Table 11-27. Analysis of Babinski Reflex (Continued)

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,208	11 (0.9)		
Background RH	380	5 (1.3)	1.48 (0.50,4.33)	0.477
Low RH	239	1 (0.4)	0.46 (0.06,3.55)	0.452
High RH	240	1 (0.4)	0.45 (0.06,3.50)	0.444
Low plus High RH	479	2 (0.4)	0.45 (0.10,2.05)	0.303

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,190		
Background RH	375	1.53 (0.45,5.14)	0.496
Low RH	235	0.38 (0.05,3.05)	0.364
High RH	236	0.41 (0.05,3.33)	0.405
Low plus High RH	471	0.40 (0.08,1.85)	0.239

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	5 (1.7)	0.58 (0.32,1.03)	0.056
Medium	287	1 (0.4)		
High	285	1 (0.4)		

[a] Relative risk for a twofold increase in 1987 dioxin.

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

Table 11-27. Analysis of Babinski Reflex (Continued)

(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED		
Analysis Results for Log_2 (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
853	0.65 (0.33,1.29)	0.223

[a] Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for diabetic class because of the sparse number of Ranch Hands with an abnormal Babinski reflex.

11.2.2.4.8 Polyneuropathy Severity Index

The results from the Model 1 unadjusted analysis of the polyneuropathy severity index revealed a significant difference between Ranch Hands and Comparisons in the percentage of participants with a moderate polyneuropathy severity index (Table 11-28(a): Est. RR=2.37, p=0.015). A marginally significant difference between Ranch Hand and Comparison enlisted flyers in the percentage of participants with a moderate polyneuropathy severity index also was observed (Table 11-28(a): Est. RR=4.54, p=0.062). Results were consistent in the adjusted analysis for both contrasts (Table 11-28(b): Adj. RR=2.32, p=0.020 for all occupations combined; Adj.RR=4.13, p=0.083 for enlisted flyers). All other Model 1 contrasts performed were nonsignificant (Table 11-28(a,b): p>0.11 for each remaining Model 1 contrast).

The Model 2 adjusted analysis revealed a significant positive association between a moderate polyneuropathy severity index and initial dioxin (Table 11-28(d): Adj. RR=1.52, p=0.042). All other Model 2 results were nonsignificant (Table 11-28(c,d): p>0.16 for the remaining Model 2 analyses results).

The Model 3 unadjusted analysis of the polyneuropathy severity index displayed several significant associations between categorized dioxin and a moderate polyneuropathy severity index. The contrasts of Ranch Hands in the low, high, and low plus high dioxin categories versus Comparisons each were significant and displayed more Ranch Hands than Comparisons with a moderate polyneuropathy severity index (Table 11-28(e): Est. RR=2.76, p=0.032; Est. RR=2.64, p=0.042; and Est. RR=2.70, p=0.011, respectively). The results remained significant in the adjusted analysis for the contrast of Comparisons with Ranch Hands in the high and the low plus high dioxin categories, and was marginally significant for the contrast of Ranch Hands in the low dioxin category with Comparisons (Table 11-28(f): Adj. RR=3.06, p=0.024; Adj. RR=2.68, p=0.014; and Adj. RR=2.35, p=0.079, respectively). The background Ranch Hand contrast was nonsignificant in both the unadjusted and adjusted analyses (Table 10-28(e): p>0.61 for each contrast).

Table 11-28. Analysis of Polyneuropathy Severity Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED									
			Number (%)			Moderate vs. None/Mild		Severe vs. None/Mild	
Occupational Category	Group	n	None/Mild	Moderate	Severe	Est. Relative Risk (95% C.I.)	p-Value	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***821***	***796 (97.0)***	***21 (2.6)***	***4 (0.5)***	***2.37 (1.18,4.76)***	***0.015***	***5.87 (0.65,52.61)***	***0.114***
	Comparison	***1,182***	***1,168 (98.8)***	***13 (1.1)***	***1 (0.1)***				
Officer	Ranch Hand	322	312 (96.9)	7 (2.2)	3 (0.9)	1.73 (0.58,5.19)	0.330	--	0.130
	Comparison	468	462 (98.7)	6 (1.3)	0 (0.0)				
Enlisted Flyer	Ranch Hand	145	138 (95.2)	7 (4.8)	0 (0.0)	4.54 (0.93,22.20)	0.062	--	--
	Comparison	181	179 (98.9)	2 (1.1)	0 (0.0)				
Enlisted Groundcrew	Ranch Hand	354	346 (97.7)	7 (2.0)	1 (0.3)	2.13 (0.67,6.77)	0.199	1.52 (0.09,24.45)	0.766
	Comparison	533	527 (98.9)	5 (0.9)	1 (0.2)				

[a] P-value determined using a chi-square test with continuity correction because of the sparse number of participants with a severe polyneuropathy severity index.

--: Results not presented because of the sparse number of participants with a severe polyneuropathy severity index.

Table 11-28. Analysis of Polyneuropathy Severity Index (Continued)

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED				
	Moderate vs. None/Mild		Severe vs. None/Mild	
Occupational Category	Adj. Relative Risk (95% C.I.)	p-Value	Adj. Relative Risk (95% C.I.)	p-Value
All	***2.32 (1.14,4.73)***	***0.020***	***5.44 (0.59,50.52)***	***0.136***
Officer	1.72 (0.57,5.24)	0.338	--	--
Enlisted Flyer	4.13 (0.83,20.52)	0.083	--	--
Enlisted Groundcrew	2.16 (0.67,7.01)	0.200	1.64 (0.09,29.24)	0.738

--: Results not presented because of the sparse number of participants with a severe polyneuropathy severity index.

Note: Results are not adjusted for diabetic class because of the sparse number of participants with a moderate or severe polyneuropathy severity index. Results for all occupations combined also are not adjusted for occupation because of the sparse number of participants with a moderate or severe polyneuropathy severity index.

Table 11-28. Analysis of Polyneuropathy Severity Index (Continued)

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED								
	Initial Dioxin Category Summary Statistics Number (%)				Analysis Results for Log_2 (Initial Dioxin)[a]			
					Moderate vs. None/Mild		Severe vs. None/Mild	
Initial Dioxin Category	n	None/Mild	Moderate	Severe	Est. Relative Risk (95% C.I.)[b]	p-Value	Est. Relative Risk (95% C.I.)[b]	p-Value
Low	152	146 (96.1)	4 (2.6)	2 (1.3)	1.29 (0.90,1.87)	0.168	0.68 (0.23,1.98)	0.476
Medium	151	147 (97.4)	4 (2.7)	0 (0.0)				
High	150	143 (95.3)	6 (4.0)	1 (0.7)				

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED				
	Analysis Results for Log_2 (Initial Dioxin)			
	Moderate vs. None/Mild		Severe vs. None/Mild	
n	Adj. Relative Risk (95% C.I.)[a]	p-Value	Adj. Relative Risk (95% C.I.)[a]	p-Value
450	1.52 (1.02,2.28)	0.042	0.87 (0.24,3.20)	0.832

[a] Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for occupation and diabetic class because of the sparse number of Ranch Hands with a moderate or severe polyneuropathy severity index.

Table 11-28. Analysis of Polyneuropathy Severity Index (Continued)

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED								
		Number (%)			Moderate vs. None/Mild		Severe vs. None/Mild	
Dioxin Category	n	None/Mild	Moderate	Severe	Est. Relative Risk (95% C.I.)[a,b]	p-Value	Est. Relative Risk (95% C.I.)[a,b]	p-Value
Comparison	1,146	1,132 (98.8)	13 (1.1)	1 (0.1)				
Background RH	361	355 (98.3)	5 (1.4)	1 (0.3)	1.30 (0.46,3.71)	0.619	3.03 (0.19,49.25)	0.435
Low RH	226	217 (96.0)	7 (3.1)	2 (0.9)	2.76 (1.09,7.02)	0.032	10.54 (0.95,116.83)	0.055
High RH	227	219 (96.5)	7 (3.1)	1 (0.4)	2.64 (1.03,6.73)	0.042	5.41 (0.33,87.73)	0.235
Low plus High RH	453	436 (96.3)	14 (3.1)	3 (0.7)	2.70 (1.26,5.81)	0.011	7.54 (0.75,75.71)	0.086

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-28. Analysis of Polyneuropathy Severity Index (Continued)

(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED					
		Moderate vs. None/Mild		Severe vs. None/Mild	
Dioxin Category	n	Adj. Relative Risk (95% C.I.)[a]	p-Value	Adj. Relative Risk (95% C.I.)[a]	p-Value
Comparison	1,145				
Background RH	358	1.29 (0.45,3.70)	0.641	2.59 (0.15,43.89)	0.511
Low RH	225	2.35 (0.90,6.09)	0.079	7.43 (0.62,89.56)	0.114
High RH	225	3.06 (1.16,8.11)	0.024	9.83 (0.52,186.07)	0.128
Low plus High RH	450	2.68 (1.22,5.90)	0.014	8.55 (0.77,94.34)	0.080

[a] Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for occupation and diabetic class because of the sparse number of participants with a moderate or severe polyneuropathy severity index.

