

**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<br>vs. Comparisons<br>(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<br>vs. Comparisons<br>(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<br>(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)

| (h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED |     |                        |   |  |         |
|---|-----|------------------------|---|--|---------|
| 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 | 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 (%)<br>Low | Est. Relative Risk<br>(95% C.I.) | p-Value      |
| <i>All</i>   | <i>Ranch Hand</i> | <i>859</i>   | <i>70 (8.1)</i>   | <i>0.73 (0.54,0.98)</i>          | <i>0.036</i> |
|  | <i>Comparison</i> | <i>1,231</i> | <i>134 (10.9)</i> |                                  |              |
| 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<br>(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 (%)<br>Low | Estimated Relative Risk<br>(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<br>(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)**

**(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED**

| Dioxin Category  | n     | Number (%)<br>Low | Est. Relative Risk<br>(95% C.I.) <sup>a,b</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.

**(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED**

| Dioxin Category  | n     | Adjusted Relative Risk<br>(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.

**(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED**

| 1987 Dioxin Category Summary Statistics |     |                   | Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1) |         |
|---|-----|-------------------|---|---------|
| 1987 Dioxin                             | n   | Number (%)<br>Low | Estimated Relative Risk<br>(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.

**(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED**

| Analysis Results for Log <sub>2</sub> (1987 Dioxin + 1) |   |         |
|---|---|---------|
| n   | Adjusted Relative Risk<br>(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<br>(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        |                        |
| HDL (mg/dl)                   |             | (Age ≥70)   | (Age ≥70)   | (Age ≥70)   |                        |
|                               | ≥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) |                        |
| Triglycerides<br>(mg/dl)      |             | ≥30         | ≥30         | ≥30         |                        |
|                               |             | (Age ≥45)   | (Age ≥45)   | (Age ≥45)   |                        |
|                               | ≤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> |                   |                                       |                |                |                |                |                                      |                                       |                      |
|---|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
| Occupational Category                           | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|   |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>                                      | <i>Ranch Hand</i> | 32.61<br>(804)                        | 33.33<br>(787) | 25.50<br>(778) | 23.03<br>(778) | 22.99<br>(804) | -9.62                                | -0.03                                 | 0.859                |
|   | <i>Comparison</i> | 32.48<br>(956)                        | 33.47<br>(938) | 25.34<br>(929) | 23.59<br>(933) | 22.89<br>(956) | -9.59                                |                                       |                      |
| Officer   | Ranch Hand        | 32.69<br>(309)                        | 34.01<br>(304) | 25.85<br>(301) | 23.69<br>(300) | 23.29<br>(309) | -9.40                                | 0.15                                  | 0.897                |
|   | Comparison        | 32.86<br>(377)                        | 33.57<br>(371) | 25.76<br>(363) | 24.00<br>(370) | 23.31<br>(377) | -9.55                                |                                       |                      |
| Enlisted<br>Flyer                               | Ranch Hand        | 31.89<br>(146)                        | 32.24<br>(143) | 24.47<br>(141) | 21.14<br>(143) | 22.19<br>(146) | -9.69                                | 0.47                                  | 0.710                |
|   | Comparison        | 33.02<br>(142)                        | 33.53<br>(141) | 25.10<br>(140) | 23.30<br>(138) | 22.87<br>(142) | -10.16                               |                                       |                      |
| Enlisted<br>Groundcrew                          | Ranch Hand        | 32.84<br>(349)                        | 33.18<br>(340) | 25.63<br>(336) | 23.28<br>(335) | 23.06<br>(349) | -9.78                                | -0.34                                 | 0.687                |
|   | Comparison        | 31.98<br>(437)                        | 33.36<br>(426) | 25.08<br>(426) | 23.32<br>(425) | 22.54<br>(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) MODEL 2: RANCH HANDS – INITIAL DIOXIN  |                |                |                |                |                |   |         |
|--|----------------|----------------|----------------|----------------|----------------|---|---------|
| Initial Dioxin Category Summary Statistics |                |                |                |                |                | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup> |         |
| Mean <sup>a</sup> /(n)<br>Examination      |                |                |                |                |                |   |         |
| Initial Dioxin                             | 1982           | 1985           | 1987           | 1992           | 1997           | Adjusted Slope<br>(Std. Error)                                      | p-Value |
| Low  | 33.11<br>(151) | 34.06<br>(147) | 25.46<br>(150) | 22.57<br>(146) | 23.39<br>(151) | -0.004 (0.012)  | 0.731   |
| Medium                                     | 33.39<br>(156) | 34.46<br>(154) | 26.08<br>(152) | 23.18<br>(152) | 23.64<br>(156) |   |         |
| High                                       | 33.54<br>(151) | 33.33<br>(148) | 25.86<br>(146) | 23.82<br>(148) | 23.56<br>(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> |   |                |                |                |                |  |  |                            |
|--|---|----------------|----------------|----------------|----------------|--|--|----------------------------|
| <b>Dioxin<br/>Category</b>   | <b>Mean<sup>a</sup>/(n)<br/>Examination</b> |                |                |                |                | <b>Exam. Mean<br/>Change<sup>b</sup></b> | <b>Difference of<br/>Exam. Mean<br/>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   | 32.46<br>(929)                              | 33.50<br>(913) | 25.35<br>(903) | 23.54<br>(907) | 22.87<br>(929) | -9.59                                    |  |                            |
| Background<br>RH   | 31.70<br>(340)                              | 32.54<br>(333) | 25.13<br>(325) | 22.78<br>(327) | 22.22<br>(340) | -9.48                                    | 0.11   | 0.574                      |
| Low RH   | 32.75<br>(226)                              | 34.41<br>(220) | 25.59<br>(222) | 23.05<br>(218) | 23.40<br>(226) | -9.34                                    | 0.25   | 0.373                      |
| High RH  | 33.94<br>(232)                              | 33.51<br>(229) | 26.00<br>(226) | 23.32<br>(228) | 23.65<br>(232) | -10.29                                   | -0.70  | 0.911                      |
| Low plus<br>High RH  | 33.35<br>(458)                              | 33.95<br>(449) | 25.80<br>(448) | 23.19<br>(446) | 23.53<br>(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              |
| All   | Ranch Hand | 99 (12.3)<br>(804)              | 51 (6.5)<br>(787) | 31 (4.0)<br>(778) | 21 (2.7)<br>(778) | 60 (7.5)<br>(804) |
|   | Comparison | 122 (12.8)<br>(956)             | 70 (7.5)<br>(938) | 26 (2.8)<br>(929) | 31 (3.3)<br>(933) | 60 (6.3)<br>(956) |
| Officer   | Ranch Hand | 34 (11.0)<br>(309)              | 24 (7.9)<br>(304) | 14 (4.7)<br>(301) | 11 (3.7)<br>(300) | 21 (6.8)<br>(309) |
|   | Comparison | 52 (13.8)<br>(377)              | 24 (6.5)<br>(371) | 13 (3.6)<br>(363) | 14 (3.8)<br>(370) | 23 (6.1)<br>(377) |
| Enlisted Flyer                                  | Ranch Hand | 16 (11.0)<br>(146)              | 7 (4.9)<br>(143)  | 4 (2.8)<br>(141)  | 1 (0.7)<br>(143)  | 10 (6.8)<br>(146) |
|   | Comparison | 20 (14.1)<br>(142)              | 13 (9.2)<br>(141) | 5 (3.6)<br>(140)  | 6 (4.3)<br>(138)  | 12 (8.5)<br>(142) |
| Enlisted Groundcrew                             | Ranch Hand | 49 (14.0)<br>(349)              | 20 (5.9)<br>(340) | 13 (3.9)<br>(336) | 9 (2.7)<br>(335)  | 29 (8.3)<br>(349) |
|   | Comparison | 50 (11.4)<br>(437)              | 33 (7.7)<br>(426) | 8 (1.9)<br>(426)  | 11 (2.6)<br>(425) | 25 (5.7)<br>(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> |
| All                   | Ranch Hand | 705            | 35 (5.0)                | 1.13 (0.70,1.81)                           | 0.614                |
|                       | Comparison | 834            | 37 (4.4)                |  |                      |
| 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> |                                    |                   |                  |                  |                    |
|--|------------------------------------|-------------------|------------------|------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                   |                  |                  |                    |
|  | 1982                               | 1985              | 1987             | 1992             | 1997               |
| Low  | 17 (11.3)<br>(151)                 | 11 (7.5)<br>(147) | 6 (4.0)<br>(150) | 4 (2.7)<br>(146) | 11 (7.3)<br>(151)  |
| Medium   | 30 (19.2)<br>(156)                 | 11 (7.1)<br>(154) | 4 (2.6)<br>(152) | 4 (2.6)<br>(152) | 20 (12.8)<br>(156) |
| High   | 23 (15.2)<br>(151)                 | 11 (7.4)<br>(148) | 7 (4.8)<br>(146) | 4 (2.7)<br>(148) | 14 (9.3)<br>(151)  |

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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).

