.45,1.97)	0.872
	Comparison	367	17 (4.6)		
Enlisted Flyer	Ranch Hand	141	15 (10.6)	1.25 (0.56,2.78)	0.584
	Comparison	138	12 (8.7)		
Enlisted Groundcrew	Ranch Hand	339	29 (8.6)	1.03 (0.62,1.71)	0.920
	Comparison	430	36 (8.4)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal HDL cholesterol level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-71. Longitudinal Analysis of HDL Cholesterol (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) Low/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	2 (1.3) (149)	5 (3.4) (145)	2 (1.4) (148)	13 (9.0) (144)	13 (8.7) (149)
Medium	4 (2.6) (154)	7 (4.6) (152)	4 (2.7) (150)	16 (10.8) (148)	15 (9.7) (154)
High	3 (2.0) (150)	7 (4.8) (147)	6 (4.1) (145)	16 (11.1) (144)	9 (6.0) (150)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) Low in 1997</b>		
Low	147	12 (8.2)	0.82 (0.60,1.12)	0.192
Medium	150	13 (8.7)		
High	147	7 (4.8)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal HDL cholesterol level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) Low/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	20 (2.2) (928)	33 (3.6) (912)	22 (2.4) (902)	78 (8.7) (901)	73 (7.9) (928)
Background RH	12 (3.5) (339)	11 (3.3) (332)	11 (3.4) (324)	34 (10.6) (322)	30 (8.8) (339)
Low RH	6 (2.7) (224)	10 (4.6) (218)	3 (1.4) (220)	19 (8.8) (215)	19 (8.5) (224)
High RH	3 (1.3) (229)	9 (4.0) (226)	9 (4.0) (223)	26 (11.8) (221)	18 (7.9) (229)
Low plus High RH	9 (2.0) (453)	19 (4.3) (444)	12 (2.7) (443)	45 (10.3) (436)	37 (8.2) (453)

**Table 13-71. Longitudinal Analysis of HDL Cholesterol (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) Low in 1997		
Comparison	908	64 (7.0)		
Background RH	327	25 (7.6)	1.25 (0.77,2.03)	0.374
Low RH	218	16 (7.3)	1.03 (0.58,1.83)	0.926
High RH	226	16 (7.1)	0.85 (0.47,1.52)	0.581
Low plus High RH	444	32 (7.2)	0.93 (0.60,1.46)	0.759

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, Initial Dioxin  $>$  94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal HDL cholesterol level in 1982 (see Chapter 7, Statistical Methods).

### 13.2.3.1.11 Cholesterol-HDL Ratio (Continuous)

The Models 1 through 3 analyses did not reveal a significant association between the cholesterol-HDL ratio and dioxin (Table 13-72(a-c):  $p > 0.23$  for each analysis).

**Table 13-72. Longitudinal Analysis of Cholesterol-HDL Ratio (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>4.71</i> (798)	<i>4.77</i> (781)	<i>4.71</i> (772)	<i>5.23</i> (763)	<i>4.65</i> (798)	<i>-0.06</i>	<i>-0.01</i>	<i>0.519</i>
	<i>Comparison</i>	<i>4.77</i> (955)	<i>4.80</i> (937)	<i>4.71</i> (928)	<i>5.27</i> (926)	<i>4.71</i> (955)	<i>-0.05</i>		
Officer	Ranch Hand	4.58 (306)	4.62 (301)	4.56 (298)	4.99 (293)	4.36 (306)	-0.22	-0.10	0.237
	Comparison	4.57 (377)	4.60 (371)	4.53 (363)	5.04 (367)	4.45 (377)	-0.12		
Enlisted Flyer	Ranch Hand	5.00 (145)	5.06 (142)	4.88 (140)	5.32 (138)	4.72 (145)	-0.28	-0.06	0.255
	Comparison	5.16 (142)	5.06 (141)	4.95 (140)	5.45 (136)	4.94 (142)	-0.22		
Enlisted Groundcrew	Ranch Hand	4.71 (347)	4.79 (338)	4.78 (334)	5.42 (332)	4.89 (347)	0.18	0.12	0.400
	Comparison	4.81 (436)	4.89 (425)	4.79 (425)	5.43 (423)	4.87 (436)	0.06		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of cholesterol-HDL ratio; results adjusted for natural logarithm of cholesterol-HDL ratio in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-72. Longitudinal Analysis of Cholesterol-HDL Ratio (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics					Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>		
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	4.70 (149)	4.81 (145)	4.73 (148)	5.17 (144)	4.51 (149)	0.005 (0.008)	0.589
Medium	4.85 (154)	4.98 (152)	4.93 (150)	5.43 (148)	4.88 (154)		
High	5.10 (150)	5.12 (147)	5.02 (145)	5.59 (144)	4.98 (150)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 cholesterol-HDL ratio and natural logarithm of 1982 GGT versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 cholesterol-HDL ratio, and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	4.76 (928)	4.81 (912)	4.71 (902)	5.28 (901)	4.72 (928)	-0.04		
Background RH	4.50 (339)	4.52 (332)	4.48 (324)	4.99 (322)	4.47 (339)	-0.03	0.01	0.473
Low RH	4.69 (224)	4.77 (218)	4.69 (220)	5.16 (215)	4.57 (224)	-0.12	-0.08	0.281
High RH	5.08 (229)	5.17 (226)	5.10 (223)	5.64 (221)	5.01 (229)	-0.06	-0.02	0.971
Low plus High RH	4.88 (453)	4.97 (444)	4.89 (443)	5.40 (436)	4.79 (453)	-0.09	-0.05	0.505

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 cholesterol-HDL ratio; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 cholesterol-HDL ratio, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.12 Cholesterol-HDL Ratio (Discrete)

The longitudinal analyses in Models 1 through 3 did not reveal a significant association between dioxin and the percentage of participants who had a normal cholesterol-HDL ratio in 1982 and a high cholesterol-HDL ratio in 1997 (Table 13-73(a-c):  $p > 0.10$  for each analysis).

**Table 13-73. Longitudinal Analysis of Cholesterol-HDL Ratio (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	350 (43.9) (798)	352 (45.1) (781)	335 (43.4) (772)	432 (56.6) (763)	324 (40.6) (798)
	<i>Comparison</i>	423 (44.3) (955)	415 (44.3) (937)	401 (43.2) (928)	533 (57.6) (926)	404 (42.3) (955)
Officer	Ranch Hand	120 (39.2) (306)	132 (43.9) (301)	124 (41.6) (298)	144 (49.1) (293)	99 (32.4) (306)
	Comparison	151 (40.1) (377)	140 (37.7) (371)	134 (36.9) (363)	182 (49.6) (367)	117 (31.0) (377)
Enlisted Flyer	Ranch Hand	74 (51.0) (145)	69 (48.6) (142)	61 (43.6) (140)	83 (60.1) (138)	56 (38.6) (145)
	Comparison	77 (54.2) (142)	71 (50.4) (141)	76 (54.3) (140)	84 (61.8) (136)	71 (50.0) (142)
Enlisted Groundcrew	Ranch Hand	156 (45.0) (347)	151 (44.7) (338)	150 (44.9) (334)	205 (61.7) (332)	169 (48.7) (347)
	Comparison	195 (44.7) (436)	204 (48.0) (425)	191 (44.9) (425)	267 (63.1) (423)	216 (49.5) (436)

  

Occupational Category	Group	Normal in 1982			
		n in 1997	Number (%) High in 1997	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
<i>All</i>	<i>Ranch Hand</i>	448	90 (20.1)	0.82 (0.60,1.12)	0.206
	<i>Comparison</i>	532	125 (23.5)		
Officer	Ranch Hand	186	27 (14.5)	1.00 (0.58,1.74)	0.996
	Comparison	226	33 (14.6)		
Enlisted Flyer	Ranch Hand	71	16 (22.5)	0.81 (0.37,1.78)	0.598
	Comparison	65	17 (26.2)		
Enlisted Groundcrew	Ranch Hand	191	47 (24.6)	0.72 (0.47,1.10)	0.131
	Comparison	241	75 (31.1)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol-HDL ratio in 1982 (see Chapter 7, Statistical Methods).

**Table 13-73. Longitudinal Analysis of Cholesterol-HDL Ratio (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	61 (40.9) (149)	66 (45.5) (145)	65 (43.9) (148)	79 (54.9) (144)	51 (34.2) (149)
Medium	74 (48.1) (154)	75 (49.3) (152)	73 (48.7) (150)	97 (65.5) (148)	72 (46.8) (154)
High	82 (54.7) (150)	78 (53.1) (147)	74 (51.0) (145)	92 (63.9) (144)	78 (52.0) (150)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	88	15 (17.0)	1.15 (0.89,1.48)	0.278
Medium	80	21 (26.3)		
High	68	17 (25.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol-HDL ratio in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	407 (43.9) (928)	406 (44.5) (912)	391 (43.3) (902)	518 (57.5) (901)	395 (42.6) (928)
Background RH	131 (38.6) (339)	130 (39.2) (332)	120 (37.0) (324)	160 (49.7) (322)	119 (35.1) (339)
Low RH	91 (40.6) (224)	93 (42.7) (218)	94 (42.7) (220)	120 (55.8) (215)	80 (35.7) (224)
High RH	126 (55.0) (229)	126 (55.8) (226)	118 (52.9) (223)	148 (67.0) (221)	121 (52.8) (229)
Low plus High RH	217 (47.9) (453)	219 (49.3) (444)	212 (47.9) (443)	268 (61.5) (436)	201 (44.4) (453)

**Table 13-73. Longitudinal Analysis of Cholesterol-HDL Ratio (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	521	124 (23.8)		
Background RH	208	35 (16.8)	0.70 (0.46, 1.07)	0.102
Low RH	133	25 (18.8)	0.74 (0.45, 1.20)	0.216
High RH	103	28 (27.2)	1.03 (0.63, 1.68)	0.899
Low plus High RH	236	53 (22.5)	0.85 (0.59, 1.24)	0.408

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, Initial Dioxin  $>$  94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal cholesterol-HDL ratio in 1982 (see Chapter 7, Statistical Methods).