Table 11-28. Analysis of Polyneuropathy Severity Index (Continued)

(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED								
	1987 Dioxin Category Summary Statistics				Analysis Results for Log_2 (1987 Dioxin + 1)			
		Number (%)			Moderate vs. None/Mild		Severe vs. None/Mild	
1987 Dioxin Category	n	None/Mild	Moderate	Severe	Est. Relative Risk (95% C.I.)[a]	p-Value	Est. Relative Risk (95% C.I.)[a]	p-Value
Low	271	267 (98.5)	4 (1.5)	0 (0.0)	1.38 (1.04,1.84)	0.024	1.13 (0.59,2.15)	0.717
Medium	275	266 (96.7)	6 (2.2)	3 (1.1)				
High	268	258 (96.3)	9 (3.4)	1 (0.4)				

[a] 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_2 (1987 Dioxin + 1)				
	Moderate vs. None/Mild			Severe vs. None/Mild	
n	Adj. Relative Risk (95% C.I.)[a]	p-Value		Adj. Relative Risk (95% C.I.)[a]	p-Value
806	1.51 (1.09,2.09)	0.013		1.48 (0.62,3.56)	0.376

[a] Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for occupation and diabetic class because of the sparse number of Ranch Hands with a moderate or severe polyneuropathy severity index.

The Model 3 unadjusted analysis of participants with a severe polyneuropathy severity index showed a marginally significant difference between Ranch Hands in the low dioxin category and Comparisons, and between Ranch Hands in the low plus high dioxin category and Comparisons (Table 11-28(e): Est. RR=10.54, p=0.055 and Est. RR=7.54, p=0.086, respectively). The contrast of Ranch Hands in the low plus high dioxin category remained marginally significant in the adjusted analysis (Table 11-28(f): Adj. RR=8.55, p=0.080). All other Model 3 contrasts of participants with a severe polyneuropathy severity index were nonsignificant (Table 11-28(e,f): p>0.11 for each remaining contrast).

The results from the Model 4 analysis of the polyneuropathy severity index were significant in both the unadjusted and adjusted analyses, showing a positive association between the percentage of Ranch Hands with a moderate polyneuropathy severity index and 1987 dioxin (Table 11-28(g,h): Est. RR=1.38, p=0.024 for the unadjusted analysis; and Adj. RR=1.51, p=0.013 for the adjusted analysis). The association between 1987 dioxin and a severe polyneuropathy severity index was nonsignificant (Table 11-28(g,h): p>0.37 for both the unadjusted and adjusted analyses).

11.2.2.4.9 Polyneuropathy Prevalence Index

All analysis results contrasting Ranch Hands and Comparisons on the polyneuropathy prevalence index in Models 1 and 3 were nonsignificant (Table 11-29(a,b,e,f): p>0.20 for each Model 1 and 3 contrast).

Table 11-29. Analysis of Polyneuropathy Prevalence Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED

Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***821***	***130 (15.8)***	***1.06 (0.83,1.35)***	***0.668***
	Comparison	***1,183***	***179 (15.1)***		
Officer	Ranch Hand	322	55 (17.1)	1.08 (0.74,1.58)	0.694
	Comparison	468	75 (16.0)		
Enlisted Flyer	Ranch Hand	145	29 (20.0)	0.92 (0.53,1.57)	0.752
	Comparison	182	39 (21.4)		
Enlisted Groundcrew	Ranch Hand	354	46 (13.0)	1.08 (0.72,1.61)	0.725
	Comparison	533	65 (12.2)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED

Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***0.99 (0.76,1.28)***	***0.923***
Officer	1.02 (0.68,1.51)	0.941
Enlisted Flyer	0.86 (0.48,1.52)	0.601
Enlisted Groundcrew	1.03 (0.67,1.59)	0.877

Table 11-29. Analysis of Polyneuropathy Prevalence Index (Continued)

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED				
Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	152	23 (15.1)	1.09 (0.91,1.31)	0.344
Medium	151	28 (18.5)		
High	150	29 (19.3)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED			
	Analysis Results for Log_2 (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value	
445	1.30 (1.03,1.65)	0.029	

[a] Relative risk for a twofold increase in initial dioxin.

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,147	175 (15.3)		
Background RH	361	47 (13.0)	0.89 (0.63,1.27)	0.530
Low RH	226	38 (16.8)	1.10 (0.75,1.62)	0.618
High RH	227	42 (18.5)	1.18 (0.81,1.72)	0.376
Low plus High RH	453	80 (17.7)	1.14 (0.85,1.53)	0.370

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-29. Analysis of Polyneuropathy Prevalence Index (Continued)

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

Dioxin Category	n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
Comparison	1,130		
Background RH	356	0.83 (0.57,1.20)	0.315
Low RH	222	0.86 (0.57,1.30)	0.484
High RH	223	1.31 (0.86,1.98)	0.206
Low plus High RH	445	1.06 (0.77,1.46)	0.708

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	271	39 (14.4)	1.09 (0.96,1.24)	0.198
Medium	275	38 (13.8)		
High	268	50 (18.7)		

[a] 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_2 (1987 Dioxin + 1)	
	Adjusted Relative Risk	
n	(95% C.I.)[a]	p-Value
801	1.16 (0.98,1.37)	0.080

[a] Relative risk for a twofold increase in 1987 dioxin.

The Model 2 unadjusted analysis of the polyneuropathy prevalence index was nonsignificant (Table 11-29(c): p=0.344). After adjustment for covariates, the association between the polyneuropathy prevalence index and initial dioxin was positive and significant (Table 11-29(d): Adj. RR=1.30, p=0.029). Similarly, the Model 4 unadjusted analysis was nonsignificant (Table 11-29(g): p=0.198, but the association between the polyneuropathy prevalence index and 1987 dioxin was marginally significant in the adjusted analysis (Table 11-29(h): Adj. RR=1.16, p=0.080).

11.2.2.4.10 Multiple Polyneuropathy Index

The difference in the multiple polyneuropathy index between Ranch Hands and Comparisons was significant and showed more Ranch Hands than Comparisons with an abnormal multiple polyneuropathy

index (Table 11-30(a): Est. RR=1.58, p=0.046). After adjustment for covariates, the difference became marginally significant (Table 11-30(b): Adj. RR=1.51, p=0.092). All other Model 1 contrasts were nonsignificant (Table 11-30(a,b): p>0.15 for all remaining Model 1 contrasts).

Table 11-30. Analysis of Multiple Polyneuropathy Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED

Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***821***	***41 (5.0)***	***1.58 (1.01,2.49)***	***0.046***
	Comparison	***1,183***	***38 (3.2)***		
Officer	Ranch Hand	322	16 (5.0)	1.39 (0.69,2.79)	0.358
	Comparison	468	17 (3.6)		
Enlisted Flyer	Ranch Hand	145	13 (9.0)	1.89 (0.79,4.56)	0.155
	Comparison	182	9 (5.0)		
Enlisted Groundcrew	Ranch Hand	354	12 (3.4)	1.52 (0.68,3.43)	0.309
	Comparison	533	12 (2.3)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED

Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***1.51 (0.94,2.45)***	***0.092***
Officer	1.44 (0.69,2.98)	0.330
Enlisted Flyer	1.77 (0.69,4.56)	0.234
Enlisted Groundcrew	1.43 (0.60,3.39)	0.421

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	152	6 (4.0)	1.30 (0.98,1.73)	0.076
Medium	151	8 (5.3)		
High	150	11 (7.3)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

Table 11-30. Analysis of Multiple Polyneuropathy Index (Continued)

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (Initial Dioxin)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
445	1.85 (1.20,2.87)	0.004

[a] Relative risk for a twofold increase in initial dioxin.

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,147	36 (3.1)		
Background RH	361	14 (3.9)	1.29 (0.68,2.43)	0.432
Low RH	226	10 (4.4)	1.42 (0.69,2.90)	0.340
High RH	227	15 (6.6)	2.12 (1.14,3.95)	0.018
Low plus High RH	453	25 (5.5)	1.73 (1.02,2.94)	0.042

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,130		
Background RH	356	1.37 (0.69,2.72)	0.366
Low RH	222	0.96 (0.44,2.10)	0.914
High RH	223	2.38 (1.18,4.82)	0.016
Low plus High RH	445	1.51 (0.84,2.71)	0.165

[a] Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-30. Analysis of Multiple Polyneuropathy Index (Continued)

(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED				
1987 Dioxin Category Summary Statistics			Analysis Results for Log_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	271	11 (4.1)	1.19 (0.96,1.46)	0.110
Medium	275	10 (3.6)		
High	268	18 (6.7)		

[a] 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_2 (1987 Dioxin + 1)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
801	1.29 (0.95,1.76)	0.101

[a] Relative risk for a twofold increase in 1987 dioxin.

The Model 2 unadjusted analysis displayed a marginally significant positive association between the multiple polyneuropathy index and initial dioxin (Table 11-30(c): Est. RR=1.30, p=0.076). After adjustment for covariates, the association became significant (Table 11-30(d): Adj. RR=1.85, p=0.004).

A significant difference between Ranch Hands in the high dioxin category and Comparisons was found from the Model 3 unadjusted and adjusted analyses of the multiple polyneuropathy index (Table 11-30(e,f): Est. RR=2.12, p=0.018 and Adj. RR=2.38, p=0.016, respectively). The difference was also significant for the unadjusted contrast of Ranch Hands in the low plus high dioxin category with Comparisons (Table 11-30(e): Est. RR=1.73, p=0.042). This contrast was nonsignificant in the adjusted analysis (Table 11-30(f): p=0.165). The other Model 3 contrasts were nonsignificant in both the unadjusted and adjusted analyses as were the results from the analyses of Model 4 (Table 11-30(e–h): p>0.10 for each remaining Model 3 contrast and Model 4 analyses).