**(c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY**

| Dioxin Category  | Number (%) High/(n)<br>Examination |                   |                   |                   |                    |
|------------------|------------------------------------|-------------------|-------------------|-------------------|--------------------|
|                  | 1982                               | 1985              | 1987              | 1992              | 1997               |
| Comparison       | 118 (12.7)<br>(929)                | 69 (7.6)<br>(913) | 25 (2.8)<br>(903) | 30 (3.3)<br>(907) | 59 (6.4)<br>(929)  |
| Background RH    | 27 (7.9)<br>(340)                  | 18 (5.4)<br>(333) | 14 (4.3)<br>(325) | 9 (2.8)<br>(327)  | 14 (4.1)<br>(340)  |
| Low RH           | 26 (11.5)<br>(226)                 | 19 (8.6)<br>(220) | 9 (4.1)<br>(222)  | 8 (3.7)<br>(218)  | 19 (8.4)<br>(226)  |
| High RH          | 44 (19.0)<br>(232)                 | 14 (6.1)<br>(229) | 8 (3.5)<br>(226)  | 4 (1.8)<br>(228)  | 26 (11.2)<br>(232) |
| Low plus High RH | 70 (15.3)<br>(458)                 | 33 (7.3)<br>(449) | 17 (3.8)<br>(448) | 12 (2.7)<br>(446) | 45 (9.8)<br>(458)  |

**Table 13-63. Longitudinal Analysis of AST (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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)**

**(a) MODEL 1: RANCH HANDS VS. COMPARISONS**

| Occupational Category  | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|------------------------|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
|                        |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>             | <i>Ranch Hand</i> | 19.84<br>(804)                        | 21.66<br>(787) | 20.52<br>(778) | 27.12<br>(778) | 42.55<br>(804) | 22.71                                | 0.89                                  | 0.214                |
|                        | <i>Comparison</i> | 20.38<br>(956)                        | 22.53<br>(938) | 20.49<br>(929) | 27.91<br>(933) | 42.20<br>(956) | 21.82                                |                                       |                      |
| Officer                | Ranch Hand        | 19.71<br>(309)                        | 21.96<br>(304) | 20.53<br>(301) | 27.01<br>(300) | 41.93<br>(309) | 22.22                                | 0.99                                  | 0.295                |
|                        | Comparison        | 20.32<br>(377)                        | 21.97<br>(371) | 20.35<br>(363) | 27.39<br>(370) | 41.55<br>(377) | 21.23                                |                                       |                      |
| Enlisted<br>Flyer      | Ranch Hand        | 18.69<br>(146)                        | 20.85<br>(143) | 19.83<br>(141) | 25.15<br>(143) | 41.33<br>(146) | 22.63                                | 0.77                                  | 0.910                |
|                        | Comparison        | 20.59<br>(142)                        | 22.01<br>(141) | 19.84<br>(140) | 28.03<br>(138) | 42.45<br>(142) | 21.86                                |                                       |                      |
| Enlisted<br>Groundcrew | Ranch Hand        | 20.46<br>(349)                        | 21.73<br>(340) | 20.79<br>(336) | 28.10<br>(335) | 43.63<br>(349) | 23.17                                | 0.85                                  | 0.377                |
|                        | Comparison        | 20.37<br>(437)                        | 23.20<br>(426) | 20.82<br>(426) | 28.33<br>(425) | 42.69<br>(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)<br>Examination |                |                |                |                | Adjusted Slope<br>(Std. Error)                                      | p-Value |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |   |         |
| Low  | 20.29<br>(151)                        | 22.08<br>(147) | 20.15<br>(150) | 26.54<br>(146) | 42.36<br>(151) | -0.007 (0.010)  | 0.444   |
| Medium   | 21.76<br>(156)                        | 24.10<br>(154) | 21.94<br>(152) | 28.72<br>(152) | 44.95<br>(156) |   |         |
| High   | 22.96<br>(151)                        | 23.82<br>(148) | 23.07<br>(146) | 30.13<br>(148) | 45.27<br>(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<br>Category   | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam. Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                   |                                       |                      |
| Comparison   | 20.34<br>(929)                        | 22.49<br>(913) | 20.46<br>(903) | 27.87<br>(907) | 42.16<br>(929) | 21.82                             |                                       |                      |
| Background<br>RH   | 17.53<br>(340)                        | 19.62<br>(33)  | 19.01<br>(325) | 25.36<br>(327) | 40.39<br>(340) | 22.87                             | 1.05                                  | 0.751                |
| Low RH   | 20.46<br>(226)                        | 23.08<br>(220) | 20.50<br>(222) | 27.51<br>(218) | 43.30<br>(226) | 22.84                             | 1.02                                  | 0.054                |
| High RH  | 22.86<br>(232)                        | 23.57<br>(229) | 22.90<br>(226) | 29.36<br>(228) | 45.07<br>(232) | 22.20                             | 0.38                                  | 0.503                |
| Low plus<br>High RH  | 21.64<br>(458)                        | 23.33<br>(449) | 21.67<br>(448) | 28.44<br>(446) | 44.18<br>(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               |
| All   | Ranch Hand | 59 (7.3)<br>804                 | 107 (13.6)<br>(787) | 92 (11.8)<br>(778) | 45 (5.8)<br>(778) | 65 (8.1)<br>(804)  |
|   | Comparison | 67 (7.0)<br>(956)               | 133 (14.2)<br>(938) | 92 (9.9)<br>(929)  | 64 (6.9)<br>(933) | 68 (7.1)<br>(956)  |
| Officer   | Ranch Hand | 23 (7.4)<br>(309)               | 46 (15.1)<br>(304)  | 38 (12.6)<br>(301) | 19 (6.3)<br>(300) | 20 (6.5)<br>(309)  |
|   | Comparison | 26 (6.9)<br>(377)               | 45 (12.1)<br>(371)  | 39 (10.7)<br>(363) | 20 (5.4)<br>(370) | 16 (4.2)<br>(377)  |
| Enlisted Flyer                                  | Ranch Hand | 10 (6.8)<br>(146)               | 15 (10.5)<br>(143)  | 14 (9.9)<br>(141)  | 7 (4.9)<br>(143)  | 15 (10.3)<br>(146) |
|   | Comparison | 11 (7.7)<br>(142)               | 19 (13.5)<br>(141)  | 9 (6.4)<br>(140)   | 11 (8.0)<br>(138) | 15 (10.6)<br>(142) |
| Enlisted Groundcrew                             | Ranch Hand | 26 (7.4)<br>(349)               | 46 (13.5)<br>(340)  | 40 (11.9)<br>(336) | 19 (5.7)<br>(335) | 30 (8.6)<br>(349)  |
|   | Comparison | 30 (6.9)<br>(437)               | 69 (16.2)<br>(426)  | 44 (10.3)<br>(426) | 33 (7.8)<br>(425) | 37 (8.5)<br>(437)  |