### 13.2.3.1.13 Triglycerides (Continuous)

The Model 1 analysis of the change in triglyceride levels did not uncover a significant difference between overall Ranch Hands and Comparisons or within each occupational stratum (Table 13-74(a):  $p > 0.12$  for each contrast). The Model 2 analysis did not reveal a significant association between the change in triglyceride levels and initial dioxin (Table 13-74(b):  $p = 0.751$ ).

Model 3 analysis of the change in mean triglyceride levels between 1982 and 1997 revealed two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-74(c): difference of examination mean change = 11.8 mg/dl,  $p = 0.020$ ; difference of examination mean change = 5.4 mg/dl,  $p = 0.094$ , respectively). The examination mean changes for Ranch Hands in the high dioxin category, Ranch Hands in the low and high dioxin categories combined, and Comparisons were 13.1 mg/dl, 6.7 mg/dl, and 1.3 mg/dl, respectively.

**Table 13-74. Longitudinal Analysis of Triglycerides (mg/dl) (Continuous)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>									
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n) Examination</b>					<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>118.8</i> <i>(803)</i>	<i>117.1</i> <i>(786)</i>	<i>120.2</i> <i>(777)</i>	<i>146.6</i> <i>(777)</i>	<i>122.7</i> <i>(803)</i>	<b>4.0</b>	<b>3.2</b>	<b>0.478</b>
	<i>Comparison</i>	<i>120.9</i> <i>(956)</i>	<i>119.1</i> <i>(938)</i>	<i>119.4</i> <i>(929)</i>	<i>146.1</i> <i>(933)</i>	<i>121.8</i> <i>(956)</i>	<b>0.8</b>		
Officer	Ranch Hand	118.8 (308)	116.3 (303)	115.1 (300)	143.1 (299)	113.7 (308)	-5.1	-1.0	0.780
	Comparison	115.5 (377)	111.9 (371)	111.8 (363)	137.7 (370)	111.4 (377)	-4.1		
Enlisted Flyer	Ranch Hand	129.1 (146)	122.7 (143)	126.7 (141)	145.0 (143)	125.0 (146)	-4.1	-8.5	0.177
	Comparison	134.2 (142)	130.4 (141)	130.0 (140)	157.3 (138)	138.6 (142)	4.4		
Enlisted Groundcrew	Ranch Hand	114.6 (349)	115.5 (340)	122.3 (336)	150.4 (335)	130.3 (349)	15.7	11.3	0.128
	Comparison	121.6 (437)	122.1 (426)	122.8 (426)	150.0 (425)	126.1 (437)	4.4		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of triglycerides; results adjusted for natural logarithm of triglycerides in 1982 and age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

**Table 13-74. Longitudinal Analysis of Triglycerides (mg/dl) (Continuous) (Continued)**

<b>(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN</b>							
Initial Dioxin Category Summary Statistics						Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup>	
Initial Dioxin	Mean <sup>a</sup> /(n) Examination					Adjusted Slope (Std. Error)	p-Value
	1982	1985	1987	1992	1997		
Low	122.1 (151)	120.8 (147)	120.1 (150)	143.2 (146)	117.6 (151)	0.006 (0.020)	0.751
Medium	129.2 (156)	129.1 (154)	142.9 (152)	163.3 (152)	141.4 (156)		
High	129.5 (151)	133.2 (148)	133.6 (146)	161.1 (148)	143.0 (151)		

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Results based on difference between natural logarithm of 1997 triglycerides and natural logarithm of 1982 triglycerides versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 triglycerides and age in 1997.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>								
Dioxin Category	Mean <sup>a</sup> /(n) Examination					Exam. Mean Change <sup>b</sup>	Difference of Exam. Mean Change	p-Value <sup>c</sup>
	1982	1985	1987	1992	1997			
Comparison	120.1 (929)	118.7 (913)	118.7 (903)	145.4 (907)	121.4 (929)	1.3		
Background RH	107.7 (339)	103.7 (332)	105.5 (324)	134.4 (326)	108.6 (339)	0.8	-0.5	0.377
Low RH	119.8 (226)	120.4 (220)	120.5 (222)	144.0 (218)	120.8 (226)	1.0	-0.3	0.820
High RH	134.3 (232)	135.0 (229)	144.1 (226)	167.8 (228)	147.3 (232)	13.1	11.8	0.020
Low plus High RH	126.9 (458)	127.6 (449)	131.9 (448)	155.7 (446)	133.6 (458)	6.7	5.4	0.094

<sup>a</sup> Transformed from natural logarithm scale.

<sup>b</sup> Difference between 1997 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of 1997 triglycerides; results adjusted for percent body fat at the date of the blood measurement of dioxin, natural logarithm of 1982 triglycerides, and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin ≤ 10 ppt.

Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.

Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.

High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations.

13.2.3.1.14 Triglycerides (Discrete)

The Model 1 analysis of the percentage of participants with a normal triglyceride level in 1982 and a high triglyceride level in 1997 did not show a significant difference between overall Ranch Hands and Comparisons or within each occupational stratum (Table 13-75(a):  $p > 0.12$  for each contrast).

**Table 13-75. Longitudinal Analysis of Triglycerides (Discrete)**

<b>(a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>						
Occupational Category	Group	Number (%) High/(n) Examination				
		1982	1985	1987	1992	1997
<i>All</i>	<i>Ranch Hand</i>	248 (30.9) (803)	58 (7.4) (786)	59 (7.6) (777)	88 (11.3) (777)	179 (22.3) (803)
	<i>Comparison</i>	313 (32.7) (956)	61 (6.5) (938)	60 (6.5) (929)	84 (9.0) (933)	203 (21.2) (956)
Officer	Ranch Hand	84 (27.3) (308)	30 (9.9) (303)	21 (7.0) (300)	33 (11.0) (299)	53 (17.2) (308)
	Comparison	113 (30.0) (377)	24 (6.5) (371)	25 (6.9) (363)	32 (8.6) (370)	62 (16.4) (377)
Enlisted Flyer	Ranch Hand	55 (37.7) (146)	14 (9.8) (143)	12 (8.5) (141)	20 (14.0) (143)	30 (20.5) (146)
	Comparison	52 (36.6) (142)	10 (7.1) (141)	9 (6.4) (140)	11 (8.0) (138)	42 (29.6) (142)
Enlisted Groundcrew	Ranch Hand	109 (31.2) (349)	14 (4.1) (340)	26 (7.7) (336)	35 (10.4) (335)	96 (27.5) (349)
	Comparison	148 (33.9) (437)	27 (6.3) (426)	26 (6.1) (426)	41 (9.6) (425)	99 (22.7) (437)

  

Occupational Category	Group	Normal in 1982			
		n in 1997	Number (%) High in 1997	Adj. Relative Risk (95% C.I.) <sup>a</sup>	p-Value <sup>a</sup>
<i>All</i>	<i>Ranch Hand</i>	555	66 (11.9)	1.31 (0.90,1.89)	0.159
	<i>Comparison</i>	643	60 (9.3)		
Officer	Ranch Hand	224	20 (8.9)	1.44 (0.73,2.82)	0.291
	Comparison	264	17 (6.4)		
Enlisted Flyer	Ranch Hand	91	8 (8.8)	0.69 (0.26,1.80)	0.443
	Comparison	90	11 (12.2)		
Enlisted Groundcrew	Ranch Hand	240	38 (15.8)	1.48 (0.89,2.46)	0.127
	Comparison	289	32 (11.1)		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal triglyceride level in 1982 (see Chapter 7, Statistical Methods).

**Table 13-75. Longitudinal Analysis of Triglycerides (Discrete) (Continued)**

<b>(b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>					
<b>Initial Dioxin</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Low	49 (32.5) (151)	13 (8.8) (147)	9 (6.0) (150)	14 (9.6) (146)	36 (23.8) (151)
Medium	56 (35.9) (156)	16 (10.4) (154)	16 (10.5) (152)	25 (16.4) (152)	44 (28.2) (156)
High	56 (37.1) (151)	11 (7.4) (148)	18 (12.3) (146)	19 (12.8) (148)	49 (32.5) (151)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1997</b>	<b>Number (%) High in 1997</b>		
Low	102	14 (13.7)	1.07 (0.83,1.38)	0.608
Medium	100	12 (12.0)		
High	95	19 (20.0)		

<sup>a</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

<sup>b</sup> Relative risk for a twofold increase in initial dioxin.

Note: Low = 27–63 ppt; Medium = >63–152 ppt; High = >152 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal triglyceride level in 1982 (see Chapter 7, Statistical Methods).

<b>(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>					
<b>Dioxin Category</b>	<b>Number (%) High/(n) Examination</b>				
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>	<b>1997</b>
Comparison	300 (32.3) (929)	58 (6.4) (913)	57 (6.3) (903)	80 (8.8) (907)	195 (21.0) (929)
Background RH	83 (24.5) (339)	17 (5.1) (332)	16 (4.9) (324)	30 (9.2) (326)	46 (13.6) (339)
Low RH	75 (33.2) (226)	20 (9.1) (220)	14 (6.3) (222)	21 (9.6) (218)	52 (23.0) (226)
High RH	86 (37.1) (232)	20 (8.7) (229)	29 (12.8) (226)	37 (16.2) (228)	77 (33.2) (232)
Low plus High RH	161 (35.2) (458)	40 (8.9) (449)	43 (9.6) (448)	58 (13.0) (446)	129 (28.2) (458)

**Table 13-75. Longitudinal Analysis of Triglycerides (Discrete) (Continued)**

Dioxin Category	Normal in 1982		Adj. Relative Risk (95% C.I.) <sup>ab</sup>	p-Value <sup>b</sup>
	n in 1997	Number (%) High in 1997		
Comparison	629	58 (9.2)		
Background RH	256	19 (7.4)	0.88 (0.51,1.52)	0.649
Low RH	151	17 (11.3)	1.29 (0.72,2.30)	0.390
High RH	146	28 (19.2)	1.97 (1.19,3.26)	0.008
Low plus High RH	297	45 (15.2)	1.59 (1.04,2.44)	0.034

<sup>a</sup> Relative risk and confidence interval relative to Comparisons.