11.2.2.4.11 Confirmed Polyneuropathy Indicator

Differences between Ranch Hands and Comparisons were marginally significant for several contrasts from the Model 1 unadjusted analysis of the confirmed polyneuropathy indicator. For all contrasts, Ranch Hands showed a higher percentage of participants with an abnormal confirmed polyneuropathy indicator than did Comparisons. The difference was marginally significant when examined across all occupations (Table 11-31(a): Est. RR=2.30, p=0.082), for enlisted flyers (Table 11-31(a): p=0.079), and for enlisted groundcrew (Table 11-31(a): Est. RR=7.62, p=0.064). After adjustment for covariates, the results were marginally significant for the analysis across all occupations and for enlisted groundcrew (Table 11-31(b): Adj. RR=2.35, p=0.082; and Adj. RR=8.59, p=0.054, respectively). The analysis of the confirmed polyneuropathy indicator was nonsignificant for officers for both the unadjusted and adjusted analyses (Table 11-31(a,b): p=0.381 and p=0.414, respectively).

Table 11-31. Analysis of Confirmed Polyneuropathy Indicator

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED

Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***811***	***11 (1.4)***	***2.30 (0.89,5.95)***	***0.082***
	Comparison	***1,176***	***7 (0.6)***		
Officer	Ranch Hand	318	2 (0.6)	0.49 (0.10,2.43)	0.381
	Comparison	468	6 (1.3)		
Enlisted Flyer	Ranch Hand	142	4 (2.8)	--	0.079[a]
	Comparison	180	0 (0.0)		
Enlisted Groundcrew	Ranch Hand	351	5 (1.4)	7.62 (0.89,65.47)	0.064
	Comparison	528	1 (0.2)		

[a] P-value determined using a chi-square test with continuity correction because of the sparse number of participants with an abnormal confirmed polyneuropathy indicator.
--: Results not presented because of the sparse number of participants with an abnormal confirmed polyneuropathy indicator.

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED

Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***2.35 (0.88,6.22)***	***0.082***
Officer	0.51 (0.10,2.59)	0.414
Enlisted Flyer	--	--
Enlisted Groundcrew	8.59 (0.97,76.27)	0.054

--: Results not presented because of the sparse number of participants with an abnormal confirmed polyneuropathy indicator.

Note: Results are not adjusted for diabetic class because of the sparse number of participants with an abnormal confirmed polyneuropathy indicator.

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	150	2 (1.3)	1.63 (1.05,2.53)	0.033
Medium	150	2 (1.3)		
High	147	5 (3.4)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

Table 11-31. Analysis of Confirmed Polyneuropathy Indicator (Continued)

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (Initial Dioxin)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
444	1.98 (1.19,3.29)	0.008

[a] Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for occupation, industrial chemicals exposure, degreasing chemicals exposure, and diabetic class because of the sparse number of Ranch Hands with an abnormal confirmed polyneuropathy indicator.

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,141	7 (0.6)		
Background RH	358	2 (0.6)	1.06 (0.22,5.16)	0.944
Low RH	224	3 (1.3)	2.08 (0.53,8.17)	0.293
High RH	223	6 (2.7)	3.89 (1.28,11.86)	0.017
Low plus High RH	447	9 (2.0)	2.85 (1.02,7.97)	0.047

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,138		
Background RH	355	0.99 (0.20,4.97)	0.988
Low RH	223	1.56 (0.38,6.40)	0.536
High RH	221	6.04 (1.63,22.42)	0.007
Low plus High RH	444	3.06 (1.02,9.23)	0.047

[a] Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Results are not adjusted for diabetic class because of the sparse number of participants with an abnormal confirmed polyneuropathy indicator.

Table 11-31. Analysis of Confirmed Polyneuropathy Indicator (Continued)

(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED				
1987 Dioxin Category Summary Statistics			Analysis Results for Log_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	270	1 (0.4)	1.80 (1.26,2.58)	0.002
Medium	271	3 (1.1)		
High	264	7 (2.7)		

[a] 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_2 (1987 Dioxin + 1)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
799	2.21 (1.24,3.96)	0.003

[a] Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for diabetic class because of the sparse number of Ranch Hands with an abnormal confirmed polyneuropathy indicator.

Both the unadjusted and adjusted analyses from Model 2 displayed a significant positive association between the confirmed polyneuropathy indicator and initial dioxin (Table 11-31(c,d): Est. RR=1.63, p=0.033, and Adj. RR=1.98, p=0.008).

In the unadjusted Model 3 analysis, significant results were found for the contrast of Ranch Hands in the high dioxin category and Ranch Hands in the low plus high dioxin category with Comparisons. The prevalence of an abnormal confirmed polyneuropathy indicator for Ranch Hands in the high dioxin category was significantly greater than for Comparisons (Table 11-31(e,f): Est. RR=3.89, p=0.017 and Adj. RR=6.04, p=0.007). The contrast of Ranch Hands from the low plus high dioxin category with Comparisons also was significant in both unadjusted and adjusted analyses (Table 11-31(e,f): Est. RR=2.85, p=0.047 and Adj. RR=3.06, p=0.047). All other Model 3 contrasts were nonsignificant (Table 11-31(e,f): p>0.29 for each remaining Model 3 contrast).

Both the unadjusted and adjusted analyses of Model 4 displayed a significant positive association between the confirmed polyneuropathy indicator and the 1987 dioxin levels (Table 11-31(g,h): Est. RR=1.80, p=0.002 and Adj. RR=2.21, p=0.003). As 1987 dioxin increased, the prevalence of an abnormal confirmed polyneuropathy indicator increased.

11.2.2.5 Physical Examination Variables – CNS Coordination Processes

11.2.2.5.1 Tremor

All results from the analyses of tremor from Models 1 through 4 were nonsignificant (Table 11-32(a–h): p>0.19 for each analysis).

Table 11-32. Analysis of Tremor

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED

Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***866***	***60 (6.9)***	***0.95 (0.68,1.33)***	***0.753***
	Comparison	***1,249***	***91 (7.3)***		
Officer	Ranch Hand	340	22 (6.5)	1.11 (0.62,1.96)	0.728
	Comparison	493	29 (5.9)		
Enlisted Flyer	Ranch Hand	151	15 (9.9)	1.26 (0.60,2.68)	0.540
	Comparison	187	15 (8.0)		
Enlisted Groundcrew	Ranch Hand	375	23 (6.1)	0.73 (0.43,1.22)	0.224
	Comparison	569	47 (8.3)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED

Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***0.90 (0.64,1.28)***	***0.564***
Officer	1.06 (0.59,1.89)	0.850
Enlisted Flyer	1.14 (0.53,2.44)	0.734
Enlisted Groundcrew	0.72 (0.42,1.21)	0.212

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	160	11 (6.9)	1.02 (0.77,1.36)	0.869
Medium	162	10 (6.2)		
High	157	9 (5.7)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED

	Analysis Results for Log_2 (Initial Dioxin)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
471	1.02 (0.73,1.44)	0.893

[a] Relative risk for a twofold increase in initial dioxin.

Table 11-32. Analysis of Tremor (Continued)

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

Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,211	90 (7.4)		
Background RH	380	30 (7.9)	1.05 (0.68,1.62)	0.821
Low RH	239	14 (5.9)	0.78 (0.43,1.39)	0.396
High RH	240	16 (6.7)	0.90 (0.52,1.57)	0.713
Low plus High RH	479	30 (6.3)	0.84 (0.55,1.29)	0.417

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,193		
Background RH	375	1.11 (0.71,1.74)	0.659
Low RH	235	0.71 (0.39,1.28)	0.248
High RH	236	0.79 (0.44,1.40)	0.420
Low plus High RH	471	0.75 (0.48,1.16)	0.194

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	23 (8.0)	0.94 (0.79,1.13)	0.527
Medium	287	21 (7.3)		
High	285	16 (5.6)		

[a] Relative risk for a twofold increase in 1987 dioxin.

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

Table 11-32. Analysis of Tremor (Continued)

(h) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (1987 Dioxin + 1)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
846	0.93 (0.75,1.14)	0.478

[a] Relative risk for a twofold increase in 1987 dioxin.

11.2.2.5.2 Coordination

All results from the analyses of coordination from Models 1 through 4 were nonsignificant (Table 11-33(a–h): p>0.11 for each analysis).

Table 11-33. Analysis of Coordination

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED					
Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***866***	***19 (2.2)***	***0.88 (0.49,1.57)***	***0.663***
	Comparison	***1,247***	***31 (2.5)***		
Officer	Ranch Hand	340	10 (2.9)	1.84 (0.72,4.70)	0.205
	Comparison	493	8 (1.6)		
Enlisted Flyer	Ranch Hand	151	1 (0.7)	0.30 (0.03,2.74)	0.288
	Comparison	186	4 (2.2)		
Enlisted Groundcrew	Ranch Hand	375	8 (2.1)	0.63 (0.27,1.45)	0.279
	Comparison	568	19 (3.4)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***0.86 (0.48,1.56)***	***0.622***
Officer	1.65 (0.64,4.26)	0.302
Enlisted Flyer	0.28 (0.03,2.58)	0.263
Enlisted Groundcrew	0.64 (0.27,1.50)	0.305

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED				
Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	160	2 (1.3)	0.90 (0.49,1.65)	0.735
Medium	162	4 (2.5)		
High	157	1 (0.6)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

Table 11-33. Analysis of Coordination (Continued)

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED

Analysis Results for Log_2 (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
471	1.18 (0.62,2.24)	0.632

[a] Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for occupation because of the sparse number of participants with abnormal coordination.