  

| Normal in 1982        |            |           |                         |  |                      |
|-----------------------|------------|-----------|-------------------------|--|----------------------|
| Occupational Category | Group      | n in 1997 | Number (%) High in 1997 | Adj. Relative Risk (95% C.I.) <sup>a</sup> | p-Value <sup>a</sup> |
| All                   | Ranch Hand | 745       | 43 (5.8)                | 0.92 (0.61,1.39)                           | 0.690                |
|                       | Comparison | 889       | 56 (6.3)                |  |                      |
| 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> |                                    |                    |                    |                   |                    |
|--|------------------------------------|--------------------|--------------------|-------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                    |                    |                   |                    |
|  | 1982                               | 1985               | 1987               | 1992              | 1997               |
| Low  | 12 (7.9)<br>(151)                  | 20 (13.6)<br>(147) | 11 (7.3)<br>(150)  | 4 (2.7)<br>(146)  | 10 (6.6)<br>(151)  |
| Medium   | 10 (6.4)<br>(156)                  | 21 (13.6)<br>(154) | 22 (14.5)<br>(152) | 13 (8.6)<br>(152) | 21 (13.5)<br>(156) |
| High   | 19 (12.6)<br>(151)                 | 27 (18.2)<br>(148) | 22 (15.1)<br>(146) | 13 (8.8)<br>(148) | 19 (12.6)<br>(151) |

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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> |                                    |                     |                    |                   |                    |
|--|------------------------------------|---------------------|--------------------|-------------------|--------------------|
| Dioxin Category  | Number (%) High/(n)<br>Examination |                     |                    |                   |                    |
|  | 1982                               | 1985                | 1987               | 1992              | 1997               |
| Comparison   | 65 (7.0)<br>(929)                  | 129 (14.1)<br>(913) | 90 (10.0)<br>(903) | 60 (6.6)<br>(907) | 67 (7.2)<br>(929)  |
| Background RH  | 17 (5.0)<br>(340)                  | 38 (11.4)<br>(333)  | 36 (11.1)<br>(325) | 14 (4.3)<br>(327) | 14 (4.1)<br>(340)  |
| Low RH   | 17 (7.5)<br>(226)                  | 30 (13.6)<br>(220)  | 21 (9.5)<br>(222)  | 10 (4.6)<br>(218) | 20 (8.8)<br>(226)  |
| High RH  | 24 (10.3)<br>(232)                 | 38 (16.6)<br>(229)  | 34 (15.0)<br>(226) | 20 (8.8)<br>(228) | 30 (12.9)<br>(232) |
| Low plus High RH   | 41 (9.0)<br>(458)                  | 68 (15.1)<br>(449)  | 55 (12.3)<br>(448) | 30 (6.7)<br>(446) | 50 (10.9)<br>(458) |

**Table 13-65. Longitudinal Analysis of ALT (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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 an 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> |                   |                                       |                |                |                |                |                                      |                                       |                      |
|---|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
| Occupational Category                           | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|   |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>                                      | <i>Ranch Hand</i> | 38.12<br>(804)                        | 31.57<br>(787) | 32.05<br>(778) | 32.38<br>(778) | 43.70<br>(804) | 5.57                                 | 0.74                                  | 0.266                |
|   | <i>Comparison</i> | 37.44<br>(955)                        | 31.53<br>(937) | 31.30<br>(928) | 31.61<br>(932) | 42.27<br>(955) | 4.83                                 |                                       |                      |
| Officer   | Ranch Hand        | 36.62<br>(309)                        | 30.88<br>(304) | 31.40<br>(301) | 31.54<br>(300) | 42.13<br>(309) | 5.51                                 | 0.41                                  | 0.567                |
|   | Comparison        | 36.09<br>(377)                        | 30.25<br>(371) | 30.70<br>(363) | 31.24<br>(370) | 41.19<br>(377) | 5.10                                 |                                       |                      |
| Enlisted<br>Flyer                               | Ranch Hand        | 38.58<br>(146)                        | 31.70<br>(143) | 31.74<br>(141) | 30.77<br>(143) | 44.65<br>(146) | 6.07                                 | 1.99                                  | 0.698                |
|   | Comparison        | 41.81<br>(142)                        | 34.81<br>(141) | 33.64<br>(140) | 34.67<br>(138) | 45.89<br>(142) | 4.08                                 |                                       |                      |
| Enlisted<br>Groundcrew                          | Ranch Hand        | 39.31<br>(349)                        | 32.13<br>(340) | 32.77<br>(336) | 33.88<br>(335) | 44.73<br>(349) | 5.42                                 | 0.61                                  | 0.442                |
|   | Comparison        | 37.28<br>(436)                        | 31.63<br>(425) | 31.08<br>(425) | 30.99<br>(424) | 42.09<br>(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> |                                       |                |                |                |                |   |         |
|--|---------------------------------------|----------------|----------------|----------------|----------------|---|---------|
| Initial Dioxin Category Summary Statistics       |                                       |                |                |                |                | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup> |         |
| Initial Dioxin                                   | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Adjusted Slope<br>(Std. Error)                                      | p-Value |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |   |         |
| Low  | 41.42<br>(151)                        | 33.83<br>(147) | 32.52<br>(150) | 32.74<br>(146) | 43.50<br>(151) | -0.009 (0.017)  | 0.579   |
| Medium   | 42.17<br>(156)                        | 35.47<br>(154) | 36.50<br>(152) | 36.72<br>(152) | 48.93<br>(156) |   |         |
| High   | 41.69<br>(151)                        | 33.53<br>(148) | 34.54<br>(146) | 35.61<br>(148) | 46.45<br>(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> |                                       |                |                |                |                |                                   |                                       |                      |
|--|---------------------------------------|----------------|----------------|----------------|----------------|-----------------------------------|---------------------------------------|----------------------|
| Dioxin<br>Category   | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam. Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                   |                                       |                      |
| Comparison   | 37.10<br>(928)                        | 31.17<br>(912) | 30.95<br>(902) | 31.19<br>(906) | 41.92<br>(928) | 4.82                              |                                       |                      |
| Background<br>RH   | 33.22<br>(340)                        | 28.00<br>(333) | 28.71<br>(325) | 28.90<br>(327) | 39.90<br>(340) | 6.69                              | 1.87                                  | 0.363                |
| Low RH   | 40.41<br>(226)                        | 33.57<br>(220) | 32.97<br>(222) | 33.56<br>(218) | 44.00<br>(226) | 3.58                              | -1.24                                 | 0.686                |
| High RH  | 43.12<br>(232)                        | 34.98<br>(229) | 36.05<br>(226) | 36.45<br>(228) | 48.59<br>(232) | 5.48                              | 0.66                                  | 0.276                |
| Low plus<br>High RH  | 41.76<br>(458)                        | 34.28<br>(449) | 34.49<br>(448) | 35.01<br>(446) | 46.27<br>(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               |
| All   | Ranch Hand | 68 (8.5)<br>(804)               | 58 (7.4)<br>(787)  | 57 (7.3)<br>(778)  | 155 (19.9)<br>(778) | 84 (10.4)<br>(804) |
|   | Comparison | 81 (8.5)<br>(955)               | 76 (8.1)<br>(937)  | 60 (6.5)<br>(928)  | 163 (17.5)<br>(932) | 94 (9.8)<br>(955)  |
| Officer   | Ranch Hand | 26 (8.4)<br>(309)               | 21 (6.9)<br>(304)  | 24 (8.0)<br>(301)  | 56 (18.7)<br>(300)  | 27 (8.7)<br>(309)  |
|   | Comparison | 31 (8.2)<br>(377)               | 27 (7.3)<br>(371)  | 23 (6.3)<br>(363)  | 64 (17.3)<br>(370)  | 32 (8.5)<br>(377)  |
| Enlisted Flyer                                  | Ranch Hand | 15 (10.3)<br>(146)              | 11 (7.7)<br>(143)  | 13 (9.2)<br>(141)  | 25 (17.5)<br>(143)  | 23 (15.8)<br>(146) |
|   | Comparison | 16 (11.3)<br>(142)              | 17 (12.1)<br>(141) | 15 (10.7)<br>(140) | 29 (21.0)<br>(138)  | 21 (14.8)<br>(142) |
| Enlisted Groundcrew                             | Ranch Hand | 27 (7.7)<br>(349)               | 26 (7.6)<br>(340)  | 20 (6.0)<br>(336)  | 74 (22.1)<br>(335)  | 34 (9.7)<br>(349)  |
|   | Comparison | 34 (7.8)<br>(436)               | 32 (7.5)<br>(425)  | 22 (5.2)<br>(425)  | 70 (16.5)<br>(424)  | 41 (9.4)<br>(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> |
| All                   | Ranch Hand | 736            | 48 (6.5)                | 1.02 (0.69,1.53)                           | 0.909                |
|                       | Comparison | 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> |                                    |                   |                   |                    |                    |
|--|------------------------------------|-------------------|-------------------|--------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                   |                   |                    |                    |
|  | 1982                               | 1985              | 1987              | 1992               | 1997               |
| Low  | 17 (11.3)<br>151                   | 12 (8.2)<br>(147) | 10 (6.7)<br>(150) | 26 (17.8)<br>(146) | 16 (10.6)<br>(151) |
| Medium   | 15 (9.6)<br>(156)                  | 12 (7.8)<br>(154) | 14 (9.2)<br>(152) | 39 (25.7)<br>(152) | 27 (17.3)<br>(156) |
| High   | 17 (11.3)<br>(151)                 | 14 (9.5)<br>(148) | 13 (8.9)<br>(146) | 33 (22.3)<br>(148) | 17 (11.3)<br>(151) |