<sup>b</sup> Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.

Comparison: 1987 Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): 1987 Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  94 ppt.

High (Ranch Hand): 1987 Dioxin  $>$ 10 ppt, Initial Dioxin  $>$  94 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the 1982, 1985, and 1997 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the 1982, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1982, 1992, and 1997 examinations. Statistical analyses are based only on participants who had a normal triglyceride level in 1982 (see Chapter 7, Statistical Methods).

The Model 2 analysis did not reveal a significant association between the change in triglyceride levels and initial dioxin (Table 13-75(b):  $p=0.608$ ). Model 3 analysis of the change in triglyceride values from normal in 1982 to high in 1997 revealed two significant contrasts: Ranch Hands in the high dioxin category versus Comparisons and Ranch Hands in the low and high dioxin categories combined versus Comparisons (Table 13-75(c): Adj. RR=1.97,  $p=0.008$ ; Adj. RR=1.59,  $p=0.034$ , respectively). Of the Comparisons, 9.2 percent had normal triglyceride levels in 1982 and high triglyceride levels in 1997. Of the Ranch Hands, 19.2 percent in the high dioxin category and 15.2 percent in the low and high dioxin categories combined had normal triglyceride levels in 1982 and high triglyceride levels in 1997.

### 13.3 DISCUSSION

The historical, physical examination, and laboratory parameters included in the gastrointestinal assessment are well established in clinical practice as screening tools in the outpatient investigation of digestive disorders. In the diagnosis of digestive disorders, it is important to recognize the limitations of the history and physical examination. Rather than pointing to a particular diagnosis, digestive symptoms are frequently nonspecific and intermittent. In this setting, even the best-designed medical history questionnaire can be subject to error. "Ulcer" and "colitis" are diagnoses that are commonly reported but often not accurately established. As a common target organ for situational stress, the bowel frequently gives rise to symptoms that can be severe but that are functional in nature and resolve over time. These caveats highlight the importance of the type of medical record verification conducted in the current study.

The physical examination of the gastrointestinal system is often of limited value and can be misleading in the differential diagnosis. For example, the detection of enlargement of the liver in the obese patient is unreliable. In obstructive airway disease, with hyperinflation of the lungs and flattening of the

diaphragms, the liver edge may descend abnormally below the right costal margin in the absence of hepatomegaly. The span of the liver by palpation or percussion is often an unreliable index of liver size.

Data collected in the laboratory can provide early insight into the presence of occult liver disease despite the limitations in the history and physical examination. The four hepatic enzymes analyzed as dependent variables (AST, ALT, GGT, and LDH) are commonly ordered in the outpatient setting. These enzymes, of which GGT is the most sensitive, are present in high intracellular concentration. They also are elevated in fatty infiltration of the liver associated with obesity and in virtually all toxic, inflammatory, and neoplastic diseases with hepatic involvement.

The hepatic enzymes are used in the detection and follow-up of parenchymal liver disease. The serum alkaline phosphatase and bilirubin are reflective of hepatobiliary function and are elevated in “cholestatic” or “obstructive” diseases. Although present in virtually all organ systems, the serum alkaline phosphatase in the adult population under study is of dual origin and close to an even mixture of liver- and bone-derived fractions. An elevated alkaline phosphatase is not diagnostic of liver disease and may occur in a broad range of unrelated clinical conditions including drug-induced cholestasis, Paget’s disease (3% of males over age 40), neoplasia with metastases to bone, and congestive heart failure.

Similarly, the bilirubin measurements are subject to numerous hereditary and acquired disorders unrelated to intrinsic hepatic disease. The benign hyperbilirubinemia of Gilbert’s syndrome will occur in 5 percent of the population under study. Many medications, including over-the-counter preparations, have been implicated in the overproduction of bilirubin that occurs in the hemolytic reactions associated with glucose-6-phosphate dehydrogenase deficiency that may be present in up to 15 percent of Black American males.

In this follow-up examination, with two exceptions, none of the analyses of historical (verified medical records review) or physical examination variables revealed any significant group differences or evidence for liver disease associated with the 1987 body burden of dioxin. Consistent with the 1992 examinations, Ranch Hands were significantly less likely than Comparisons to have a history of jaundice (1.4% vs. 2.9%), a finding that is consistent with the highly significant ( $p < 0.001$ ) inverse dose-response pattern in the model relating this variable to 1987 serum dioxin. Also consistent with the 1992 follow-up examination, Ranch Hands were more likely than Comparisons to have a history of other liver disorders, primarily based on enlisted groundcrew (30.8% vs. 25.2%). An increasing history of other liver disorders as dioxin levels increased also was observed. Twelve percent of this category of “other liver disorders” comprised participants with nonspecific laboratory test elevations at previous examinations.

The laboratory data examined can be divided broadly into parenchymal (serum enzymes), hepatobiliary (serum bilirubin and alkaline phosphatase), lipid or carbohydrate indices, and a 10-element protein profile including prealbumin, albumin,  $\alpha$ -1-acid glycoprotein,  $\alpha$ -1-antitrypsin,  $\alpha$ -2-macroglobulin, apolipoprotein B, C3 complement, C4 complement, haptoglobin, and transferrin. The components of the protein profile were selected to provide a comprehensive reflection of multiple organ systems involved in homeostasis and to investigate the possibility of a subclinical inflammatory process that might be associated with prior TCDD exposure or the current body burden of dioxin. Produced in the liver, the proteins measured are most sensitive to hepatic function but also provide a reliable assessment of nutritional status. Selected proteins ( $\alpha$ -1-acid glycoprotein,  $\alpha$ -1-antitrypsin, and haptoglobin) are nonspecifically elevated in association with inflammation, whereas reductions in the C3 and C4 complement indices are associated with immune system responses.

Few of the laboratory analyses revealed any significant differences between the Ranch Hand and Comparison cohorts. Ranch Hands continued to have a slightly higher mean alkaline phosphatase than

Comparisons by continuous analysis. In the analyses relating alkaline phosphatase to the initial and the 1987 body burden of dioxin within Ranch Hands, a marginally significant inverse relation was noted. In the analyses of laboratory data in discrete form, no significant group differences were defined.

The analyses of two protein variables in continuous form,  $\alpha$ -1-antitrypsin and haptoglobin, yielded statistically significant ( $p=0.002$  for both variables) overall group differences with Ranch Hands adversely affected. In neither instance was there any evidence for an association with 1987 serum dioxin levels and, by all discrete analyses, the prevalence of abnormalities was similar in each cohort.

Several analyses yielded results that have been documented consistently in prior examinations. Although no overall group differences were defined by both continuous and discrete analyses, three of four liver enzymes—ALT, AST, and GGT—revealed significant positive associations with 1987 serum dioxin levels. Similar results were noted as well in the analysis of serum triglycerides. These results, while consistent with a dose-response effect, might be explained as well on the basis of the hyperlipidemia and fatty infiltration of the liver that occur in association with obesity. A causal relation with prior dioxin exposure remains to be established.

Dependent variable-covariate associations yielded results similar to those documented in previous examinations and that are well established in clinical practice. Highly significant positive correlations were noted relating lifetime alcohol consumption with the history of chronic liver disease and cirrhosis, the finding of enlargement of the liver upon physical examination, and an elevation in GGT, the most sensitive liver enzyme. The mean creatine phosphokinase level in Blacks was almost twice as high as in non-Blacks, a finding that was noted in both the 1987 and 1992 examinations and that appears to be race- and gender-specific.

Throughout 15 years of observation, the longitudinal analyses have yielded marginally significant results in several of the laboratory indices, most of which were similar to those documented in the 1992 examination. Although no significant overall group differences were identified, a consistent gradual reduction in serum AST occurred in both Ranch Hands and Comparisons across all occupational and exposure categories. In the analyses of ALT in discrete form, Ranch Hand enlisted groundcrew, those most heavily exposed to dioxin, remained less likely than Comparisons to have abnormal elevations in this index (5.6% vs. 7.9%, respectively) in 1997. Relative to Comparisons, the increase in mean serum triglyceride levels over time was most pronounced in Ranch Hands in the highest serum dioxin category in a pattern consistent with a dose-response effect (13.1 mg vs. 1.3 mg;  $p=0.020$ ). Finally, Ranch Hands in the enlisted groundcrew occupational stratum whose cholesterol levels were normal in 1982 were significantly more likely than Comparisons to develop abnormal elevations in 1997 (15.6% vs. 9.9%), an effect most pronounced in those participants with the highest levels of serum dioxin relative to Comparisons (17.2% vs. 10.3%).

Data analyzed for the gastrointestinal assessment confirm observations that would be anticipated in clinical practice and reflect no apparent increase in organ-specific morbidity in Ranch Hands relative to Comparisons. Although the results cited above are consistent with a subtle effect of dioxin on lipid metabolism, an association with body habitus and obesity cannot be excluded.

## 13.4 SUMMARY

### 13.4.1 Model 1: Group Analysis

The adjusted group analysis for medical records variables revealed a significant difference between Ranch Hands and Comparisons over all occupational strata for jaundice. Comparisons had a greater history of jaundice than Ranch Hands.

The adjusted Model 1 analyses of the continuous variables found that Ranch Hands had significantly higher mean levels of alkaline phosphatase,  $\alpha$ -1-antitrypsin, haptoglobin, and transferrin than Comparisons. In the discrete analyses, significantly more Ranch Hands than Comparisons had high haptoglobin levels and more Comparisons than Ranch Hands had evidence of prior hepatitis B infection and low transferrin values.

After stratifying by occupation, the adjusted analyses revealed significantly lower mean levels of serum amylase, apolipoprotein B, and C4 complement among the Ranch Hand officers versus Comparison officers. In the discrete analysis, more Comparison officers than Ranch Hand officers had prior hepatitis B infection. Ranch Hand enlisted flyers had a significantly lower percentage of high apolipoprotein B values than Comparison enlisted flyers.