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

Dioxin Category	n	Number (%) Abnormal	Rel. Relative Risk 95% C.I.[a]	p-Value
Comparison	1,209	30 (2.5)		
Background RH	380	12 (3.2)	1.33 (0.67,2.65)	0.412
Low RH	239	4 (1.7)	0.66 (0.23,1.90)	0.443
High RH	240	3 (1.3)	0.48 (0.15,1.59)	0.231
Low plus High RH	479	7 (1.5)	0.56 (0.24,1.30)	0.181

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,191		
Background RH	375	1.46 (0.71,3.01)	0.298
Low RH	235	0.61 (0.21,1.79)	0.371
High RH	236	0.42 (0.12,1.42)	0.161
Low plus High RH	471	0.51 (0.22,1.19)	0.117

[a] Relative risk and confidence interval relative to Comparisons.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-33. Analysis of Coordination (Continued)

(g) MODEL 4: RANCH HANDS – 1987 DIOXIN – UNADJUSTED				
1987 Dioxin Category Summary Statistics			Analysis Results for Log_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	8 (2.8)	0.81 (0.58,1.13)	0.211
Medium	287	7 (2.4)		
High	285	4 (1.4)		

[a] 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_2 (1987 Dioxin + 1)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
846	0.83 (0.57,1.21)	0.330

[a] Relative risk for a twofold increase in 1987 dioxin.

11.2.2.5.3 Romberg Sign

All results from the analyses of Romberg sign from Models 1 through 4 were nonsignificant (Table 11-34(a–h): p>0.12 for each analysis).

Table 11-34. Analysis of Romberg Sign

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED					
Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***866***	***7 (0.8)***	***1.44 (0.50,4.13)***	***0.494***
	Comparison	***1,248***	***7 (0.6)***		
Officer	Ranch Hand	340	5 (1.5)	3.66 (0.71,19.00)	0.122
	Comparison	493	2 (0.4)		
Enlisted Flyer	Ranch Hand	151	0 (0.0)	--	0.999[a]
	Comparison	186	1 (0.5)		
Enlisted Groundcrew	Ranch Hand	375	2 (0.5)	0.76 (0.14,4.16)	0.749
	Comparison	569	4 (0.7)		

[a] P-value determined using a chi-square test with continuity correction because of the sparse number of participants with an abnormal Romberg sign.
--: Results not presented because of the sparse number of participants with an abnormal Romberg sign.

Table 11-34. Analysis of Romberg Sign (Continued)

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED

Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***1.38 (0.47,4.03)***	***0.553***
Officer	3.37 (0.64,17.73)	0.151
Enlisted Flyer	--	--
Enlisted Groundcrew	0.73 (0.13,4.07)	0.719

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	160	0 (0.0)	1.27 (0.48,3.35)	0.638
Medium	162	1 (0.6)		
High	157	1 (0.6)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED

Analysis Results for Log_2 (Initial Dioxin)		
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
476	1.65 (0.61,4.45)	0.350

[a] Relative risk for a twofold increase in initial dioxin.

Note: Results are not adjusted for race, occupation, insecticide exposure, and diabetic class because of the sparse number of participants with an abnormal Romberg sign.

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

Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,210	7 (0.6)		
Background RH	380	5 (1.3)	2.52 (0.78,8.10)	0.121
Low RH	239	1 (0.4)	0.70 (0.09,5.74)	0.741
High RH	240	1 (0.4)	0.66 (0.08,5.43)	0.699
Low plus High RH	479	2 (0.4)	0.68 (0.14,3.31)	0.633

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-34. Analysis of Romberg Sign (Continued)

(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
Comparison	1,192		
Background RH	375	2.54 (0.74,8.72)	0.138
Low RH	235	0.63 (0.08,5.24)	0.667
High RH	236	0.63 (0.07,5.49)	0.672
Low plus High RH	471	0.63 (0.13,3.11)	0.567

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	3 (1.1)	0.88 (0.52,1.50)	0.642
Medium	287	2 (0.7)		
High	285	2 (0.7)		

[a] 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_2 (1987 Dioxin + 1)		
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
846	0.95 (0.52,1.75)	0.862

[a] Relative risk for a twofold increase in 1987 dioxin.

Note: Results are not adjusted for race and occupation because of the sparse number of participants with an abnormal Romberg sign.

11.2.2.5.4 Gait

The adjusted Model 1 analysis of gait displayed a marginally significant increase in the prevalence of an abnormal gait for Ranch Hand enlisted groundcrew relative to Comparison enlisted groundcrew (Table 11-35(b): Adj. RR=1.79, p=0.090). All other results from the analysis of gait for Models 1 through 4 were nonsignificant (Table 11-35(a–h): p>0.11 for all remaining analyses).

Table 11-35. Analysis of Gait

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED					
Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***866***	***50 (5.8)***	***1.28 (0.87,1.89)***	***0.214***
	Comparison	***1,249***	***57 (4.6)***		
Officer	Ranch Hand	340	19 (5.6)	1.06 (0.58,1.95)	0.844
	Comparison	493	26 (5.3)		
Enlisted Flyer	Ranch Hand	151	11 (7.3)	1.26 (0.53,2.98)	0.604
	Comparison	187	11 (5.9)		
Enlisted Groundcrew	Ranch Hand	375	20 (5.3)	1.55 (0.82,2.92)	0.178
	Comparison	569	20 (3.5)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***1.26 (0.83,1.89)***	***0.275***
Officer	1.01 (0.54,1.89)	0.972
Enlisted Flyer	1.05 (0.43,2.59)	0.911
Enlisted Groundcrew	1.79 (0.91,3.49)	0.090

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED				
Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	160	8 (5.0)	1.00 (0.74,1.35)	0.998
Medium	162	11 (6.8)		
High	157	7 (4.5)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (Initial Dioxin)	
	Adjusted Relative Risk	
n	(95% C.I.)[a]	p-Value
471	1.12 (0.79,1.60)	0.530

[a] Relative risk for a twofold increase in initial dioxin.

Table 11-35. Analysis of Gait (Continued)

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,211	55 (4.5)		
Background RH	380	23 (6.1)	1.50 (0.91,2.49)	0.115
Low RH	239	11 (4.6)	0.98 (0.51,1.91)	0.963
High RH	240	15 (6.3)	1.28 (0.71,2.32)	0.414
Low plus High RH	479	26 (5.4)	1.12 (0.69,1.83)	0.640

[a] Relative risk and confidence interval relative to Comparisons.
[b] 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 (95% C.I.)[a]	p-Value
Comparison	1,193		
Background RH	375	1.52 (0.90,2.59)	0.121
Low RH	235	0.77 (0.38,1.57)	0.479
High RH	236	1.44 (0.76,2.74)	0.262
Low plus High RH	471	1.06 (0.63,1.78)	0.832

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	17 (5.9)	1.00 (0.83,1.22)	0.966
Medium	287	15 (5.2)		
High	285	17 (6.0)		

[a] Relative risk for a twofold increase in 1987 dioxin.

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

Table 11-35. Analysis of Gait (Continued)

(b) MODEL 4: RANCH HANDS – 1987 DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (1987 Dioxin + 1)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
846	0.99 (0.78,1.25)	0.905

[a] Relative risk for a twofold increase in 1987 dioxin.

11.2.2.5.5 CNS Index

All results from the analyses of the CNS index from Models 1 through 4 were nonsignificant (Table 11-36(a–h): p>0.10 for each analysis).

Table 11-36. Analysis of CNS Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED					
Occupational Category	Group	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)	p-Value
All	***Ranch Hand***	***866***	***107 (12.4)***	***1.05 (0.80,1.37)***	***0.731***
	Comparison	***1,248***	***148 (11.9)***		
Officer	Ranch Hand	340	39 (11.5)	1.08 (0.69,1.67)	0.745
	Comparison	493	53 (10.8)		
Enlisted Flyer	Ranch Hand	151	24 (15.9)	1.07 (0.59,1.94)	0.816
	Comparison	187	28 (15.0)		
Enlisted Groundcrew	Ranch Hand	375	44 (11.7)	0.99 (0.66,1.49)	0.977
	Comparison	568	67 (11.8)		

(b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED		
Occupational Category	Adjusted Relative Risk (95% C.I.)	p-Value
All	***0.99 (0.75,1.31)***	***0.957***
Officer	1.01 (0.64,1.58)	0.975
Enlisted Flyer	0.92 (0.50,1.70)	0.799
Enlisted Groundcrew	1.01 (0.67,1.54)	0.950

Table 11-36. Analysis of CNS Index (Continued)

(c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED				
Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
Initial Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[b]	p-Value
Low	160	18 (11.3)	1.00 (0.81,1.24)	0.976
Medium	162	21 (13.0)		
High	157	15 (9.6)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin.
[b] Relative risk for a twofold increase in initial dioxin.

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

(d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED		
	Analysis Results for Log_2 (Initial Dioxin)	
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
471	1.03 (0.80,1.33)	0.840

[a] Relative risk for a twofold increase in initial dioxin.