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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> |                                    |                   |                   |                     |                    |
|--|------------------------------------|-------------------|-------------------|---------------------|--------------------|
| Dioxin Category  | Number (%) High/(n)<br>Examination |                   |                   |                     |                    |
|  | 1982                               | 1985              | 1987              | 1992                | 1997               |
| Comparison   | 74 (8.0)<br>(928)                  | 71 (7.8)<br>(912) | 55 (6.1)<br>(902) | 151 (16.7)<br>(906) | 89 (9.6)<br>(928)  |
| Background RH  | 17 (5.0)<br>(340)                  | 19 (5.7)<br>(333) | 19 (5.8)<br>(325) | 55 (16.8)<br>(327)  | 22 (6.5)<br>(340)  |
| Low RH   | 22 (9.7)<br>(226)                  | 16 (7.3)<br>(220) | 15 (6.8)<br>(222) | 43 (19.7)<br>(218)  | 27 (11.9)<br>(226) |
| High RH  | 27 (11.6)<br>(232)                 | 22 (9.6)<br>(229) | 22 (9.7)<br>(226) | 55 (24.1)<br>(228)  | 33 (14.2)<br>(232) |
| Low plus High RH   | 49 (10.7)<br>(458)                 | 38 (8.5)<br>(449) | 37 (8.3)<br>(448) | 98 (22.0)<br>(446)  | 60 (13.1)<br>(458) |

**Table 13-67. Longitudinal Analysis of GGT (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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  $\leq$  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 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> |                   |                                       |                |                |                |                |                                      |                                       |                      |
|---|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
| Occupational Category                           | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|   |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>                                      | <i>Ranch Hand</i> | 212.3<br>(804)                        | 214.9<br>(787) | 216.0<br>(778) | 215.9<br>(778) | 210.8<br>(804) | -1.5                                 | 2.0                                   | 0.877                |
|   | <i>Comparison</i> | 215.8<br>(956)                        | 217.2<br>(938) | 215.8<br>(929) | 216.0<br>(933) | 212.4<br>(956) | -3.5                                 |                                       |                      |
| Officer   | Ranch Hand        | 212.2<br>(309)                        | 215.4<br>(304) | 215.9<br>(301) | 214.3<br>(300) | 205.7<br>(309) | -6.5                                 | -3.8                                  | 0.075                |
|   | Comparison        | 213.6<br>(377)                        | 215.2<br>(371) | 214.6<br>(363) | 213.0<br>(370) | 210.8<br>(377) | -2.7                                 |                                       |                      |
| Enlisted<br>Flyer                               | Ranch Hand        | 217.4<br>(146)                        | 220.0<br>(143) | 218.6<br>(141) | 219.8<br>(143) | 213.5<br>(146) | -3.9                                 | 4.4                                   | 0.838                |
|   | Comparison        | 224.7<br>(142)                        | 222.5<br>(141) | 221.8<br>(140) | 221.8<br>(138) | 216.4<br>(142) | -8.3                                 |                                       |                      |
| Enlisted<br>Groundcrew                          | Ranch Hand        | 210.3<br>(349)                        | 212.4<br>(340) | 214.9<br>(336) | 215.8<br>(335) | 214.3<br>(349) | 4.0                                  | 6.5                                   | 0.082                |
|   | Comparison        | 214.9<br>(437)                        | 217.3<br>(426) | 214.9<br>(426) | 216.9<br>(425) | 212.4<br>(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>  |   |                |                |                |                | <b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b> |                |
|---|---|----------------|----------------|----------------|----------------|--|----------------|
| <b>Initial Dioxin Category Summary Statistics</b> |   |                |                |                |                |  |                |
| <b>Initial Dioxin</b>                             | <b>Mean<sup>a</sup>/(n)<br/>Examination</b> |                |                |                |                | <b>Adjusted Slope<br/>(Std. Error)</b>                                   | <b>p-Value</b> |
|   | <b>1982</b>                                 | <b>1985</b>    | <b>1987</b>    | <b>1992</b>    | <b>1997</b>    |  |                |
| Low   | 213.4<br>(151)                              | 216.4<br>(147) | 216.9<br>(150) | 215.5<br>(146) | 205.6<br>(151) | 0.063 (0.041)  | 0.128          |
| Medium  | 212.5<br>(156)                              | 215.7<br>(154) | 217.0<br>(152) | 215.8<br>(152) | 213.8<br>(156) |  |                |
| High  | 218.6<br>(151)                              | 219.0<br>(148) | 219.0<br>(146) | 220.8<br>(148) | 217.9<br>(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> |   |                |                |                |                |  |  |                            |
|--|---|----------------|----------------|----------------|----------------|--|--|----------------------------|
| <b>Dioxin<br/>Category</b>   | <b>Mean<sup>a</sup>/(n)<br/>Examination</b> |                |                |                |                | <b>Exam. Mean<br/>Change<sup>b</sup></b> | <b>Difference of<br/>Exam. Mean<br/>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   | 215.5<br>(929)                              | 217.2<br>(913) | 215.7<br>(903) | 215.8<br>(907) | 212.3<br>(929) | –3.2                                     |  |                            |
| Background<br>RH   | 208.9<br>(340)                              | 212.1<br>(333) | 214.0<br>(325) | 214.1<br>(327) | 208.8<br>(340) | –0.1                                     | 3.1  | 0.800                      |
| Low RH   | 212.8<br>(226)                              | 215.8<br>(220) | 215.7<br>(222) | 216.4<br>(218) | 208.0<br>(226) | –4.8                                     | –1.6   | 0.410                      |
| High RH  | 216.7<br>(232)                              | 218.2<br>(229) | 219.5<br>(226) | 218.2<br>(228) | 216.7<br>(232) | 0.0                                      | 3.2  | 0.168                      |
| Low plus<br>High RH  | 214.8<br>(458)                              | 217.0<br>(449) | 217.6<br>(448) | 217.3<br>(446) | 212.4<br>(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                |
| All   | Ranch Hand | 121 (15.0)<br>(804)             | 127 (16.1)<br>(787) | 131 (16.8)<br>(778) | 108 (13.9)<br>(778) | 121 (15.0)<br>(804) |
|   | Comparison | 156 (16.3)<br>(956)             | 170 (18.1)<br>(938) | 135 (14.5)<br>(929) | 121 (13.0)<br>(933) | 142 (14.9)<br>(956) |
| Officer   | Ranch Hand | 34 (11.0)<br>(309)              | 49 (16.1)<br>(304)  | 49 (16.3)<br>(301)  | 35 (11.7)<br>(300)  | 36 (11.7)<br>(309)  |
|   | Comparison | 43 (11.4)<br>(377)              | 53 (14.3)<br>(371)  | 43 (11.8)<br>(363)  | 40 (10.8)<br>(370)  | 53 (14.1)<br>(377)  |
| Enlisted Flyer                                  | Ranch Hand | 27 (18.5)<br>(146)              | 27 (18.9)<br>(143)  | 30 (21.3)<br>(141)  | 26 (18.2)<br>(143)  | 21 (14.4)<br>(146)  |
|   | Comparison | 29 (20.4)<br>(142)              | 34 (24.1)<br>(141)  | 27 (19.3)<br>(140)  | 19 (13.8)<br>(138)  | 21 (14.8)<br>(142)  |
| Enlisted Groundcrew                             | Ranch Hand | 60 (17.2)<br>(349)              | 51 (15.0)<br>(340)  | 52 (15.5)<br>(336)  | 47 (14.0)<br>(335)  | 64 (18.3)<br>(349)  |
|   | Comparison | 84 (19.2)<br>(437)              | 83 (19.5)<br>(426)  | 65 (15.3)<br>(426)  | 62 (14.6)<br>(425)  | 68 (15.6)<br>(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> |
| All                   | Ranch Hand | 683            | 81 (11.9)               | 1.18 (0.85,1.63)                           | 0.323                |
|                       | Comparison | 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> |                                    |                    |                    |                    |                    |
|--|------------------------------------|--------------------|--------------------|--------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                    |                    |                    |                    |
|  | 1982                               | 1985               | 1987               | 1992               | 1997               |
| Low  | 18 (11.9)<br>(151)                 | 25 (17.0)<br>(147) | 25 (16.7)<br>(150) | 19 (13.0)<br>(146) | 18 (11.9)<br>(151) |
| Medium   | 24 (15.4)<br>(156)                 | 25 (16.2)<br>(154) | 23 (15.1)<br>(152) | 21 (13.8)<br>(152) | 29 (18.6)<br>(156) |
| High   | 39 (25.8)<br>(151)                 | 26 (17.6)<br>(148) | 23 (15.8)<br>(146) | 27 (18.2)<br>(148) | 30 (19.9)<br>(151) |