The adjusted analysis of the continuous variables showed that among the enlisted groundcrew, the Ranch Hand mean levels of alkaline phosphatase,  $\alpha$ -1-acid glycoprotein,  $\alpha$ -1-antitrypsin, and haptoglobin were significantly higher than the corresponding Comparison group mean levels. The adjusted discrete analyses found significantly more high triglyceride levels and low prealbumin levels among enlisted groundcrew Ranch Hands than among enlisted groundcrew Comparisons. A significantly smaller prevalence of serological evidence of prior hepatitis B infection was seen for Ranch Hand enlisted groundcrew versus Comparison enlisted groundcrew.

The results of all unadjusted and adjusted Model 1 analyses are summarized in Table 13-76.

**Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons)**

Variable	UNADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
<b>Medical Records</b>				
Uncharacterized Hepatitis (D)	NS	NS	NS	NS
Jaundice (Unspecified) (D)	-0.025	ns*	NS	ns*
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	NS	NS	ns	ns
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS	ns	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	NS	ns	--	NS
Enlarged Liver (Hepatomegaly) (D)	ns	ns	NS	ns*
Other Liver Disorders (D)	NS*	NS	NS	NS*
<b>Physical Examination</b>				
Current Hepatomegaly (D)	NS	NS	NS	NS

**Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	UNADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
<b>Laboratory</b>				
AST (C)	NS	NS	ns	NS
AST (D)	NS	NS	ns	NS
ALT (C)	NS	NS	ns	NS
ALT (D)	NS	NS	ns	ns
GGT (C)	NS	NS	ns	NS
GGT (D)	NS	NS	NS	ns
Alkaline Phosphatase (C)	+0.024	NS	NS	+0.030
Alkaline Phosphatase (D)	NS	ns	NS	NS*
Total Bilirubin (C)	ns	NS	ns	NS
Total Bilirubin (D)	ns	ns	NS	ns
Direct Bilirubin (D)	ns	ns	--	ns
Lactic Dehydrogenase (C)	NS	ns	ns	NS
Lactic Dehydrogenase (D)	ns	ns	NS	ns
Cholesterol (C)	ns	ns	ns	NS
Cholesterol (D)	NS	ns	ns	NS
HDL Cholesterol (C) <sup>a</sup>	NS	ns	NS	ns
HDL Cholesterol (D)	NS	NS	NS	NS
Cholesterol-HDL Ratio (C)	ns	ns	ns	NS
Cholesterol-HDL Ratio (D)	NS	NS	ns	NS
Triglycerides (C)	NS	NS	ns	NS
Triglycerides (D)	NS	NS	ns	NS*
Creatine Phosphokinase (C)	NS	NS	ns	NS
Creatine Phosphokinase (D)	ns	ns	ns	NS
Serum Amylase (C)	NS	-0.048	NS	NS
Serum Amylase (D)	ns	ns*	NS	NS
Antibodies for Hepatitis A (D)	ns	NS	NS	ns
Serological Evidence of Prior Hepatitis B Infection (D)	-0.001	-0.031	ns*	-0.036
Current Hepatitis B (D)	ns	--	--	ns
Antibodies for Hepatitis C (D)	ns	ns	ns	ns
Antibodies for Hepatitis D (D)	--	--	--	--
Stool Hemocult (D)	ns	ns	ns	ns
Prealbumin (C) <sup>a</sup>	ns	ns	NS	ns
Prealbumin (D)	NS	NS	NS	NS*
Albumin (C) <sup>a</sup>	ns	ns	NS	NS
Albumin (D)	ns	NS	ns	ns
α-1-Acid Glycoprotein (C)	NS	ns	ns	+0.044
α-1-Acid Glycoprotein (D)	NS	ns	NS	NS
α-1-Antitrypsin (C):	+0.002	NS	NS	+0.001
α-1-Antitrypsin (D):				
Low vs. Normal	ns	NS	NS	ns
High vs. Normal	NS	NS	ns	NS
α-2-Macroglobulin (C)	ns	ns	ns	ns
α-2-Macroglobulin (D)	ns	ns	ns	ns
Apolipoprotein B (C)	ns	ns*	ns	NS
Apolipoprotein B (D)	ns*	ns	-0.007	NS
C3 Complement (C) <sup>a</sup>	NS	NS	ns	NS
C3 Complement (D)	ns	ns	ns	NS

**Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	UNADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
C4 Complement (C) <sup>a</sup>	ns	-0.024	NS*	ns
C4 Complement (D)	NS	NS	ns	--
Haptoglobin (C)	+0.002	NS	NS	+0.016
Haptoglobin (D)	+0.017	NS	NS	NS*
Transferrin (C) <sup>a</sup>	+0.044	NS	NS	NS*
Transferrin (D)	-0.036	ns*	ns	ns

Note: NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; difference of means nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis; difference of means negative for continuous analysis.

--: Analysis not performed because of the sparse number of participants with an abnormality.

<sup>a</sup> Negative difference considered adverse for this variable.

P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk of 1.00 or greater for discrete analysis or differences of means nonnegative for continuous analysis. A lowercase "ns" denotes relative risk less than 1.00 for discrete analyses or difference of means negative for continuous analysis.

Variable	ADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
<b>Medical Records</b>				
Uncharacterized Hepatitis (D)	NS	NS	NS	NS
Jaundice (Unspecified) (D)	-0.028	ns	NS	ns*
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	ns	NS	ns	ns
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS	ns	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	NS	--	--	--
Enlarged Liver (Hepatomegaly) (D)	ns	ns	NS	ns*
Other Liver Disorders (D)	NS*	NS	ns	NS*
<b>Physical Examination</b>				
Current Hepatomegaly (D)	NS	NS	--	NS
<b>Laboratory</b>				
AST (C)	NS	NS	ns	NS
AST (D)	NS	NS	ns	NS
ALT (C)	NS	NS	ns	NS
ALT (D)	NS	NS	ns	ns
GGT (C)	NS	NS	NS	NS
GGT (D)	NS	NS	NS	ns
Alkaline Phosphatase (C)	+0.016	NS	NS	+0.021
Alkaline Phosphatase (D)	NS	ns	NS	NS*
Total Bilirubin (C)	NS	NS	ns	NS
Total Bilirubin (D)	ns	ns	NS	ns
Direct Bilirubin (D)	ns	ns	--	--

**Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	ADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
Lactic Dehydrogenase (C)	NS	ns	ns	NS
Lactic Dehydrogenase (D)	ns	ns	NS	ns
Cholesterol (C)	ns	ns	ns	NS
Cholesterol (D)	NS	ns	NS	NS
HDL Cholesterol (C) <sup>a</sup>	NS	ns	NS*	ns
HDL Cholesterol (D)	NS	NS	ns	NS
Cholesterol-HDL Ratio (C)	ns	ns	ns*	NS
Cholesterol-HDL Ratio (D)	NS	NS	ns*	NS
Triglycerides (C)	NS	NS	ns	NS
Triglycerides (D)	NS	NS	ns	+0.047
Creatine Phosphokinase (C)	NS	NS	ns	NS
Creatine Phosphokinase (D)	ns	ns	ns	NS
Serum Amylase (C)	ns	-0.037	NS	NS
Serum Amylase (D)	ns	ns*	NS	NS
Antibodies for Hepatitis A (D)	ns	ns	NS	ns
Serological Evidence of Prior Hepatitis B Infection (D)	<-0.001	-0.024	ns*	-0.035
Current Hepatitis B (D)	ns	--	--	ns
Antibodies for Hepatitis C (D)	ns	ns	ns	ns
Antibodies for Hepatitis D (D)	--	--	--	--
Stool Hemocult (D)	ns	ns	ns	ns
Prealbumin (C) <sup>a</sup>	ns	ns	NS	ns
Prealbumin (D)	NS	NS	NS	+0.043
Albumin (C) <sup>a</sup>	ns	ns	NS	NS
Albumin (D)	ns	NS	--	--
α-1-Acid Glycoprotein (C)	NS	ns	NS	+0.030
α-1-Acid Glycoprotein (D)	NS	ns	NS	NS*
α-1-Antitrypsin (C)	+0.001	NS	NS*	+<0.001
α-1-Antitrypsin (D):				
Low vs. Normal	ns	NS	--	ns
High vs. Normal	NS	--	ns	NS
α-2-Macroglobulin (C)	ns	ns	ns	ns
α-2-Macroglobulin (D)	ns	ns	ns	NS
Apolipoprotein B (C)	ns	-0.048	ns	NS
Apolipoprotein B (D)	ns*	ns	-0.005	NS
C3 Complement (C) <sup>a</sup>	NS	NS	ns	NS
C3 Complement (D)	ns	ns	ns	NS
C4 Complement (C) <sup>a</sup>	ns	-0.017	NS	ns
C4 Complement (D)	NS	NS	--	--
Haptoglobin (C)	+0.003	NS	NS	+0.016
Haptoglobin (D)	+0.020	NS	NS	NS*
Transferrin (C) <sup>a</sup>	+0.037	NS	NS	NS*
Transferrin (D)	-0.027	ns*	ns	ns

**Table 13-76. Summary of Group Analysis (Model 1) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Note: NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; difference of means nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis; difference of means negative for continuous analysis.

--: Analysis not performed because of the sparse number of participants with an abnormality.

<sup>a</sup> Negative difference considered adverse for this variable.

P-value given if  $p \leq 0.05$ .

A capital “NS” denotes a relative risk of 1.00 or greater for discrete analysis or differences of means nonnegative for continuous analysis. A lowercase “ns” denotes relative risk less than 1.00 for discrete analysis or difference of means negative for continuous analysis.

### 13.4.2 Model 2: Initial Dioxin Analysis

Model 2 analyses of medical records variables revealed a significant positive association between initial dioxin and other liver disorders.

Adjusted Model 2 analysis of the laboratory examination variables revealed a significant positive association between initial dioxin and the discrete form of ALT. A significant inverse association was seen between initial dioxin and the discrete form of HDL cholesterol in the adjusted analysis.