(e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – UNADJUSTED				
Dioxin Category	n	Number (%) Abnormal	Est. Relative Risk (95% C.I.)[ab]	p-Value
Comparison	1,210	146 (12.1)		
Background RH	380	52 (13.7)	1.18 (0.84,1.66)	0.339
Low RH	239	24 (10.0)	0.81 (0.51,1.28)	0.363
High RH	240	30 (12.5)	1.02 (0.67,1.56)	0.923
Low plus High RH	479	54 (11.3)	0.91 (0.65,1.27)	0.576

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin > 10 ppt, Initial Dioxin > 94 ppt.

Table 11-36. Analysis of CNS Index (Continued)

(f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY – ADJUSTED			
Dioxin Category	n	Adjusted Relative Risk (95% C.I.)[a]	p-Value
Comparison	1,192		
Background RH	375	1.24 (0.86,1.77)	0.249
Low RH	235	0.67 (0.42,1.09)	0.105
High RH	236	0.94 (0.60,1.47)	0.789
Low plus High RH	471	0.80 (0.56,1.13)	0.205

[a] 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_2 (1987 Dioxin + 1)	
1987 Dioxin	n	Number (%) Abnormal	Estimated Relative Risk (95% C.I.)[a]	p-Value
Low	287	39 (13.6)	0.97 (0.84,1.12)	0.672
Medium	287	35 (12.2)		
High	285	32 (11.2)		

[a] 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_2 (1987 Dioxin + 1)			
n	Adjusted Relative Risk (95% C.I.)[a]	p-Value	
846	0.94 (0.80,1.10)	0.443	

[a] Relative risk for a twofold increase in 1987 dioxin.

11.2.3 Longitudinal Analysis

Longitudinal analyses were conducted on two indices—the cranial nerve function index and the CNS index—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 1985 or 1997. For both indices, the longitudinal analyses investigated the differences between the 1985 follow-up examination and the 1997 follow-up examination, because Scripps Clinic conducted both of the neurological examinations. A different clinic performed the

neurological examinations for the 1982 baseline study, and the prevalence of abnormalities was much higher for the neurological parameters in 1982, suggesting a different method of examination.

The longitudinal analyses for all of these variables investigated the difference between the 1985 examination and the 1997 examination. These analyses were used to investigate the temporal effects of dioxin during the 12-year period between 1985 and 1997. Participants considered abnormal in 1985 were not included in the analyses because they were already abnormal before this period. Consequently, only participants considered normal at the 1985 examination (i.e., a normal index) were considered to be at risk when the effects of dioxin over this period of time were explored. The rate of abnormalities under this restriction approximates an incidence rate between 1985 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 (44). Summary statistics are provided for reference purposes for the 1987 and 1992 examinations. 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.

11.2.3.1 Physical Examination Variables

11.2.3.1.1 Cranial Nerve Index

The longitudinal analysis of the cranial nerve index was based on participants with a normal index in 1985. All results from the Model 1 analysis indicate no significant difference between Ranch Hands and Comparisons (Table 11-37(a): p>0.61 for each contrast).

Table 11-37. Longitudinal Analysis of Cranial Nerve Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS

Occupational Category	Group	Number (%) Abnormal/(n) Examination			
		1985	1987	1992	1997
All	***Ranch Hand***	***30 (3.7)***	***35 (4.5)***	***39 (5.0)***	***55 (6.9)***
		(802)	***(777)***	***(777)***	***(802)***
	Comparison	***21 (2.0)***	***43 (4.2)***	***31 (3.1)***	***59 (5.6)***
		(1,048)	***(1,018)***	***(1,014)***	***(1,048)***
Officer	Ranch Hand	8 (2.6)	11 (3.6)	13 (4.3)	17 (5.5)
		(308)	(302)	(301)	(308)
	Comparison	7 (1.7)	11 (2.7)	16 (4.0)	23 (5.6)
		(414)	(403)	(404)	(414)
Enlisted Flyer	Ranch Hand	5 (3.4)	7 (4.9)	5 (3.5)	13 (8.9)
		(146)	(143)	(142)	(146)
	Comparison	1 (0.6)	7 (4.7)	3 (2.0)	8 (5.1)
		(156)	(150)	(154)	(156)
Enlisted Groundcrew	Ranch Hand	17 (4.9)	17 (5.1)	21 (6.3)	25 (7.2)
		(348)	(332)	(334)	(348)
	Comparison	13 (2.7)	25 (5.4)	12 (2.6)	28 (5.9)
		(478)	(465)	(456)	(478)

Table 11-37. Longitudinal Analysis of Cranial Nerve Index (Continued)

Occupational Category	Group	Normal in 1985: n in 1997	Normal in 1985: Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[a]	p-Value[a]
All	***Ranch Hand***	***772***	***41 (5.3)***	***1.05 (0.69,1.59)***	***0.836***
	Comparison	***1,027***	***52 (5.1)***		
Officer	Ranch Hand	300	16 (5.3)	1.20 (0.60,2.39)	0.613
	Comparison	407	18 (4.4)		
Enlisted Flyer	Ranch Hand	141	9 (6.4)	1.23 (0.46,3.28)	0.684
	Comparison	155	8 (5.2)		
Enlisted Groundcrew	Ranch Hand	331	16 (4.8)	0.89 (0.47,1.68)	0.710
	Comparison	465	26 (5.6)		

[a] Relative risk, confidence interval, and p-values are in reference to a contrast of 1985 and 1997 results; results adjusted for age in 1997.

Note: Summary statistics for 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal cranial nerve index in 1985 (see Chapter 7, Statistical Methods).

(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN

Initial Dioxin	Number (%) Abnormal/(n) Examination: 1985	1987	1992	1997
Low	3 (2.0)	6 (4.1)	9 (6.3)	13 (8.8)
	(148)	(147)	(142)	(148)
Medium	5 (3.1)	10 (6.5)	4 (2.6)	9 (5.7)
	(159)	(154)	(155)	(159)
High	5 (3.4)	5 (3.6)	9 (6.4)	7 (4.8)
	(146)	(140)	(141)	(146)

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
	Normal in 1985			
Initial Dioxin	n in 1997	Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[b]	p-Value
Low	145	12 (8.3)	0.66 (0.42,1.03)	0.049
Medium	154	5 (3.3)		
High	141	4 (2.8)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.
[b] Relative risk for a twofold increase in initial dioxin.

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

Summary statistics for 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal cranial nerve index in 1985 (see Chapter 7, Statistical Methods).

Table 11-37. Longitudinal Analysis of Cranial Nerve Index (Continued)

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

Dioxin Category	Number (%) Abnormal/(n) Examination			
	1985	1987	1992	1997
Comparison	20 (2.0) (1,019)	43 (4.3) (991)	30 (3.0) (987)	56 (5.5) (1,019)
Background RH	17 (5.0) (343)	14 (4.2) (330)	17 (5.1) (333)	25 (7.3) (343)
Low RH	7 (3.1) (224)	13 (5.9) (220)	12 (5.6) (215)	19 (8.5) (224)
High RH	6 (2.6) (229)	8 (3.6) (221)	10 (4.5) (223)	10 (4.4) (229)
Low plus High RH	13 (2.9) (453)	21 (4.8) (441)	22 (5.0) (438)	29 (6.4) (453)

Dioxin Category	Normal in 1985			
	n in 1997	Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[ab]	p-Value[b]
Comparison	999	50 (5.0)		
Background RH	326	19 (5.8)	1.21 (0.70,2.10)	0.496
Low RH	217	15 (6.9)	1.29 (0.71,2.35)	0.410
High RH	223	6 (2.7)	0.54 (0.23,1.29)	0.167
Low plus High RH	440	21 (4.8)	0.83 (0.47,1.47)	0.522

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin >10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin >10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal cranial nerve index in 1985 (see Chapter 7, Statistical Methods).

The Model 2 longitudinal analysis revealed an inverse significant relation between initial dioxin and the cranial nerve index (Table 11-37(b): Adj. RR=0.66, p=0.049). As initial dioxin increased, the prevalence of an abnormal cranial nerve index decreased.

All results from the Model 3 longitudinal analysis of cranial nerve index were nonsignificant (Table 11-37(c): p>0.16 for each Model 3 contrast).

11.2.3.1.2 CNS Index

Based on participants with a normal CNS index in 1985, all results from the longitudinal analysis of the CNS index for Models 1 through 3 were nonsignificant (Table 11-38(a–c): p>0.20 for each analysis).