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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> |                                    |                     |                     |                     |                     |
|--|------------------------------------|---------------------|---------------------|---------------------|---------------------|
| Dioxin Category  | Number (%) High/(n)<br>Examination |                     |                     |                     |                     |
|  | 1982                               | 1985                | 1987                | 1992                | 1997                |
| Comparison   | 150 (16.1)<br>(929)                | 165 (18.1)<br>(913) | 131 (14.5)<br>(903) | 115 (12.7)<br>(907) | 138 (14.9)<br>(929) |
| Background RH  | 40 (11.8)<br>(340)                 | 51 (15.3)<br>(333)  | 60 (18.5)<br>(325)  | 40 (12.2)<br>(327)  | 44 (12.9)<br>(340)  |
| Low RH   | 29 (12.8)<br>(226)                 | 37 (16.8)<br>(220)  | 35 (15.8)<br>(222)  | 31 (14.2)<br>(218)  | 31 (13.7)<br>(226)  |
| High RH  | 52 (22.4)<br>(232)                 | 39 (17.0)<br>(229)  | 36 (15.9)<br>(226)  | 36 (15.8)<br>(228)  | 46 (19.8)<br>(232)  |
| Low plus High RH   | 81 (17.7)<br>(458)                 | 76 (16.9)<br>(449)  | 71 (15.8)<br>(448)  | 67 (15.0)<br>(446)  | 77 (16.8)<br>(458)  |

**Table 13-69. Longitudinal Analysis of Cholesterol (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>a,b</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|---|----------------------|
|                  | n in 1997      | Number (%)<br>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  $\leq$  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 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> |                   |                                       |                |                |                |                |                                      |                                       |                      |
|---|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
| Occupational Category                           | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|   |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>                                      | <i>Ranch Hand</i> | 44.61<br>(798)                        | 44.66<br>(781) | 45.43<br>(772) | 40.85<br>(763) | 45.03<br>(798) | 0.42                                 | 0.57                                  | 0.235                |
|   | <i>Comparison</i> | 44.89<br>(955)                        | 44.90<br>(937) | 45.45<br>(928) | 40.60<br>(926) | 44.74<br>(955) | -0.15                                |                                       |                      |
| Officer   | Ranch Hand        | 45.96<br>(306)                        | 46.24<br>(301) | 46.94<br>(298) | 42.59<br>(293) | 46.91<br>(306) | 0.95                                 | 0.28                                  | 0.844                |
|   | Comparison        | 46.31<br>(377)                        | 46.43<br>(371) | 47.05<br>(363) | 41.90<br>(367) | 46.98<br>(377) | 0.67                                 |                                       |                      |
| Enlisted<br>Flyer                               | Ranch Hand        | 42.99<br>(145)                        | 42.99<br>(142) | 44.26<br>(140) | 40.48<br>(138) | 44.86<br>(145) | 1.87                                 | 1.49                                  | 0.146                |
|   | Comparison        | 43.14<br>(142)                        | 43.51<br>(141) | 44.41<br>(140) | 40.28<br>(136) | 43.53<br>(142) | 0.38                                 |                                       |                      |
| Enlisted<br>Groundcrew                          | Ranch Hand        | 44.13<br>(347)                        | 44.00<br>(338) | 44.61<br>(334) | 39.52<br>(332) | 43.50<br>(347) | -0.63                                | 0.37                                  | 0.527                |
|   | Comparison        | 44.27<br>(436)                        | 44.06<br>(425) | 44.47<br>(425) | 39.60<br>(423) | 43.27<br>(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) MODEL 2: RANCH HANDS – INITIAL DIOXIN  |                                       |                |                |                |                |   |         |
|--|---------------------------------------|----------------|----------------|----------------|----------------|---|---------|
| Initial Dioxin Category Summary Statistics |                                       |                |                |                |                | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup> |         |
| Initial Dioxin                             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Adjusted Slope<br>(Std. Error)                                      | p-Value |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |   |         |
| Low  | 44.90<br>(149)                        | 44.49<br>(145) | 45.38<br>(148) | 41.26<br>(144) | 45.14<br>(149) | 0.007 (0.008)   | 0.382   |
| Medium                                     | 43.22<br>(154)                        | 43.05<br>(152) | 43.71<br>(150) | 39.43<br>(148) | 43.51<br>(154) |   |         |
| High                                       | 42.38<br>(150)                        | 42.38<br>(147) | 43.37<br>(145) | 38.86<br>(144) | 43.39<br>(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<br>Category   | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam. Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                   |                                       |                      |
| Comparison   | 44.90<br>(928)                        | 44.80<br>(912) | 45.37<br>(902) | 40.54<br>(901) | 44.65<br>(928) | –0.24                             |                                       |                      |
| Background<br>RH   | 46.06<br>(339)                        | 46.57<br>(332) | 47.32<br>(324) | 42.43<br>(322) | 46.44<br>(339) | 0.38                              | 0.62                                  | 0.437                |
| Low RH   | 44.89<br>(224)                        | 44.77<br>(218) | 45.54<br>(220) | 41.52<br>(215) | 45.07<br>(224) | 0.18                              | 0.42                                  | 0.598                |
| High RH  | 42.15<br>(229)                        | 41.91<br>(226) | 42.81<br>(223) | 38.26<br>(221) | 42.97<br>(229) | 0.83                              | 1.07                                  | 0.105                |
| Low plus<br>High RH  | 43.48<br>(453)                        | 43.29<br>(444) | 44.14<br>(443) | 39.83<br>(436) | 44.00<br>(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               |
| All   | Ranch Hand | 21 (2.6)<br>(798)              | 30 (3.8)<br>(781) | 24 (3.1)<br>(772) | 82 (10.7)<br>(763) | 67 (8.4)<br>(798)  |
|   | Comparison | 20 (2.1)<br>(955)              | 33 (3.5)<br>(937) | 22 (2.4)<br>(928) | 80 (8.6)<br>(926)  | 74 (7.7)<br>(955)  |
| Officer   | Ranch Hand | 9 (2.9)<br>(306)               | 11 (3.7)<br>(301) | 7 (2.3)<br>(298)  | 31 (10.6)<br>(293) | 16 (5.2)<br>(306)  |
|   | Comparison | 10 (2.7)<br>(377)              | 13 (3.5)<br>(371) | 4 (1.1)<br>(363)  | 28 (7.6)<br>(367)  | 19 (5.0)<br>(377)  |
| Enlisted Flyer                                  | Ranch Hand | 4 (2.8)<br>(145)               | 8 (5.6)<br>(142)  | 8 (5.7)<br>(140)  | 12 (8.7)<br>(138)  | 16 (11.0)<br>(145) |
|   | Comparison | 4 (2.8)<br>(142)               | 8 (5.7)<br>(141)  | 6 (4.3)<br>(140)  | 14 (10.3)<br>(136) | 15 (10.6)<br>(142) |
| Enlisted Groundcrew                             | Ranch Hand | 8 (2.3)<br>(347)               | 11 (3.3)<br>(338) | 9 (2.7)<br>(334)  | 39 (11.7)<br>(332) | 35 (10.1)<br>(347) |
|   | Comparison | 6 (1.4)<br>(436)               | 12 (2.8)<br>(425) | 12 (2.8)<br>(425) | 38 (9.0)<br>(423)  | 40 (9.2)<br>(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> |
| All                   | Ranch Hand | 777            | 57 (7.3)               | 1.06 (0.73,1.53)                           | 0.760                |
|                       | Comparison | 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> |                                   |                  |                  |                    |                   |
|--|-----------------------------------|------------------|------------------|--------------------|-------------------|
| Initial Dioxin                                   | Number (%) Low/(n)<br>Examination |                  |                  |                    |                   |
|  | 1982                              | 1985             | 1987             | 1992               | 1997              |
| Low  | 2 (1.3)<br>(149)                  | 5 (3.4)<br>(145) | 2 (1.4)<br>(148) | 13 (9.0)<br>(144)  | 13 (8.7)<br>(149) |
| Medium   | 4 (2.6)<br>(154)                  | 7 (4.6)<br>(152) | 4 (2.7)<br>(150) | 16 (10.8)<br>(148) | 15 (9.7)<br>(154) |
| High   | 3 (2.0)<br>(150)                  | 7 (4.8)<br>(147) | 6 (4.1)<br>(145) | 16 (11.1)<br>(144) | 9 (6.0)<br>(150)  |