The results of all unadjusted and adjusted Model 2 analyses are summarized in Table 13-77.

**Table 13-77. Summary of Initial Dioxin Analysis (Model 2) for Gastrointestinal Variables (Ranch Hands Only)**

Variable	Unadjusted	Adjusted
<b>Medical Records</b>		
Uncharacterized Hepatitis (D)	NS	NS
Jaundice (Unspecified) (D)	NS	NS
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	NS	NS
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	NS	NS
Enlarged Liver (Hepatomegaly) (D)	ns	ns
Other Liver Disorders (D)	NS	+0.022
<b>Physical Examination</b>		
Current Hepatomegaly (D)	ns	ns
<b>Laboratory</b>		
AST (C)	NS	NS
AST (D)	NS	NS
ALT (C)	NS	NS
ALT (D)	NS	+0.049
GGT (C)	NS	NS
GGT (D)	NS	NS
Alkaline Phosphatase (C)	ns	ns*
Alkaline Phosphatase (D)	ns	NS
Total Bilirubin (C)	ns	NS

**Table 13-77. Summary of Initial Dioxin Analysis (Model 2) for Gastrointestinal Variables (Ranch Hands Only) (Continued)**

Variable	Unadjusted	Adjusted
Total Bilirubin (D)	ns	ns
Direct Bilirubin (D)	--	--
Lactic Dehydrogenase (C)	ns	NS
Lactic Dehydrogenase (D)	ns	ns
Cholesterol (C)	+0.005	NS
Cholesterol (D)	+0.036	NS*
HDL Cholesterol (C) <sup>a</sup>	ns	NS
HDL Cholesterol (D)	ns	-0.029
Cholesterol-HDL Ratio (C)	+0.003	NS
Cholesterol-HDL Ratio (D)	+0.002	NS
Triglycerides (C)	NS	NS
Triglycerides (D)	NS	ns
Creatine Phosphokinase (C)	NS	ns
Creatine Phosphokinase (D)	NS	NS
Serum Amylase (C)	ns*	ns*
Serum Amylase (D)	ns	NS
Antibodies for Hepatitis A (D)	ns	NS
Serological Evidence of Prior Hepatitis B Infection (D)	NS	ns
Current Hepatitis B (D)	ns	ns
Antibodies for Hepatitis C (D)	ns	ns
Antibodies for Hepatitis D (D)	--	--
Stool Hemocult (D)	ns	ns
Prealbumin (C) <sup>a</sup>	ns	ns
Prealbumin (D)	NS	NS*
Albumin (C) <sup>a</sup>	NS	ns
Albumin (D)	--	--
α-1-Acid Glycoprotein (C)	NS	ns*
α-1-Acid Glycoprotein (D)	NS	ns
α-1-Antitrypsin (C)	NS*	NS
α-1-Antitrypsin (D):		
Low vs. Normal	ns	ns
High vs. Normal	NS	ns
α-2-Macroglobulin (C)	ns	NS
α-2-Macroglobulin (D)	NS	NS*
Apolipoprotein B (C)	+0.009	NS
Apolipoprotein B (D)	NS*	NS
C3 Complement (C) <sup>a</sup>	+0.023	NS
C3 Complement (D)	NS	NS
C4 Complement (C) <sup>a</sup>	ns	ns
C4 Complement (D)	--	--
Haptoglobin (C)	NS	ns
Haptoglobin (D)	NS	ns
Transferrin (C) <sup>a</sup>	NS	ns
Transferrin (D)	ns	ns

**Table 13-77. Summary of Initial Dioxin Analysis (Model 2) for Gastrointestinal Variables (Ranch Hands Only) (Continued)**

Note: NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; slope nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis.

--: Analysis not performed because of the sparse number of Ranch Hands with an abnormality.

<sup>a</sup> Negative slope considered adverse for this variable.

P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk of 1.00 or greater for discrete analysis or slope nonnegative for continuous analysis. A lowercase "ns" denotes relative risk less than 1.00 for discrete analysis or slope negative for continuous analysis.

---

### 13.4.3 Model 3: Categorized Dioxin Analysis

Adjusted Model 3 analyses revealed a significantly higher percentage of other liver disorders among Ranch Hands in the high dioxin category than among Comparisons.

The adjusted results of the Ranch Hands in the high dioxin category versus Comparisons contrast revealed Ranch Hands had significantly higher mean levels of GGT, triglycerides,  $\alpha$ -1-antitrypsin, and transferrin than Comparisons. The discrete analyses for AST, triglycerides, and prealbumin were also significant, with Ranch Hands in the high dioxin category having a higher prevalence of abnormal values than Comparisons. In addition, significantly less serological evidence of prior hepatitis B and low transferrin levels were noted in Ranch Hands in the high dioxin category than in Comparisons.

The adjusted result of the contrast between Ranch Hands in the low and high dioxin categories combined versus Comparisons revealed that Ranch Hands had significantly higher mean levels of ALT, GGT,  $\alpha$ -1-antitrypsin, haptoglobin, and transferrin than Comparisons. The discrete analyses for AST and triglycerides were also significant, with Ranch Hands in the low and high dioxin categories combined having a greater prevalence of high values than Comparisons. In addition, significantly less serological evidence of prior hepatitis B and low transferrin levels were noted in the Ranch Hands in the low and high dioxin categories combined than in Comparisons.

The adjusted analyses also found several significant differences for the contrast between Ranch Hands in the background dioxin category versus Comparisons. Ranch Hands had significantly higher mean levels of alkaline phosphatase,  $\alpha$ -1-antitrypsin, and haptoglobin than Comparisons. The discrete analyses for HDL cholesterol and haptoglobin were also significant, with Ranch Hands in the background dioxin category having a higher prevalence of abnormal values than Comparisons. In addition, significantly fewer Ranch Hands in the background dioxin category had serological evidence of prior hepatitis B and high apolipoprotein B levels than did Comparisons.

The results of all unadjusted and adjusted Model 3 analyses are summarized in Table 13-78.

**Table 13-78. Summary of Categorized Dioxin Analysis (Model 3) for Gastrointestinal Variables (Ranch Hands vs. Comparisons)**

Variable	UNADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
<b>Medical Records</b>				
Uncharacterized Hepatitis (D)	NS	ns	NS	NS
Jaundice (Unspecified) (D)	NS	-0.017	ns*	-0.001
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	ns	NS	NS	NS
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS	NS	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	ns	ns	NS	NS
Enlarged Liver (Hepatomegaly) (D)	ns	ns	NS	ns
Other Liver Disorders (D)	NS	NS	+0.009	+0.042
<b>Physical Examination</b>				
Current Hepatomegaly (D)	NS	NS	NS	NS
<b>Laboratory</b>				
AST (C)	ns	NS	NS	NS
AST (D)	ns	NS	NS*	NS*
ALT (C)	ns	NS	+0.027	+0.041
ALT (D)	ns	NS	+0.015	NS*
GGT (C)	ns	NS	+0.003	+0.007
GGT (D)	ns	NS	NS	NS*
Alkaline Phosphatase (C)	NS	NS*	NS	NS*
Alkaline Phosphatase (D)	NS	ns	NS	NS
Total Bilirubin (C)	NS	ns	ns	ns
Total Bilirubin (D)	ns	NS	ns	ns
Direct Bilirubin (D)	ns	--	--	--
Lactic Dehydrogenase (C)	NS	ns	NS	NS
Lactic Dehydrogenase (D)	NS	ns	ns	ns
Cholesterol (C)	ns	ns	+0.032	NS
Cholesterol (D)	ns	ns	+0.023	NS
HDL Cholesterol (C) <sup>a</sup>	NS	NS	ns	ns
HDL Cholesterol (D)	NS	NS	ns	NS
Cholesterol-HDL Ratio (C)	ns*	ns	+0.005	NS
Cholesterol-HDL Ratio (D)	ns	ns	+0.002	NS
Triglycerides (C)	ns	ns	+<0.001	+0.023
Triglycerides (D)	ns*	NS	+<0.001	+0.006
Creatine Phosphokinase (C)	NS	NS	NS	NS
Creatine Phosphokinase (D)	ns	ns	NS	ns
Serum Amylase (C)	ns	+0.019	ns	NS
Serum Amylase (D)	ns	NS	ns	NS
Antibodies for Hepatitis A (D)	ns	NS	NS	NS
Serological Evidence of Prior Hepatitis B Infection (D)	-<0.001	ns	ns	ns
Current Hepatitis B (D)	--	NS	--	NS
Antibodies for Hepatitis C (D)	ns	ns	ns	ns
Antibodies for Hepatitis D (D)	--	--	--	--
Stool Hemocult (D)	ns	NS	ns	ns

**Table 13-78. Summary of Categorized Dioxin Analysis (Model 3) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	UNADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Prealbumin (C) <sup>a</sup>	ns	ns	NS	ns
Prealbumin (D)	NS	ns	NS*	NS
Albumin (C) <sup>a</sup>	NS	ns*	NS	ns
Albumin (D)	ns	ns	ns	ns*
α-1-Acid Glycoprotein (C)	ns	NS	+0.045	NS
α-1-Acid Glycoprotein (D)	NS	NS	NS	NS
α-1-Antitrypsin (C)	NS	NS	<0.001	+0.001
α-1-Antitrypsin (D):				
Low vs. Normal	NS	ns	ns	ns
High vs. Normal	NS	NS	NS	NS
α-2-Macroglobulin (C)	ns	ns	ns	ns
α-2-Macroglobulin (D)	ns*	ns	NS	ns
Apolipoprotein B (C)	ns*	ns	NS*	NS
Apolipoprotein B (D)	-0.017	ns	NS	ns
C3 Complement (C) <sup>a</sup>	ns	NS	+0.003	+0.013
C3 Complement (D)	NS	ns	ns	ns*
C4 Complement (C) <sup>a</sup>	ns	NS	NS	NS
C4 Complement (D)	NS	ns	ns	ns
Haptoglobin (C)	NS	NS*	+0.001	+0.001
Haptoglobin (D)	NS	NS	+0.023	+0.015
Transferrin (C) <sup>a</sup>	NS	NS	+0.010	+0.019
Transferrin (D)	ns	ns	-0.039	ns*

Note: NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; difference of means nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis.