Table 11-38. Longitudinal Analysis of CNS Index

(a) MODEL 1: RANCH HANDS VS. COMPARISONS

Occupational Category	Group	Number (%) Abnormal/(n) Examination			
		1985	1987	1992	1997
All	***Ranch Hand***	***29 (3.5)***	***44 (5.5)***	***39 (4.9)***	***105 (12.7)***
		(826)	***(805)***	***(804)***	***(826)***
	Comparison	***27 (2.6)***	***45 (4.4)***	***50 (4.8)***	***128 (12.1)***
		(1,060)	***(1,034)***	***(1,033)***	***(1,060)***
Officer	Ranch Hand	7 (2.2)	10 (3.2)	15 (4.8)	38 (11.8)
		(322)	(316)	(316)	(322)
	Comparison	5 (1.2)	17 (4.2)	24 (5.8)	47 (11.2)
		(420)	(410)	(413)	(420)
Enlisted Flyer	Ranch Hand	7 (4.8)	6 (4.2)	8 (5.6)	24 (16.4)
		(146)	(143)	(144)	(146)
	Comparison	7 (4.4)	5 (3.2)	2 (1.3)	21 (13.2)
		(159)	(155)	(157)	(159)
Enlisted Groundcrew	Ranch Hand	15 (4.2)	28 (8.1)	16 (4.7)	43 (12.0)
		(358)	(346)	(344)	(358)
	Comparison	15 (3.1)	23 (4.9)	24 (5.2)	60 (12.5)
		(481)	(469)	(463)	(481)

Occupational Category	Group	Normal in 1985			
		n in 1997	Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[a]	p-Value[a]
All	***Ranch Hand***	***797***	***90 (11.3)***	***1.05 (0.78,1.42)***	***0.725***
	Comparison	***1,033***	***111 (10.8)***		
Officer	Ranch Hand	315	34 (10.8)	0.99 (0.61,1.59)	0.955
	Comparison	415	45 (10.8)		
Enlisted Flyer	Ranch Hand	139	21 (15.1)	1.59 (0.78,3.24)	0.201
	Comparison	152	15 (9.9)		
Enlisted Groundcrew	Ranch Hand	343	35 (10.2)	0.95 (0.60,1.51)	0.835
	Comparison	466	51 (10.9)		

[a] 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 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal CNS index in 1985 (see Chapter 7, Statistical Methods).

Table 11-38. Longitudinal Analysis of CNS Index (Continued)

(b) MODEL 2: RANCH HANDS – INITIAL DIOXIN

Initial Dioxin	Number (%) Abnormal/(n) Examination			
	1985	1987	1992	1997
Low	7 (4.6) (153)	4 (2.6) (153)	6 (4.1) (148)	18 (11.8) (153)
Medium	4 (2.5) (159)	8 (5.1) (156)	8 (5.2) (155)	21 (13.2) (159)
High	4 (2.7) (151)	10 (6.8) (147)	4 (2.7) (147)	15 (9.9) (151)

Initial Dioxin Category Summary Statistics			Analysis Results for Log_2 (Initial Dioxin)[a]	
	Normal in 1985			
Initial Dioxin	n in 1997	Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[b]	p-Value
Low	146	15 (10.3)	1.13 (0.89,1.42)	0.319
Medium	155	20 (12.9)		
High	147	14 (9.5)		

[a] Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.
[b] Relative risk for a twofold increase in initial dioxin.

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

Summary statistics for 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal CNS index in 1985 (see Chapter 7, Statistical Methods).

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

Dioxin Category	Number (%) Abnormal/(n) Examination			
	1985	1987	1992	1997
Comparison	26 (2.5) (1,031)	44 (4.4) (1,007)	49 (4.9) (1,006)	126 (12.2) (1,031)
Background RH	14 (3.9) (357)	21 (6.1) (343)	20 (5.8) (348)	50 (14.0) (357)
Low RH	7 (3.1) (229)	6 (2.6) (227)	9 (4.1) (221)	24 (10.5) (229)
High RH	8 (3.4) (234)	16 (7.0) (229)	9 (3.9) (229)	30 (12.8) (234)
Low plus High RH	15 (3.2) (463)	22 (4.8) (456)	18 (4.0) (450)	54 (11.7) (463)

Table 11-38. Longitudinal Analysis of CNS Index (Continued)

Dioxin Category	Normal in 1985: n in 1997	Normal in 1985: Number (%) Abnormal in 1997	Adj. Relative Risk (95% C.I.)[ab]	p-Value[b]
Comparison	1,005	110 (11.0)		
Background RH	343	40 (11.7)	1.07 (0.72,1.58)	0.749
Low RH	222	21 (9.5)	0.76 (0.46,1.25)	0.279
High RH	226	28 (12.4)	1.31 (0.83,2.06)	0.244
Low plus High RH	448	49 (10.9)	1.00 (0.69,1.44)	0.999

[a] Relative risk and confidence interval relative to Comparisons.
[b] Adjusted for percent body fat at the time of the blood measurement of dioxin and age in 1997.

Note: RH = Ranch Hand.
Comparison: 1987 Dioxin ≤ 10 ppt.
Background (Ranch Hand): 1987 Dioxin ≤ 10 ppt.
Low (Ranch Hand): 1987 Dioxin >10 ppt, 10 ppt < Initial Dioxin ≤ 94 ppt.
High (Ranch Hand): 1987 Dioxin >10 ppt, Initial Dioxin > 94 ppt.

Summary statistics for 1987 are provided for reference purposes for participants who attended the 1985, 1987, and 1997 examinations. Summary statistics for 1992 are provided for reference purposes for participants who attended the 1985, 1992, and 1997 examinations. Statistical analyses are based only on participants with a normal CNS index in 1985 (see Chapter 7, Statistical Methods).

11.3 DISCUSSION

The data analyzed in the neurological assessment can be relied upon to detect the presence, if not the cause, of neurological disease, including disorders of the peripheral nervous system. CNS, cranial, and peripheral nerve variables examined can provide specific clues to the anatomical site of neurological lesions and clarify the need for additional diagnostic studies. Pertinent to the current study, the neurological examination is highly sensitive in detecting the presence of peripheral neuropathy, a suspected clinical condition related to herbicide exposure.

In clinical practice, it is convenient to divide the neurological assessment into examinations of the peripheral and cranial nerves. The motor and sensory peripheral nerve variables and the cranial nerve variables examined provide highly specific clues to the anatomic site of neurological lesions and clarify which additional diagnostic studies would be most helpful in establishing a diagnosis. As indices of CNS function, tremor and coordination are less specific and more subject to individual variation in the absence of underlying neurological disease. Tremor, for example, may occur as a benign familial trait, may be reflective of alcohol withdrawal, or may be a marker of extra-pyramidal motor system disease as in Parkinson's syndrome. The Romberg sign may signal a lesion in the cerebellum but is more often indicative of impaired position sense in the lower extremities or of inner ear disease. Finally, the mental status examination is of obvious importance in the CNS assessment and, as in previous AFHS examinations, extensive psychometric studies were conducted and are reported in Chapter 12, Psychology Assessment.

Analysis of inflammatory diseases confirmed by a medical records review found a significant excess among Ranch Hands (n=7 or 0.8%) relative to Comparisons (n=1 or 0.1%). Of the seven Ranch Hands with inflammatory diseases, three (42.9%) had meningitis caused by bacterial infections. The single Comparison with an inflammatory disease had encephalitis of unknown cause, suggesting that this

finding is unrelated to herbicide or dioxin exposure. Consistent with the 1987 and 1992 examinations, Ranch Hands with low and high levels of categorized dioxin were more likely than Comparisons to develop other neurological disorders, although the associations were not significant after adjustment for covariates. Similar results were noted with respect to 1987 serum dioxin levels. Although the prevalence of peripheral neurological disorders established by a medical records review was similar in Ranch Hands and Comparisons (21.8% and 19.3%, respectively), there was evidence for an association with dioxin levels in two of the models. Ranch Hands in the low plus high dioxin category were at significantly greater risk than Comparisons (25.1% versus 19.3%, respectively), a contrast that remained marginally significant after adjustment for covariates. Further, in both the unadjusted and adjusted analyses, a significant positive association was noted between the occurrence of peripheral disorders and 1987 dioxin levels.

With one exception, no significant associations were noted in the analyses of any of the directly measured physical examination variables. Ranch Hands were significantly more likely than Comparisons to develop restricted range of motion at the neck, a common occurrence in any aging population and one that is usually related to osteoarthritis of the cervical spine rather than any primary neurological cause. Across occupational strata, the contrast was significant only in the enlisted flyer category. Ranch Hands with low and high levels of categorized dioxin were at significantly greater risk for the development of restricted neck range of motion.

Only one of the analyses of peripheral motor and sensory nerve function yielded significant group differences. By inspection and palpation, Ranch Hands were more likely than Comparisons to have abnormalities of muscle mass (4.5% versus 3.0%, respectively) particularly in the enlisted groundcrew occupational category (4.3% versus 2.1%), even after adjustment for covariates. In none of the individual analyses was there any significant associations with 1987 serum dioxin levels, nor were any group differences detected in the analyses of CNS coordination variables.

Significant group differences were found in three of the four composite polyneuropathy indices described earlier in this chapter. Ranch Hands were significantly more likely than Comparisons to have abnormalities in the confirmed polyneuropathy index (1.4% versus 0.6%), the polyneuropathy severity index of moderate degree (2.6% versus 1.1%), and the multiple polyneuropathy index (5.0% versus 3.2%). In each case, Ranch Hands in the high dioxin category were at a significantly greater risk for abnormal scores than Comparisons; the prevalence of abnormalities increased as initial dioxin increased.

Longitudinal analyses conducted during 12 years of observation yielded no significant differences between the Ranch Hand and Comparison cohorts, nor was there any evidence for dose responses with respect to either initial or 1987 dioxin levels.

Dependent variable-covariate analyses confirmed associations with age and diabetes that are well established. Diabetes was by far the strongest covariate and significantly associated with neurological disease historically, on physical examination, and as assessed by all of the composite indices. Associations with alcohol were sporadic and less prominent than during previous AFHS examinations.

In summary, in contrast to previous examinations, the history of neurological disease now appears significantly greater in Ranch Hands than Comparisons historically (diseases of inflammatory origin and peripheral disorders), on physical examination (restriction of range of motion), and as reflected in several of the composite indices described above. Further, the associations of neck range of motion with categorized dioxin and a history of peripheral disorders with 1987 dioxin provide evidence of an

association of neurological disease with prior exposure to dioxin. The results of the analysis of the polyneuropathy indices also provide support of an association between dioxin and neurological disease.