| Initial Dioxin Category Summary Statistics |                |                           | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|---------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                           | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>Low in 1997 |   |         |
| 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> |                                   |                   |                   |                    |                   |
|--|-----------------------------------|-------------------|-------------------|--------------------|-------------------|
| Dioxin Category  | Number (%) Low/(n)<br>Examination |                   |                   |                    |                   |
|  | 1982                              | 1985              | 1987              | 1992               | 1997              |
| Comparison   | 20 (2.2)<br>(928)                 | 33 (3.6)<br>(912) | 22 (2.4)<br>(902) | 78 (8.7)<br>(901)  | 73 (7.9)<br>(928) |
| Background RH  | 12 (3.5)<br>(339)                 | 11 (3.3)<br>(332) | 11 (3.4)<br>(324) | 34 (10.6)<br>(322) | 30 (8.8)<br>(339) |
| Low RH   | 6 (2.7)<br>(224)                  | 10 (4.6)<br>(218) | 3 (1.4)<br>(220)  | 19 (8.8)<br>(215)  | 19 (8.5)<br>(224) |
| High RH  | 3 (1.3)<br>(229)                  | 9 (4.0)<br>(226)  | 9 (4.0)<br>(223)  | 26 (11.8)<br>(221) | 18 (7.9)<br>(229) |
| Low plus High RH   | 9 (2.0)<br>(453)                  | 19 (4.3)<br>(444) | 12 (2.7)<br>(443) | 45 (10.3)<br>(436) | 37 (8.2)<br>(453) |

**Table 13-71. Longitudinal Analysis of HDL Cholesterol (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                           | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|---------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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)**

**(a) MODEL 1: RANCH HANDS VS. COMPARISONS**

| Occupational Category  | Group             | Mean <sup>a</sup> /(n)<br>Examination |               |               |               |               | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|------------------------|-------------------|---------------------------------------|---------------|---------------|---------------|---------------|--------------------------------------|---------------------------------------|----------------------|
|                        |                   | 1982                                  | 1985          | 1987          | 1992          | 1997          |                                      |                                       |                      |
| <i>All</i>             | <i>Ranch Hand</i> | 4.71<br>(798)                         | 4.77<br>(781) | 4.71<br>(772) | 5.23<br>(763) | 4.65<br>(798) | -0.06                                | -0.01                                 | 0.519                |
|                        | <i>Comparison</i> | 4.77<br>(955)                         | 4.80<br>(937) | 4.71<br>(928) | 5.27<br>(926) | 4.71<br>(955) | -0.05                                |                                       |                      |
| Officer                | Ranch Hand        | 4.58<br>(306)                         | 4.62<br>(301) | 4.56<br>(298) | 4.99<br>(293) | 4.36<br>(306) | -0.22                                | -0.10                                 | 0.237                |
|                        | Comparison        | 4.57<br>(377)                         | 4.60<br>(371) | 4.53<br>(363) | 5.04<br>(367) | 4.45<br>(377) | -0.12                                |                                       |                      |
| Enlisted<br>Flyer      | Ranch Hand        | 5.00<br>(145)                         | 5.06<br>(142) | 4.88<br>(140) | 5.32<br>(138) | 4.72<br>(145) | -0.28                                | -0.06                                 | 0.255                |
|                        | Comparison        | 5.16<br>(142)                         | 5.06<br>(141) | 4.95<br>(140) | 5.45<br>(136) | 4.94<br>(142) | -0.22                                |                                       |                      |
| Enlisted<br>Groundcrew | Ranch Hand        | 4.71<br>(347)                         | 4.79<br>(338) | 4.78<br>(334) | 5.42<br>(332) | 4.89<br>(347) | 0.18                                 | 0.12                                  | 0.400                |
|                        | Comparison        | 4.81<br>(436)                         | 4.89<br>(425) | 4.79<br>(425) | 5.43<br>(423) | 4.87<br>(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>  |   |               |               |               |               | <b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b> |                |
|---|---|---------------|---------------|---------------|---------------|--|----------------|
| <b>Initial Dioxin Category Summary Statistics</b> |   |               |               |               |               |  |                |
| <b>Initial Dioxin</b>                             | <b>Mean<sup>a</sup>/(n)<br/>Examination</b> |               |               |               |               | <b>Adjusted Slope<br/>(Std. Error)</b>                                   | <b>p-Value</b> |
|   | <b>1982</b>                                 | <b>1985</b>   | <b>1987</b>   | <b>1992</b>   | <b>1997</b>   |  |                |
| Low   | 4.70<br>(149)                               | 4.81<br>(145) | 4.73<br>(148) | 5.17<br>(144) | 4.51<br>(149) | 0.005 (0.008)  | 0.589          |
| Medium  | 4.85<br>(154)                               | 4.98<br>(152) | 4.93<br>(150) | 5.43<br>(148) | 4.88<br>(154) |  |                |
| High  | 5.10<br>(150)                               | 5.12<br>(147) | 5.02<br>(145) | 5.59<br>(144) | 4.98<br>(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> |   |               |               |               |               |  |  |                            |
|--|---|---------------|---------------|---------------|---------------|--|--|----------------------------|
| <b>Dioxin<br/>Category</b>   | <b>Mean<sup>a</sup>/(n)<br/>Examination</b> |               |               |               |               | <b>Exam. Mean<br/>Change<sup>b</sup></b> | <b>Difference of<br/>Exam. Mean<br/>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   | 4.76<br>(928)                               | 4.81<br>(912) | 4.71<br>(902) | 5.28<br>(901) | 4.72<br>(928) | –0.04                                    |  |                            |
| Background<br>RH   | 4.50<br>(339)                               | 4.52<br>(332) | 4.48<br>(324) | 4.99<br>(322) | 4.47<br>(339) | –0.03                                    | 0.01   | 0.473                      |
| Low RH   | 4.69<br>(224)                               | 4.77<br>(218) | 4.69<br>(220) | 5.16<br>(215) | 4.57<br>(224) | –0.12                                    | –0.08  | 0.281                      |
| High RH  | 5.08<br>(229)                               | 5.17<br>(226) | 5.10<br>(223) | 5.64<br>(221) | 5.01<br>(229) | –0.06                                    | –0.02  | 0.971                      |
| Low plus<br>High RH  | 4.88<br>(453)                               | 4.97<br>(444) | 4.89<br>(443) | 5.40<br>(436) | 4.79<br>(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                |
| All   | Ranch Hand | 350 (43.9)<br>(798)             | 352 (45.1)<br>(781) | 335 (43.4)<br>(772) | 432 (56.6)<br>(763) | 324 (40.6)<br>(798) |
|   | Comparison | 423 (44.3)<br>(955)             | 415 (44.3)<br>(937) | 401 (43.2)<br>(928) | 533 (57.6)<br>(926) | 404 (42.3)<br>(955) |
| Officer   | Ranch Hand | 120 (39.2)<br>(306)             | 132 (43.9)<br>(301) | 124 (41.6)<br>(298) | 144 (49.1)<br>(293) | 99 (32.4)<br>(306)  |
|   | Comparison | 151 (40.1)<br>(377)             | 140 (37.7)<br>(371) | 134 (36.9)<br>(363) | 182 (49.6)<br>(367) | 117 (31.0)<br>(377) |
| Enlisted Flyer                                  | Ranch Hand | 74 (51.0)<br>(145)              | 69 (48.6)<br>(142)  | 61 (43.6)<br>(140)  | 83 (60.1)<br>(138)  | 56 (38.6)<br>(145)  |
|   | Comparison | 77 (54.2)<br>(142)              | 71 (50.4)<br>(141)  | 76 (54.3)<br>(140)  | 84 (61.8)<br>(136)  | 71 (50.0)<br>(142)  |
| Enlisted Groundcrew                             | Ranch Hand | 156 (45.0)<br>(347)             | 151 (44.7)<br>(338) | 150 (44.9)<br>(334) | 205 (61.7)<br>(332) | 169 (48.7)<br>(347) |
|   | Comparison | 195 (44.7)<br>(436)             | 204 (48.0)<br>(425) | 191 (44.9)<br>(425) | 267 (63.1)<br>(423) | 216 (49.5)<br>(436) |