--: Analysis not performed because of the sparse number of participants with an abnormality.

<sup>a</sup> Negative difference considered adverse for this variable.

P-value given if  $p \leq 0.05$ .

A capital “NS” denotes a relative risk of 1.00 or greater for discrete analysis or differences of means nonnegative for continuous analysis. A lowercase “ns” denotes relative risk less than 1.00 for discrete analysis or difference of means negative for continuous analysis.

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
<b>Medical Records</b>				
Uncharacterized Hepatitis (D)	NS	NS	NS	NS
Jaundice (Unspecified) (D)	ns	--	ns*	--
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	NS	ns	ns	ns

**Table 13-78. Summary of Categorized Dioxin Analysis (Model 3) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS	NS	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	--	--	NS	--
Enlarged Liver (Hepatomegaly) (D)	ns	ns	NS	ns
Other Liver Disorders (D)	NS	NS	+0.009	NS*
<b>Physical Examination</b>				
Current Hepatomegaly (D)	NS	NS	NS	NS
<b>Laboratory</b>				
AST (C)	ns	NS	NS	NS*
AST (D)	ns	NS	+0.024	+0.041
ALT (C)	ns	NS*	NS*	+0.026
ALT (D)	ns	NS	NS*	NS*
GGT (C)	ns	NS	+0.006	+0.006
GGT (D)	ns	NS	NS	NS*
Alkaline Phosphatase (C)	+0.008	NS*	ns	NS
Alkaline Phosphatase (D)	NS	ns	NS	NS
Total Bilirubin (C)	ns	ns	NS	NS
Total Bilirubin (D)	ns	NS	ns	ns
Direct Bilirubin (D)	NS	--	--	--
Lactic Dehydrogenase (C)	NS	ns	NS	NS
Lactic Dehydrogenase (D)	NS	ns	ns	ns
Cholesterol (C)	ns	ns	NS	NS
Cholesterol (D)	ns	NS	NS*	NS
HDL Cholesterol (C) <sup>a</sup>	NS	NS	NS	NS
HDL Cholesterol (D)	+0.049	NS	ns	ns
Cholesterol-HDL Ratio (C)	ns	ns	NS	NS
Cholesterol-HDL Ratio (D)	NS	ns	NS	NS
Triglycerides (C)	ns	NS	+0.013	NS*
Triglycerides (D)	ns	NS	+0.009	+0.012
Creatine Phosphokinase (C)	ns	NS	NS	NS
Creatine Phosphokinase (D)	ns	ns	NS	ns
Serum Amylase (C)	ns	NS*	ns	NS
Serum Amylase (D)	ns	NS	NS	NS
Antibodies for Hepatitis A (D)	ns	ns	ns	ns
Serological Evidence of Prior Hepatitis B Infection (D)	-0.004	ns	-0.021	-0.012
Current Hepatitis B (D)	--	NS	--	--
Antibodies for Hepatitis C (D)	ns	ns	ns	ns
Antibodies for Hepatitis D (D)	--	--	--	--
Stool Hemocult (D)	ns	NS	ns	ns
Prealbumin (C) <sup>a</sup>	ns	NS	NS	NS
Prealbumin (D)	NS	ns	+0.021	NS
Albumin (C) <sup>a</sup>	NS	ns	NS	ns
Albumin (D)	ns	--	--	--
α-1-Acid Glycoprotein (C)	ns	NS	NS	NS
α-1-Acid Glycoprotein (D)	NS	NS	NS	NS
α-1-Antitrypsin (C)	+0.024	NS	+0.011	+0.020

**Table 13-78. Summary of Categorized Dioxin Analysis (Model 3) for Gastrointestinal Variables (Ranch Hands vs. Comparisons) (Continued)**

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
$\alpha$ -1-Antitrypsin (D):				
Low vs. Normal	ns	ns	NS	NS
High vs. Normal	NS	NS	NS	NS
$\alpha$ -2-Macroglobulin (C)	ns	ns	NS	ns
$\alpha$ -2-Macroglobulin (D)	ns*	ns	NS	ns
Apolipoprotein B (C)	ns	ns	NS	ns
Apolipoprotein B (D)	-0.050	ns	ns	ns
C3 Complement (C) <sup>a</sup>	ns	NS	NS	NS
C3 Complement (D)	NS	ns	ns	ns*
C4 Complement (C) <sup>a</sup>	ns	NS	ns	ns
C4 Complement (D)	NS	--	--	--
Haptoglobin (C)	+0.014	NS	NS	+0.036
Haptoglobin (D)	+0.042	NS	NS	NS
Transferrin (C) <sup>a</sup>	NS	NS	+0.050	+0.032
Transferrin (D)	ns	ns	-0.045	-0.039

Note: NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; difference of means nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis.

--: Analysis not performed because of the sparse number of participants with an abnormality.

<sup>a</sup> Negative difference considered adverse for this variable.

P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk of 1.00 or greater for discrete analysis or differences of means nonnegative for continuous analysis. A lowercase "ns" denotes relative risk less than 1.00 for discrete analysis or difference of means negative for continuous analysis.

#### 13.4.4 Model 4: 1987 Dioxin Level Analysis

The Model 4 analysis revealed a significant inverse association between jaundice and 1987 dioxin.

Many significant associations between the laboratory examination variables and 1987 dioxin levels were seen in the Model 4 analyses. In both the continuous and discrete forms, the hepatic enzymes ALT, AST, and GGT revealed significant, positive associations with 1987 dioxin. Alkaline phosphatase revealed significant inverse associations with 1987 dioxin in both the continuous and discrete analyses.

For the lipid and carbohydrate indices, the Model 4 continuous and discrete analyses detected significant positive associations with the cholesterol-HDL ratio and triglycerides. A significant inverse relation was seen between 1987 dioxin and HDL cholesterol for both discrete and continuous analyses.

Analysis of creatine phosphokinase in both its continuous and discrete forms revealed a significant positive association with 1987 dioxin. In addition, a significant inverse association between 1987 dioxin and the continuous form of serum amylase was found.

The adjusted results of the protein profile variables yielded several significant findings. A significant inverse association between 1987 dioxin and the continuous form of  $\alpha$ -1-acid glycoprotein and a significant positive association between 1987 dioxin and C3 complement in its continuous form were found. The discrete analysis showed more Ranch Hands than Comparisons with a high  $\alpha$ -2-macroglobulin level, and more Comparisons than Ranch Hands with low C3 complement and C4 complement levels.

The results of all Model 4 analyses are summarized in Table 13-79.

**Table 13-79. Summary of 1987 Dioxin Analysis (Model 4) for Gastrointestinal Variables (Ranch Hands Only)**

Variable	Unadjusted	Adjusted
<b>Medical Records</b>		
Uncharacterized Hepatitis (D)	ns	ns
Jaundice (Unspecified) (D)	-<0.001	-<0.001
Chronic Liver Disease and Cirrhosis (Alcohol-related) (D)	NS	NS
Chronic Liver Disease and Cirrhosis (Non-alcohol-related) (D)	NS	NS
Liver Abscess and Sequelae of Chronic Liver Disease (D)	NS	NS
Enlarged Liver (Hepatomegaly) (D)	ns	ns
Other Liver Disorders (D)	NS*	NS*
<b>Physical Examination</b>		
Current Hepatomegaly (D)	NS	NS
<b>Laboratory</b>		
AST (C)	+0.033	+0.002
AST (D)	+0.008	+0.002
ALT (C)	+<0.001	+<0.001
ALT (D)	+0.001	+<0.001
GGT (C)	+0.002	+0.003
GGT (D)	+0.034	+0.012
Alkaline Phosphatase (C)	ns	-0.003
Alkaline Phosphatase (D)	ns	-0.020
Total Bilirubin (C)	ns	NS
Total Bilirubin (D)	ns	ns
Direct Bilirubin (D)	ns	ns
Lactic Dehydrogenase (C)	NS	NS
Lactic Dehydrogenase (D)	NS	NS
Cholesterol (C)	+0.009	NS
Cholesterol (D)	+0.025	NS
HDL Cholesterol (C) <sup>a</sup>	-<0.001	-0.037
HDL Cholesterol (D)	ns	-0.029
Cholesterol-HDL Ratio (C)	+<0.001	+0.006
Cholesterol-HDL Ratio (D)	+<0.001	+0.025
Triglycerides (C)	+<0.001	+<0.001
Triglycerides (D)	+<0.001	+0.001
Creatine Phosphokinase (C)	NS*	+0.011
Creatine Phosphokinase (D)	NS	+0.043
Serum Amylase (C)	-0.035	-0.003
Serum Amylase (D)	ns	ns
Antibodies for Hepatitis A (D)	NS	NS
Serological Evidence of Prior Hepatitis B Infection (D)	+0.023	NS
Current Hepatitis B (D)	NS	NS

**Table 13-79. Summary of 1987 Dioxin Analysis (Model 4) for Gastrointestinal Variables (Ranch Hands Only) (Continued)**

Variable	Unadjusted	Adjusted
Antibodies for Hepatitis C (D)	ns	ns
Antibodies for Hepatitis D (D)	--	--
Stool Hemocult (D)	NS	NS
Prealbumin (C) <sup>a</sup>	ns	ns
Prealbumin (D)	NS	NS
Albumin (C) <sup>a</sup>	ns	ns
Albumin (D)	ns	ns
α-1-Acid Glycoprotein (C)	NS	-0.049
α-1-Acid Glycoprotein (D)	NS	ns
α-1-Antitrypsin (C)	NS	ns*
α-1-Antitrypsin (D):		
Low vs. Normal	ns	ns
High vs. Normal	ns	ns
α-2-Macroglobulin (C)	ns	ns
α-2-Macroglobulin (D)	+0.020	+0.014
Apolipoprotein B (C)	+0.002	NS
Apolipoprotein B (D)	+0.017	NS
C3 Complement (C) <sup>a</sup>	+<0.001	+<0.001
C3 Complement (D)	-0.011	-0.004
C4 Complement (C) <sup>a</sup>	NS*	NS
C4 Complement (D)	-0.033	-0.024
Haptoglobin (C)	NS	ns
Haptoglobin (D)	NS	ns
Transferrin (C) <sup>a</sup>	NS*	NS
Transferrin (D)	NS	NS

Note: NS or ns: Not significant ( $p>0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05<p\leq 0.10$ ).