11.4 SUMMARY

Four neurological disorders, which were verified by a medical records review, and extensive physical examination data on cranial nerve function, peripheral nerve status, and CNS coordination processes were analyzed in the neurological assessment. Each endpoint was examined for a significant association, both unadjusted and adjusted for covariates, with group (Model 1), initial dioxin (Model 2), categorized dioxin (Model 3), and 1987 dioxin levels (Model 4). Summaries of the Model 1 through 4 analyses are tabled and discussed below, with emphasis on significant findings from the adjusted analysis.

11.4.1 Model 1: Group Analysis

The prevalence of inflammatory diseases, a restricted neck range of motion, and a moderate polyneuropathy severity index was significantly greater for Ranch Hands than for Comparisons when combining all occupations. Significantly more Comparisons than Ranch Hands had an abnormal light reaction. Other neurological disorders, the multiple polyneuropathy index, the confirmed polyneuropathy index, and muscle status showed a marginally significant increase in all Ranch Hands relative to Comparisons. No significant differences were observed between Ranch Hand and Comparison officers. The neck range of motion and moderate polyneuropathy severity index results were significant or marginally significant in the contrast of Ranch Hand and Comparison enlisted flyers. The confirmed polyneuropathy indicator and muscle status results were significant or marginally significant in the enlisted groundcrew. Table 11-39 displays the Model 1 results of all unadjusted and adjusted analyses.

Table 11-39. Summary of Group Analysis (Model 1) for Neurology Variables (Ranch Hands vs. Comparisons)

	UNADJUSTED			
Variable	All	Officer	Enlisted Flyer	Enlisted Groundcrew
Medical Records				
Inflammatory Diseases	+0.006	NS	NS	NS
Hereditary and Degenerative Diseases	NS	NS	NS	ns
Peripheral Disorders	NS	NS	NS	NS
Other Neurological Disorders	NS*	NS	NS	NS
Physical Examination				
Smell	NS	ns	NS*	NS
Visual Fields	ns	ns	ns	ns
Light Reaction	-0.007	ns	ns	ns
Ocular Movement	NS	ns	NS	NS
Facial Sensation	NS	NS	ns	NS
Jaw Clench	NS	NS	--	--
Smile	NS	ns	NS	NS
Palpebral Fissure	ns	ns	NS	NS
Balance	NS	NS	ns	ns
Speech	ns	ns	ns	ns
Tongue Position Relative to Midline	NS	NS	--	--
Palate and Uvula Movement	NS	NS	--	--

Table 11-39. Summary of Group Analysis (Model 1) for Neurology Variables (Ranch Hands vs. Comparisons) (Continued)

Variable	UNADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
Cranial Nerve Index	NS	ns	NS	NS
Neck Range of Motion	+0.016	NS	+0.009	NS
Pinprick	NS	NS	NS	ns
Light Touch	NS	NS	NS	ns
Muscle Status	NS*	NS	NS	NS*
Patellar Reflex	ns	NS	ns*	NS
Achilles Reflex	NS	NS	NS	NS
Biceps Reflex	NS	NS	NS	NS
Babinski Reflex	ns	NS	ns	ns
Polyneuropathy Severity Index				
Moderate vs. None/Mild	+0.015	NS	NS*	NS
Severe vs. None/Mild	NS	NS	--	NS
Polyneuropathy Prevalence Index	NS	NS	ns	NS
Multiple Polyneuropathy Index	+0.046	NS	NS	NS
Confirmed Polyneuropathy Indicator	NS*	ns	NS*	NS*
Tremor	ns	NS	NS	ns
Coordination	ns	NS	ns	ns
Romberg Sign	NS	NS	ns	ns
Gait	NS	NS	NS	NS
CNS Index	NS	NS	NS	ns

Note: NS or ns: Not significant ($p>0.10$).
NS* or ns*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥1.00.
-: Relative risk <1.00.
--: Analysis not performed because of the sparse number of participants with an abnormality.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

Variable	ADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
Medical Records				
Inflammatory Diseases	+0.002	--	--	NS
Hereditary and Degenerative Diseases	NS	NS	NS	ns
Peripheral Disorders	NS	NS	ns	NS
Other Neurological Disorders	NS*	NS	NS	NS
Physical Examination				
Smell	NS	ns	NS	NS
Visual Fields	ns	--	ns	ns
Light Reaction	-0.010	--	ns	--
Ocular Movement	NS	ns	NS	NS
Facial Sensation	NS	NS	--	--
Jaw Clench	--	--	--	--
Smile	NS	ns	--	NS
Palpebral Fissure	ns	ns	ns	ns

Table 11-39. Summary of Group Analysis (Model 1) for Neurology Variables (Ranch Hands vs. Comparisons) (Continued)

Variable	ADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
Balance	NS	NS	--	ns
Speech	ns	ns	--	ns
Tongue Position Relative to Midline	--	--	--	--
Palate and Uvula Movement	--	--	--	--
Cranial Nerve Index	NS	ns	NS	NS
Neck Range of Motion	+0.015	NS	+0.016	NS
Pinprick	NS	NS	NS	ns
Light Touch	NS	NS	NS	ns
Muscle Status	NS*	ns	NS	+0.046
Patellar Reflex	ns	NS	ns*	NS
Achilles Reflex	NS	NS	ns	NS
Biceps Reflex	NS	NS	NS	NS
Babinski Reflex	ns	NS	ns	ns
Polyneuropathy Severity Index				
Moderate vs. None/Mild	+0.020	NS	NS*	NS
Severe vs. None/Mild	NS	--	--	NS
Polyneuropathy Prevalence Index	ns	NS	ns	NS
Multiple Polyneuropathy Index	NS*	NS	NS	NS
Confirmed Polyneuropathy Indicator	NS*	ns	--	NS*
Tremor	ns	NS	NS	ns
Coordination	ns	NS	ns	ns
Romberg Sign	NS	NS	--	ns
Gait	NS	NS	NS	NS*
CNS Index	ns	NS	ns	NS

Note: NS or ns: Not significant ($p>0.10$).
NS* or ns*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥ 1.00.
-: Relative risk <1.00.
--: Analysis not performed because of the sparse number of participants with an abnormality.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

11.4.2 Model 2: Initial Dioxin Analysis

Table 11-40 summarizes the results from the Model 2 analyses. Several positive and significant associations between the neurological variables and initial dioxin were found in adjusted analyses. In assessing the cranial nerve function, abnormal visual fields increased as initial dioxin increased. The assessment of measures of peripheral nerve status showed a significant or marginally significant positive association between initial dioxin and the patellar and Achilles reflexes. An association between all four polyneuropathy indices and dioxin was observed. The moderate classification of the polyneuropathy severity index, the polyneuropathy prevalence index, the multiple polyneuropathy index, and the confirmed polyneuropathy indicator were all significant and positively associated with initial dioxin.

Table 11-40. Summary of Initial Dioxin Analysis (Model 2) for Neurology Variables (Ranch Hands Only)

Variable	Unadjusted	Adjusted
Medical Records		
Inflammatory Diseases	NS	ns
Hereditary and Degenerative Diseases	NS	NS
Peripheral Disorders	NS	NS
Other Neurological Disorders	NS	ns
Physical Examination		
Smell	ns	ns
Visual Fields	+0.040	+0.049
Light Reaction	--	--
Ocular Movement	ns	ns
Facial Sensation	ns	ns
Jaw Clench	ns	ns
Smile	NS	NS
Palpebral Fissure	NS	NS
Balance	NS	NS
Speech	ns	ns*
Tongue Position Relative to Midline	ns	ns
Palate and Uvula Movement	ns	ns
Cranial Nerve Index	ns	ns
Neck Range of Motion	ns*	ns
Pinprick	NS	NS
Light Touch	ns	NS
Muscle Status	ns	ns
Patellar Reflex	NS	+0.019
Achilles Reflex	NS	NS*
Biceps Reflex	ns	ns
Babinski Reflex	ns	NS
Polyneuropathy Severity Index		
Moderate vs. None/Mild	NS	+0.042
Severe vs. None/Mild	ns	ns
Polyneuropathy Prevalence Index	NS	+0.029
Multiple Polyneuropathy Index	NS*	+0.004
Confirmed Polyneuropathy Indicator	+0.033	+0.008
Tremor	NS	NS
Coordination	ns	NS
Romberg Sign	NS	NS
Gait	NS	NS
CNS Index	NS	NS

Note: NS or ns: Not significant ($p>0.10$).
NS* or ns*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥ 1.00.
--: Analysis not performed because of the sparse number of participants with an abnormality.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

11.4.3 Model 3: Categorized Dioxin Analysis

Results from the Model 3 analyses of the neurology variables are presented in Table 11-41. Each significant or marginally significant result from the Model 3 adjusted analyses displayed more Ranch Hands than Comparisons with a neurological abnormality. The adjusted analysis of inflammatory diseases displayed significant results for all levels of categorized dioxin. Results for peripheral disorders showed a marginally significant increased prevalence in the low plus high Ranch Hand dioxin category after adjustment for covariates. Neck range of motion was significantly greater for Ranch Hands in the low, high, and low plus high dioxin categories than for Comparisons. An increased prevalence of an abnormal muscle status was observed in the low and low plus high Ranch Hand dioxin categories. A marginally significant increase in an abnormal biceps reflex also was found for Ranch Hands in the low dioxin category. The polyneuropathy severity index showed an increase in the moderate classification of severity for Ranch Hands in the low, high, and low plus high dioxin categories. An increase in the severe classification of the polyneuropathy index was found for Ranch Hands in the low plus high dioxin category. Significant results also were found for Ranch Hands in the high dioxin category for the multiple polyneuropathy index and the confirmed polyneuropathy indicator. The prevalence of an abnormal confirmed polyneuropathy indicator was significantly greater for the low plus high Ranch Hand dioxin category than for Comparisons.