  

| Normal in 1982        |            |           |                         |  |                      |
|-----------------------|------------|-----------|-------------------------|--|----------------------|
| Occupational Category | Group      | n in 1997 | Number (%) High in 1997 | Adj. Relative Risk (95% C.I.) <sup>a</sup> | p-Value <sup>a</sup> |
| All                   | Ranch Hand | 448       | 90 (20.1)               | 0.82 (0.60,1.12)                           | 0.206                |
|                       | Comparison | 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> |                                    |                    |                    |                    |                    |
|--|------------------------------------|--------------------|--------------------|--------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                    |                    |                    |                    |
|  | 1982                               | 1985               | 1987               | 1992               | 1997               |
| Low  | 61 (40.9)<br>(149)                 | 66 (45.5)<br>(145) | 65 (43.9)<br>(148) | 79 (54.9)<br>(144) | 51 (34.2)<br>(149) |
| Medium   | 74 (48.1)<br>(154)                 | 75 (49.3)<br>(152) | 73 (48.7)<br>(150) | 97 (65.5)<br>(148) | 72 (46.8)<br>(154) |
| High   | 82 (54.7)<br>(150)                 | 78 (53.1)<br>(147) | 74 (51.0)<br>(145) | 92 (63.9)<br>(144) | 78 (52.0)<br>(150) |

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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> |                                    |                     |                     |                     |                     |
|--|------------------------------------|---------------------|---------------------|---------------------|---------------------|
| Dioxin Category  | Number (%) High/(n)<br>Examination |                     |                     |                     |                     |
|  | 1982                               | 1985                | 1987                | 1992                | 1997                |
| Comparison   | 407 (43.9)<br>(928)                | 406 (44.5)<br>(912) | 391 (43.3)<br>(902) | 518 (57.5)<br>(901) | 395 (42.6)<br>(928) |
| Background RH  | 131 (38.6)<br>(339)                | 130 (39.2)<br>(332) | 120 (37.0)<br>(324) | 160 (49.7)<br>(322) | 119 (35.1)<br>(339) |
| Low RH   | 91 (40.6)<br>(224)                 | 93 (42.7)<br>(218)  | 94 (42.7)<br>(220)  | 120 (55.8)<br>(215) | 80 (35.7)<br>(224)  |
| High RH  | 126 (55.0)<br>(229)                | 126 (55.8)<br>(226) | 118 (52.9)<br>(223) | 148 (67.0)<br>(221) | 121 (52.8)<br>(229) |
| Low plus High RH   | 217 (47.9)<br>(453)                | 219 (49.3)<br>(444) | 212 (47.9)<br>(443) | 268 (61.5)<br>(436) | 201 (44.4)<br>(453) |

**Table 13-73. Longitudinal Analysis of Cholesterol-HDL Ratio (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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)**