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; slope nonnegative for continuous analysis.

-: Relative risk  $< 1.00$  for discrete analysis; slope negative for continuous analysis.

--: Analysis not performed because of the sparse number of Ranch Hands with an abnormality.

<sup>a</sup> Negative slope considered adverse for this variable.

P-value given if  $p\leq 0.05$ .

A capital "NS" denotes a relative risk of 1.00 or greater for discrete analysis or slope nonnegative for continuous analysis. A lowercase "ns" denotes relative risk less than 1.00 for discrete analysis or slope negative for continuous analysis.

### 13.5 CONCLUSION

The gastrointestinal assessment was based on eight disorders as determined from a review and verification of each participant's medical records, a physical examination determination of hepatomegaly, and 29 laboratory measurements or indices. The laboratory parameters included measurements of hepatic enzyme activity, hepatobiliary function, lipid and carbohydrate indices, and a protein profile. In addition, the presence of hepatitis and fecal occult blood was investigated.

Analyses of Ranch Hands versus Comparisons showed higher mean levels of alkaline phosphatase,  $\alpha$ -1-antitrypsin, and haptoglobin in Ranch Hands than in Comparisons. In addition, significantly more Ranch Hands than Comparisons had high haptoglobin levels. A review of medical records showed a positive association between initial dioxin and other liver disorders. Twelve percent of the participants with the other liver disorders condition had nonspecific laboratory test elevations. A significant association between initial dioxin and high levels of AST also was revealed.

Analyses of categorized dioxin revealed a significantly higher percentage of other liver disorders among Ranch Hands in the high dioxin category than among Comparisons. Higher mean levels of GGT, triglycerides, and  $\alpha$ -1-antitrypsin were observed in Ranch Hands in the high dioxin category than in Comparisons. Ranch Hands in the high dioxin category had a greater prevalence of abnormal AST, triglyceride, and prealbumin levels than did Comparisons.

Many significant associations between the laboratory examination variables and 1987 dioxin levels were observed. In both the continuous and discrete forms, the hepatic enzymes ALT, AST, and GGT revealed significant, positive associations with 1987 dioxin. In addition, significant positive associations between 1987 dioxin and the cholesterol-HDL ratio, triglycerides, and creatine phosphokinase were present.

In summary, the analysis of the 1997 follow-up data reflected patterns that have been observed and documented in prior examinations. A composite category of disease named "other liver disorders" exhibited a dose-response relation with dioxin. Isolated group differences exist, but 1987 dioxin levels are strongly related to hepatic enzymes such as AST, ALT, and GGT, and to lipid-related health indices such as cholesterol, HDL, and triglycerides. These results are consistent with a dose-response effect and may be related to unknown subclinical effects of dioxin. Although hepatic enzymes showed an association with dioxin, there was no evidence of an increase in overt liver disease. The relation between other liver disorders and herbicide exposure and dioxin levels will be described in greater detail in a separate report.

## REFERENCES

---

1. Poiger, H., and C. Schlatter. 1986. Pharmacokinetics of 2,3,7,8-TCDD in man. *Chemosphere* 15:1489-94.
2. Kancir, C. B., C. Andersen, and A. S. Olesen. 1988. Marked hypocalcemia in a fatal poisoning with chlorinated phenoxy acid derivatives. *Clinical Toxicology* 26:257-64.
3. Meulenbelt, J., J. H. Zwaveling, P. van Zoonen, and N. C. Notermans. 1988. Acute MCPP intoxication: Report of two cases. *Human Toxicology* 7:289-92.
4. McNulty, W. P. 1977. Toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin for Rhesus monkeys: Brief report. *Bulletin of Environmental Contamination and Toxicology* 18:108-9.
5. Olson, J. R., M. A. Holscher, and R. A. Neal. 1980. Toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin in the golden Syrian hamster. *Toxicology and Applied Pharmacology* 55:67-78.
6. Palmer, J. S., and R. D. Radeleff. 1964. The toxicologic effects of certain fungicides and herbicides on sheep and cattle. *Annals of the New York Academy of Sciences* 11:729-36.
7. Goldstein, J. A., P. Hickman, H. Bergman, and J. G. Vos. 1973. Hepatic porphyria induced by 2,3,7,8-tetrachlorodibenzo-p-dioxin in the mouse. *Research Communications in Chemical Pathology and Pharmacology* 6:919.
8. Madhukar, B. V., and F. Matsumura. 1981. Difference in the nature of induction of mixed-function oxidase systems of the rat liver among phenobarbital, DDT, 3-methylcholanthrene, and TCDD. *Toxicology and Applied Pharmacology* 61:110-8.
9. Brooks, A. L., S. W. Jordan, K. K. Bose, J. Smith, and D. C. Allison. 1988. The cytogenetic and hepatotoxic effects of dioxin on mouse liver cells. *Cell Biology and Toxicology* 4:31-40.
10. Potter, C. L., I. G. Sipes, and D. H. Russell. 1983. Hypothyroxinemia and hypothermia in rats in response to 2,3,7,8-tetrachlorodibenzo-p-dioxin administration. *Toxicology and Applied Pharmacology* 69:89-95.
11. Theobald, H. M., G. B. Ingall, T. A. Mably, and R. E. Peterson. 1991. Response of the antral mucosa of the rat stomach to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Toxicology and Applied Pharmacology* 108:167-79.
12. Norback, D. H., and J. R. Allen. 1973. Biological responses of the nonhuman primate, chicken, and rat to chlorinated dibenzo-p-dioxin ingestion. *Environmental Health Perspectives* 5:233-40.
13. Becker, G. M., and W. P. McNulty. 1984. Gastric epithelial cell proliferation in monkeys fed 3,4,3,4-tetrachlorobiphenyl. *Journal of Pathology* 143:267-74.
14. Richter, E., G. Hunder, and W. Forth. 1992. Inhibition of intestinal glucose absorption in rats treated with 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Veterinary and Human Toxicology* 34:123-6.
15. Shen, E. S., S. I. Gutman, and J. R. Olson. 1991. Comparison of 2,3,7,8-tetrachlorodibenzo-p-dioxin-mediated hepatotoxicity in C57BL/6J and DBA/2J mice. *Journal of Toxicology and Environmental Health* 32(4):367-81.
16. Piper, W. N., R. Q. Rose, and P. J. Gehring. 1973. Excretion and tissue distribution of 2,3,7,8-tetrachlorodibenzo-p-dioxin in the rat. *Environmental Health Perspectives* 5:241-4.

17. Allen, J. R., J. P. Van Miller, and D. H. Norback. 1977. Tissue distribution, excretion, and biological effects of (14C) tetrachlorodibenzo-p-dioxin in rats. *Food and Cosmetic Toxicology* 15:401-10.
18. Tsuda, S., A. Rosenberg, and T. Nakatsugawa. 1988. Translobular uptake patterns of environmental toxicants in the rat liver. *Bulletin of Environmental Contamination and Toxicology* 40:410-7.
19. Lakshman, M. R., B. S. Campbell, S. J. Chirtel, N. Ekarohita, and M. Ezekiel. 1986. Studies on the mechanism of absorption and distribution of 2,3,7,8-tetrachlorodibenzo-p-dioxin in the rat. *Journal of Pharmacology and Experimental Therapeutics* 239:673-7.
20. Pohjanvirta, R., T. Vartiainen, A. Uusi-Rauva, J. Monkkonen, and J. Tuomisto. 1990. Tissue distribution, metabolism, and excretion of 14C-TCDD in a TCDD-susceptible and a TCDD-resistant rat strain. *Pharmacology and Toxicology* 66:93-100.
21. Hagenmaier, H., T. Wiesmuller, G. Golor, R. Krowke, H. Helge, and D. Neubert. 1990. Transfer of various polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs and PCDFs) via placenta and through milk in a marmoset monkey. *Archives of Toxicology* 64:601-15.
22. Gehring, P. J., and J. E. Betso. 1978. Phenoxy acids: effects and fate in mammals. *Ecology Bulletin* 27:122-33.
23. U. S. Environmental Protection Agency. 1984. Health assessment document for polychlorinated dibenzo-p-dioxins. Cincinnati, Ohio: EPA.
24. Dragan, Y. P., X. H. Xu, T. L. Goldsworthy, H. A. Campbell, R. R. Maronpot, and H. C. Pitot. 1992. Characterization of the promotion of altered hepatic foci by 2,3,7,8-tetrachlorodibenzo-p-dioxin in the female rat. *Carcinogenesis* 13(8):1389-95.
25. Kociba, R. J., D. G. Keyes, J. E. Beyer, R. M. Carreon, C. E. Wade, D. A. Dittenber, R. P. Kalnins, L. E. Frauson, C. N. Park, S. D. Barnard, R. A. Hummel, and C. G. Humiston. 1978. Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. *Toxicology and Applied Pharmacology* 46:279-303.
26. Goodman, D. G., and R. M. Sauer. 1992. Hepatotoxicity and carcinogenicity in female Sprague-Dawley rats treated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD): a pathology working group reevaluation. *Regulatory Toxicology and Pharmacology* 15(3):245-52.
27. National Toxicology Program. 1982. Bioassay of 2,3,7,8-tetrachlorodibenzo-p-dioxin for possible carcinogenicity (Gavage study). Technical Report Series No. 209. National Toxicology Program, Research Triangle Park, North Carolina.
28. Mably, T. A., H. M. Theobald, G. B. Ingall, and R. E. Peterson. 1990. Hypergastrinemia is associated with decreased gastric acid secretion in 2,3,7,8-tetrachlorodibenzo-p-dioxin-treated rats. *Toxicology and Applied Pharmacology* 106:518-28.
29. Al-Turk, W. A., M. A. Shara, H. Mohammadpour, and S. J. Stohs. 1988. Dietary iron and 2,3,7,8-tetrachlorodibenzo-p-dioxin-induced alterations in hepatic lipid peroxidation glutathione content and body weight. *Drug and Chemical Toxicology* 11:55-70.
30. Shara, M. A., and S. J. Stohs. 1987. Biochemical and toxicological effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Archives of Environmental Contamination and Toxicology* 16:599-606.
31. Al-Bayati, Z. A. F., and S. J. Stohs. 1991. The possible role of phospholipase A2 in hepatic microsomal lipid peroxidation induced by 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. *Archives of Environmental Contamination and Toxicology* 20(3):361-5.