Table 11-41. Summary of Categorized Dioxin Analysis (Model 3) for Neurology Variables (Ranch Hands vs. Comparisons)

	UNADJUSTED			
Variable	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Medical Records				
Inflammatory Diseases	NS*	NS*	NS*	+0.035
Hereditary and Degenerative Diseases	NS	NS	NS	NS
Peripheral Disorders	ns	+0.033	NS*	+0.014
Other Neurological Disorders	ns	+0.023	+0.005	+0.001
Physical Examination				
Smell	NS	NS	NS	NS
Visual Fields	ns	ns	ns	ns
Light Reaction	ns	ns	ns	ns*
Ocular Movement	ns	NS	NS	NS
Facial Sensation	NS	NS	ns	NS
Jaw Clench	NS	NS	--	NS
Smile	NS	NS	NS	NS
Palpebral Fissure	NS	ns	ns	ns
Balance	NS	ns	ns	ns
Speech	ns	NS	ns	ns
Tongue Position Relative to Midline	NS	NS	--	NS
Palate and Uvula Movement	--	NS	--	NS
Cranial Nerve Index	NS	NS	ns	NS
Neck Range of Motion	NS	+0.002	NS	+0.003
Pinprick	NS	NS	NS*	NS
Light Touch	NS	NS	NS	NS
Muscle Status	NS	+0.021	NS	+0.033
Patellar Reflex	ns	NS	NS	NS
Achilles Reflex	ns	NS	NS	NS
Biceps Reflex	ns	+0.029	NS	NS

Table 11-41. Summary of Categorized Dioxin Analysis (Model 3) for Neurology Variables (Ranch Hands vs. Comparisons) (Continued)

Variable	UNADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Babinski Reflex	NS	ns	ns	ns
Polyneuropathy Severity Index				
Moderate vs. None/Mild	NS	+0.032	+0.042	+0.011
Severe vs. None/Mild	NS	NS*	NS	NS*
Polyneuropathy Prevalence Index	ns	NS	NS	NS
Multiple Polyneuropathy Index	NS	NS	+0.018	+0.042
Confirmed Polyneuropathy Indicator	NS	NS	+0.017	+0.047
Tremor	NS	ns	ns	ns
Coordination	NS	ns	ns	ns
Romberg Sign	NS	ns	ns	ns
Gait	NS	ns	NS	NS
CNS Index	NS	ns	NS	ns

Note: NS or ns: Not significant ($p>0.10$).
NS* or ns*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥1.00.
--: Analysis not performed because of the sparse number of participants with an abnormality.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Medical Records				
Inflammatory Diseases	+0.029	+0.035	+0.047	+0.024
Hereditary and Degenerative Diseases	NS	ns	NS	ns
Peripheral Disorders	ns	NS	NS	NS*
Other Neurological Disorders	NS	NS	NS	NS
Physical Examination				
Smell	NS	NS	ns	NS
Visual Fields	ns	--	ns	--
Light Reaction	ns	--	--	--
Ocular Movement	NS	NS	NS	NS
Facial Sensation	NS	NS	--	--
Jaw Clench	--	--	--	--
Smile	NS	NS	NS	NS
Palpebral Fissure	ns	ns	ns	ns
Balance	NS	ns	ns	ns
Speech	NS	NS	--	--
Tongue Position Relative to Midline	--	--	--	--
Palate and Uvula Movement	--	--	--	--

Table 11-41. Summary of Categorized Dioxin Analysis (Model 3) for Neurology Variables (Ranch Hands vs. Comparisons) (Continued)

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
Cranial Nerve Index	NS	NS	ns	ns
Neck Range of Motion	NS	+0.010	+0.028	+0.002
Pinprick	NS	ns	NS	NS
Light Touch	NS	NS	NS	NS
Muscle Status	NS	NS*	NS	NS*
Patellar Reflex	ns	ns	NS	NS
Achilles Reflex	ns	ns	NS	NS
Biceps Reflex	ns	NS*	NS	NS
Babinski Reflex	NS	ns	ns	ns
Polyneuropathy Severity Index				
Moderate vs. None/Mild	NS	NS*	+0.024	+0.014
Severe vs. None/Mild	NS	NS	NS	NS*
Polyneuropathy Prevalence Index	ns	ns	NS	NS
Multiple Polyneuropathy Index	NS	ns	+0.016	NS
Confirmed Polyneuropathy Indicator	ns	NS	+0.007	+0.047
Tremor	NS	ns	ns	ns
Coordination	NS	ns	ns	ns
Romberg Sign	NS	ns	ns	ns
Gait	NS	ns	NS	NS
CNS Index	NS	ns	ns	ns

Note: NS or ns: Not significant ($p>0.10$).
NS*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥ 1.00.
--: Analysis not performed because of the sparse number of participants with an abnormality.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

11.4.4 Model 4: 1987 Dioxin Analysis

Significant positive associations were found between 1987 dioxin and peripheral disorders, the moderate classification of the polyneuropathy severity index, and the confirmed polyneuropathy indicator. A marginally significant positive association between the polyneuropathy prevalence index and 1987 dioxin was found. Complete Model 4 analysis results are presented in Table 11-42.

Table 11-42. Summary of 1987 Dioxin Analysis (Model 4) for Neurology Variables (Ranch Hands Only)

Variable	Unadjusted	Adjusted
Medical Records		
Inflammatory Diseases	ns	ns
Hereditary and Degenerative Diseases	ns	ns
Peripheral Disorders	+0.010	+0.011
Other Neurological Disorders	+0.038	ns
Physical Examination		
Smell	ns	ns
Visual Fields	NS	NS
Light Reaction	ns	ns
Ocular Movement	NS	ns
Facial Sensation	ns	ns
Jaw Clench	ns	NS
Smile	NS	ns
Palpebral Fissure	NS	NS
Balance	ns	ns
Speech	ns	ns
Tongue Position Relative to Midline	ns	NS
Palate and Uvula Movement	NS	NS
Cranial Nerve Index	ns	ns
Neck Range of Motion	NS	NS
Pinprick	NS	NS
Light Touch	NS	NS
Muscle Status	NS	ns
Patellar Reflex	NS	NS
Achilles Reflex	NS	NS
Biceps Reflex	NS	NS
Babinski Reflex	ns*	ns
Polyneuropathy Severity Index		
Moderate vs. None/Mild	+0.024	+0.013
Severe vs. None/Mild	NS	NS
Polyneuropathy Prevalence Index	NS	NS*
Multiple Polyneuropathy Index	NS	NS
Confirmed Polyneuropathy Indicator	+0.002	+0.003
Tremor	ns	ns
Coordination	ns	ns
Romberg Sign	ns	ns
Gait	NS	ns
CNS Index	ns	ns

Table 11-42. Summary of 1987 Dioxin Analysis (Model 4) for Neurology Variables (Ranch Hands Only) (Continued)

Note: NS or ns: Not significant ($p>0.10$).
NS* or ns*: Marginally significant ($0.05<p\leq0.10$).
+: Relative risk ≥ 1.00.

P-value given if $p\leq0.05$.

A capital "NS" denotes a relative risk of 1.00 or greater. A lowercase "ns" denotes a relative risk less than 1.00.

11.5 CONCLUSION

Four neurological disorders and extensive physical examination data on cranial nerve function, peripheral nerve status, and CNS coordination processes were analyzed in the neurological assessment. Inflammatory diseases verified by a medical records review found a significant excess among Ranch Hands (n=7) relative to Comparisons (n=1); however, three of the seven Ranch Hand diseases were caused by bacterial infections, suggesting that this finding is unrelated to herbicide or dioxin exposure. Peripheral disorders, as verified by a medical records review, increased in Ranch Hands as levels of 1987 dioxin increased. Neck range of motion abnormalities were increased in Ranch Hands relative to Comparisons in terms of both a group designation and categorized dioxin levels. The increase in abnormalities for Ranch Hands relative to Comparisons was noted in enlisted flyers. An increase in the risk of an abnormal muscle status was observed in Ranch Hand enlisted groundcrew. A significant association between initial dioxin and both visual field and patellar reflex abnormalities was observed. Indices of polyneuropathy showed an increase in the prevalence of abnormality in Ranch Hands relative to Comparisons and a positive association with initial and 1987 dioxin levels. The clinical importance of the increased risk of polyneuropathy is uncertain due to the small number of affected veterans.

In summary, although a common etiology in these findings is not apparent, a statistically significant increase in neurological disease appears in Ranch Hands historically, on physical examination, and as reflected in several of the composite polyneuropathy indices. Further, the associations of neck range of motion abnormalities with categorized dioxin and a history of peripheral disorders with 1987 dioxin provide evidence of an association of neurological disease with elevated dioxin levels. The results of the analysis of the polyneuropathy indices also provide support of an association between elevated dioxin levels and neurological disease; however, the clinical importance of this finding is uncertain.

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