**(a) MODEL 1: RANCH HANDS VS. COMPARISONS**

| Occupational Category  | Group             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam.<br>Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|------------------------|-------------------|---------------------------------------|----------------|----------------|----------------|----------------|--------------------------------------|---------------------------------------|----------------------|
|                        |                   | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                      |                                       |                      |
| <i>All</i>             | <i>Ranch Hand</i> | 118.8<br>(803)                        | 117.1<br>(786) | 120.2<br>(777) | 146.6<br>(777) | 122.7<br>(803) | 4.0                                  | 3.2                                   | 0.478                |
|                        | <i>Comparison</i> | 120.9<br>(956)                        | 119.1<br>(938) | 119.4<br>(929) | 146.1<br>(933) | 121.8<br>(956) | 0.8                                  |                                       |                      |
| Officer                | Ranch Hand        | 118.8<br>(308)                        | 116.3<br>(303) | 115.1<br>(300) | 143.1<br>(299) | 113.7<br>(308) | -5.1                                 | -1.0                                  | 0.780                |
|                        | Comparison        | 115.5<br>(377)                        | 111.9<br>(371) | 111.8<br>(363) | 137.7<br>(370) | 111.4<br>(377) | -4.1                                 |                                       |                      |
| Enlisted<br>Flyer      | Ranch Hand        | 129.1<br>(146)                        | 122.7<br>(143) | 126.7<br>(141) | 145.0<br>(143) | 125.0<br>(146) | -4.1                                 | -8.5                                  | 0.177                |
|                        | Comparison        | 134.2<br>(142)                        | 130.4<br>(141) | 130.0<br>(140) | 157.3<br>(138) | 138.6<br>(142) | 4.4                                  |                                       |                      |
| Enlisted<br>Groundcrew | Ranch Hand        | 114.6<br>(349)                        | 115.5<br>(340) | 122.3<br>(336) | 150.4<br>(335) | 130.3<br>(349) | 15.7                                 | 11.3                                  | 0.128                |
|                        | Comparison        | 121.6<br>(437)                        | 122.1<br>(426) | 122.8<br>(426) | 150.0<br>(425) | 126.1<br>(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) MODEL 2: RANCH HANDS – INITIAL DIOXIN  |                                       |                |                |                |                |   |         |
|--|---------------------------------------|----------------|----------------|----------------|----------------|---|---------|
| Initial Dioxin Category Summary Statistics |                                       |                |                |                |                | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>b</sup> |         |
| Initial Dioxin                             | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Adjusted Slope<br>(Std. Error)                                      | p-Value |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |   |         |
| Low  | 122.1<br>(151)                        | 120.8<br>(147) | 120.1<br>(150) | 143.2<br>(146) | 117.6<br>(151) | 0.006 (0.020)   | 0.751   |
| Medium                                     | 129.2<br>(156)                        | 129.1<br>(154) | 142.9<br>(152) | 163.3<br>(152) | 141.4<br>(156) |   |         |
| High                                       | 129.5<br>(151)                        | 133.2<br>(148) | 133.6<br>(146) | 161.1<br>(148) | 143.0<br>(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<br>Category   | Mean <sup>a</sup> /(n)<br>Examination |                |                |                |                | Exam. Mean<br>Change <sup>b</sup> | Difference of<br>Exam. Mean<br>Change | p-Value <sup>c</sup> |
|  | 1982                                  | 1985           | 1987           | 1992           | 1997           |                                   |                                       |                      |
| Comparison   | 120.1<br>(929)                        | 118.7<br>(913) | 118.7<br>(903) | 145.4<br>(907) | 121.4<br>(929) | 1.3                               |                                       |                      |
| Background<br>RH   | 107.7<br>(339)                        | 103.7<br>(332) | 105.5<br>(324) | 134.4<br>(326) | 108.6<br>(339) | 0.8                               | –0.5                                  | 0.377                |
| Low RH   | 119.8<br>(226)                        | 120.4<br>(220) | 120.5<br>(222) | 144.0<br>(218) | 120.8<br>(226) | 1.0                               | –0.3                                  | 0.820                |
| High RH  | 134.3<br>(232)                        | 135.0<br>(229) | 144.1<br>(226) | 167.8<br>(228) | 147.3<br>(232) | 13.1                              | 11.8                                  | 0.020                |
| Low plus<br>High RH  | 126.9<br>(458)                        | 127.6<br>(449) | 131.9<br>(448) | 155.7<br>(446) | 133.6<br>(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)<br>(803)             | 58 (7.4)<br>(786) | 59 (7.6)<br>(777) | 88 (11.3)<br>(777) | 179 (22.3)<br>(803) |
|   | <i>Comparison</i> | 313 (32.7)<br>(956)             | 61 (6.5)<br>(938) | 60 (6.5)<br>(929) | 84 (9.0)<br>(933)  | 203 (21.2)<br>(956) |
| Officer   | Ranch Hand        | 84 (27.3)<br>(308)              | 30 (9.9)<br>(303) | 21 (7.0)<br>(300) | 33 (11.0)<br>(299) | 53 (17.2)<br>(308)  |
|   | Comparison        | 113 (30.0)<br>(377)             | 24 (6.5)<br>(371) | 25 (6.9)<br>(363) | 32 (8.6)<br>(370)  | 62 (16.4)<br>(377)  |
| Enlisted Flyer                                  | Ranch Hand        | 55 (37.7)<br>(146)              | 14 (9.8)<br>(143) | 12 (8.5)<br>(141) | 20 (14.0)<br>(143) | 30 (20.5)<br>(146)  |
|   | Comparison        | 52 (36.6)<br>(142)              | 10 (7.1)<br>(141) | 9 (6.4)<br>(140)  | 11 (8.0)<br>(138)  | 42 (29.6)<br>(142)  |
| Enlisted Groundcrew                             | Ranch Hand        | 109 (31.2)<br>(349)             | 14 (4.1)<br>(340) | 26 (7.7)<br>(336) | 35 (10.4)<br>(335) | 96 (27.5)<br>(349)  |
|   | Comparison        | 148 (33.9)<br>(437)             | 27 (6.3)<br>(426) | 26 (6.1)<br>(426) | 41 (9.6)<br>(425)  | 99 (22.7)<br>(437)  |

  

| Normal in 1982        |                   |           |                         |  |                      |
|-----------------------|-------------------|-----------|-------------------------|--|----------------------|
| Occupational Category | Group             | 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> |                                    |                    |                    |                    |                    |
|--|------------------------------------|--------------------|--------------------|--------------------|--------------------|
| Initial Dioxin                                   | Number (%) High/(n)<br>Examination |                    |                    |                    |                    |
|  | 1982                               | 1985               | 1987               | 1992               | 1997               |
| Low  | 49 (32.5)<br>(151)                 | 13 (8.8)<br>(147)  | 9 (6.0)<br>(150)   | 14 (9.6)<br>(146)  | 36 (23.8)<br>(151) |
| Medium   | 56 (35.9)<br>(156)                 | 16 (10.4)<br>(154) | 16 (10.5)<br>(152) | 25 (16.4)<br>(152) | 44 (28.2)<br>(156) |
| High   | 56 (37.1)<br>(151)                 | 11 (7.4)<br>(148)  | 18 (12.3)<br>(146) | 19 (12.8)<br>(148) | 49 (32.5)<br>(151) |

  

| Initial Dioxin Category Summary Statistics |                |                            | Analysis Results for Log <sub>2</sub> (Initial Dioxin) <sup>a</sup> |         |
|--|----------------|----------------------------|---|---------|
| Initial Dioxin                             | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>b</sup>                       | p-Value |
|  | n in 1997      | Number (%)<br>High in 1997 |   |         |
| 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> |                                    |                   |                    |                    |                     |
|--|------------------------------------|-------------------|--------------------|--------------------|---------------------|
| Dioxin Category  | Number (%) High/(n)<br>Examination |                   |                    |                    |                     |
|  | 1982                               | 1985              | 1987               | 1992               | 1997                |
| Comparison   | 300 (32.3)<br>(929)                | 58 (6.4)<br>(913) | 57 (6.3)<br>(903)  | 80 (8.8)<br>(907)  | 195 (21.0)<br>(929) |
| Background RH  | 83 (24.5)<br>(339)                 | 17 (5.1)<br>(332) | 16 (4.9)<br>(324)  | 30 (9.2)<br>(326)  | 46 (13.6)<br>(339)  |
| Low RH   | 75 (33.2)<br>(226)                 | 20 (9.1)<br>(220) | 14 (6.3)<br>(222)  | 21 (9.6)<br>(218)  | 52 (23.0)<br>(226)  |
| High RH  | 86 (37.1)<br>(232)                 | 20 (8.7)<br>(229) | 29 (12.8)<br>(226) | 37 (16.2)<br>(228) | 77 (33.2)<br>(232)  |
| Low plus High RH   | 161 (35.2)<br>(458)                | 40 (8.9)<br>(449) | 43 (9.6)<br>(448)  | 58 (13.0)<br>(446) | 129 (28.2)<br>(458) |



**Table 13-75. Longitudinal Analysis of Triglycerides (Discrete) (Continued)**

| Dioxin Category  | Normal in 1982 |                            | Adj. Relative Risk<br>(95% C.I.) <sup>ab</sup> | p-Value <sup>b</sup> |
|------------------|----------------|----------------------------|--|----------------------|
|                  | n in 1997      | Number (%)<br>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 a 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<br>Flyer | Enlisted<br>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<br>(Alcohol-related) (D)      | NS         | NS      | ns                | ns                     |
| Chronic Liver Disease and Cirrhosis (Non-<br>alcohol-related) (D) | NS         | NS      | ns                | NS                     |
| Liver Abscess and Sequelae of Chronic<br>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<br>Flyer | Enlisted<br>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                     |
| $\alpha$ -1-Acid Glycoprotein (C)                       | NS         | ns      | ns                | +0.044                 |
| $\alpha$ -1-Acid Glycoprotein (D)                       | NS         | ns      | NS                | NS                     |
| $\alpha$ -1-Antitrypsin (C):                            | +0.002     | NS      | NS                | +0.001                 |
| $\alpha$ -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)                                    | 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<br>Flyer | Enlisted<br>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)   | --         | --       |
| $\alpha$ -1-Acid Glycoprotein (C)                       | NS         | ns*      |
| $\alpha$ -1-Acid Glycoprotein (D)                       | NS         | ns       |
| $\alpha$ -1-Antitrypsin (C)                             | NS*        | NS       |
| $\alpha$ -1-Antitrypsin (D):                            |            |          |
| Low vs. Normal  | ns         | ns       |
| High vs. Normal   | NS         | ns       |
| $\alpha$ -2-Macroglobulin (C)                           | ns         | NS       |
| $\alpha$ -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.