32. Al-Bayati, Z. A. F., and S. J. Stohs. 1987. The role of iron in 2,3,7,8-tetrachlorodibenzo-p-dioxin-induced lipid peroxidation by rat liver microsomes. *Toxicology Letters* 38:115-21.
33. Lakshman, M. R., P. Ghosh, and S. J. Chirtel. 1991. Mechanism of action of 2,3,7,8-tetrachlorodibenzo-p-dioxin on intermediary metabolism in the rat. *Journal of Pharmacology and Experimental Therapeutics* 258(1):317-9.
34. Kohli, K. K., and J. A. Goldstein. 1981. Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin on hepatic and renal prostaglandin synthetase. *Life Sciences* 19:299-305.
35. Lakshman, M. R., S. J. Chirtel, L. L. Chambers, and P. J. Coutlakis. 1989. Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin on lipid synthesis and lipogenic enzymes in the rat. *Journal of Pharmacology and Experimental Therapeutics* 248:62-6.
36. Martin, J. V. 1984. Lipid abnormalities in workers exposed to dioxin. *British Journal of Industrial Medicine* 41:254-6.
37. Lakshman, M. R., B. S. Campbell, S. J. Chirtel, and N. Ekarohita. 1988. Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) on de-novo fatty acid and cholesterol synthesis in the rat. *Lipids* 23:904-6.
38. Cantoni, L., A. Graziani, M. Rizzardini, and M. C. Saletti. 1986. Porphyrinogenic effect of hexachlorobenzene and 2,3,7,8-tetrachlorodibenzo-para-dioxin: Is an inhibitor involved in uroporphyrinogen decarboxylase inactivation? *IARC Scientific Publications* No. 77:449-56.
39. Goldstein, J. A., P. Hickman, and D. L. Jue. 1974. Experimental hepatic porphyria induced by polychlorinated biphenyls. *Toxicology and Applied Pharmacology* 27:437.
40. Bleiberg, J., M. Wallen, R. Brodtkin, and I. L. Applebaum. 1964. Industrially acquired porphyria. *Archives of Dermatology* 89:793-7.
41. Jirasek, L., J. Kalensky, K. Kubec, J. Pazderova, and E. Lukas. 1974. In Part 2, Acne chlorina, porphyria cutanea tarda and other manifestations of general intoxication during the manufacture of herbicides. *Czech Dermatology* 49:145-57.
42. Lucier, G. W., R. C. Rumbaugh, Z. McCoy, R. Hass, D. Harvan, and P. Albro. 1986. Ingestion of soil contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) alters hepatic enzyme activities in rats. *Fundamental and Applied Toxicology* 6:364-71.
43. Ideo, G., G. Bellati, A. Bellobuono, A. Mocarelli, P. Marocchi, A. and P. Brambilla. 1982. Increased urinary d-glucaric acid excretion by children living in an area polluted with tetrachlorodibenzodioxin (TCDD). *Clinica Chimica Acta* 120:273-83.
44. Ideo, G., G. Bellati, A. Bellobuono, and L. Bisanti. 1985. Urinary d-glucaric acid excretion in the Seveso area, polluted by tetrachlorodibenzo-p-dioxin (TCDD): Five years of experience. *Environmental Health Perspectives* 60:151-7.
45. U.S. Centers for Disease Control. Health status of Vietnam veterans. In Part 2, Physical health. The Centers for Disease Control Vietnam experience study. *Journal of the American Medical Association* 259:2708-14.
46. Hoffman, R. E., P. A. Stehr-Green, K. B. Webb, G. Evans, A. P. Knutsen, W. F. Schramm, J. L. Staake, B. B. Gibson, and K. K. Steinberg. 1986. Health effects of long-term exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Journal of the American Medical Association* 255:2031-8.
47. Calvert, G. M., R. W. Hornung, M. H. Sweeney, M. A. Fingerhut, and W. E. Halperin. 1992. Hepatic and gastrointestinal effects in an occupational cohort exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Journal of the American Medical Association* 267(16):2209-14.

48. Caramaschi, F., G. Del Corno, C. Favaretti, S. E. Giambelluca, E. Montesarchio, and G. M. Fara. 1981. Chloracne following environmental contamination by TCDD in Seveso, Italy. *International Journal of Epidemiology* 10:135-43.
49. Suskind, R. R., and V. S. Hertzberg. 1984. Human health effects of 2,4,5-T and its toxic contaminants. *Journal of the American Medical Association* 251:2372-80.
50. Bond, G. G., M. G. Ott, F. E. Brenner, and R. R. Cook. 1983. Medical and morbidity surveillance findings among employees potentially exposed to TCDD. *British Journal of Industrial Medicine* 40:318-24.
51. Oliver, R. M. 1975. Toxic effects of 2,3,7,8-tetrachlorodibenzo 1,4-dioxin in laboratory workers. *British Journal of Industrial Medicine* 32:49-53.
52. Reggiani, G. 1980. Acute human exposure to TCDD in Seveso, Italy. *Journal of Toxicology and Environmental Health* 6:27-43.
53. May, G. 1973. Chloracne from the accidental production of tetrachlorodibenzodioxin. *British Journal of Industrial Medicine* 30:276-83.
54. Mocarelli, P., A. Marocchi, P. Brambilla, P. Gerthoux, D. S. Young, and N. Mantel. 1986. Clinical laboratory manifestations of exposure to dioxin in children. *Journal of the American Medical Association* 256:2687-95.
55. May, G. 1982. Tetrachlorodibenzodioxin: A survey of subjects ten years after exposure. *British Journal of Industrial Medicine* 39:128-35.
56. Moses, M., R. Lilis, K. D. Crow, J. Thornton, A. Fischbein, H. A. Anderson, and I. J. Selikoff. 1984. Health status of workers with past exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin in the manufacture of 2,4,5-trichlorophenoxyacetic acid: Comparison of findings with and without chloracne. *American Journal of Industrial Medicine* 5:161-82.
57. Assennato, G., P. Cannatalli, and I. Ghezzi. 1986. Health surveillance of a potential TCDD-exposed industrial population in Seveso: Pattern of some liver-related biochemical indicators. In *Occupational and Environmental Chemical Hazards: Cellular and Biochemical Indices for Monitoring Toxicity*. Eds. V. Foa, E. A. Emmett, M. Maroni, and A. Colombi. Chichester, England: Ellis Horwood Limited.
58. Webb, K. B., R. G. Evans, A. P. Knutsen, S. T. Roodman, D. W. Roberts, W. F. Schramm, B. B. Gibson, J. S. Andrews Jr., L. L. Needham, and D. G. Patterson. 1989. Medical evaluation of subjects with known body levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Journal of Toxicology and Environmental Health* 28:183-93.
59. Von Benner, A., L. Edler, K. Mayer, and A. Zober. 1994. 'Dioxin' investigation program of the chemical industry professional association. *Arbeitsmedizin Sozialmedizin Präventivmedizin* 29:11-6.
60. Ott, M. G., A. Zober, and C. Germann. 1994. Laboratory results for selected target organs in 138 individuals occupationally exposed to TCDD. *Chemosphere* 29:2423-37.
61. Zober, A., M. G. Ott, and P. Messerer. 1994. Morbidity follow-up study of BASF employees exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) after a 1953 chemical reactor incident. *Occupational and Environmental Medicine* 51:479-86.
62. Tamburro, C. H. 1992. Chronic liver injury in phenoxy herbicide-exposed Vietnam veterans. *Environmental Research* 59:175-88.

63. Thomas, T. L., and H. K. Kang. 1990. Mortality and morbidity among Army Chemical Corps Vietnam veterans: A preliminary report. *American Journal of Industrial Medicine* 18:665-73.
64. Roegner, R. H., W. D. Grubbs, M. B. Lustik, A. S. Brockman, S. C. Henderson, D. E. Williams, W. H. Wolfe, J. E. Michalek, and J. C. Miner. 1991. The Air Force Health Study: An epidemiologic investigation of health effects in Air Force personnel following exposure to herbicides: Serum Dioxin Analysis of 1987 Examination Results. NTIS: AD A 237 516-24. USAF School of Medicine, Brooks Air Force Base, Texas.
65. Grubbs, W. D., W. H. Wolfe, J. E. Michalek, D. E. Williams, M. B. Lustik, A. S. Brockman, S. C. Henderson, F. R. Burnett, R. G. Land, D. J. Osborne, V. K. Rocconi, M. E. Schreiber, J. C. Miner, G. L. Henriksen, and J. A. Swaby. 1995. The Air Force Health Study: An epidemiologic investigation of health effects in Air Force personnel following exposure to herbicides: Final Report. 1992 Followup Examination Results. NTIS: AD A 304 306, 304 308-316. USAF School of Medicine, Brooks Air Force Base, Texas.
66. Michalek, J. E., J. L. Pirkle, S. P. Caudill, R. C. Tripathi, D. G. Patterson Jr., and L. L. Needham. 1996. Pharmacokinetics of TCDD in Veterans of Operation Ranch Hand: 10-year Followup. *Journal of Toxicology and Environmental Health* 47:209-20.
67. Mausner, J. S., and A. K. Bahn. 1974. *Epidemiology – An Introductory Text*. Philadelphia: W. B. Saunders Company.