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8 COVARIATE ASSOCIATIONS WITH ESTIMATES OF DIOXIN EXPOSURE

8.1 INTRODUCTION

The associations between the covariates used throughout this report and four estimates of dioxin exposure are evaluated in this chapter. The purpose of studying these associations was to determine if these covariates, which have been determined to be associated with one or more of the health endpoints considered in this study, were associated with an estimate of dioxin exposure, and, therefore, could potentially be confounding variables in subsequent statistical analyses in this report. These covariates and estimates of dioxin exposure are used extensively in the statistical analyses in Chapters 9 through 18. Specific definitions of the covariates are contained in these chapters. The results contained in this chapter are associations and should not be interpreted as indicating causal relations between the estimates of dioxin exposure and covariate levels.

In previous reports, the relations between the covariate and the estimates of dioxin exposure were not adjusted for other covariates, but some of the relations may have been confounded with military occupation. In this report, the unadjusted relations between dioxin exposure and all covariates were evaluated, as well as the relations when military occupation was considered. Consequently, for each association between a covariate and either group or dioxin, analyses unadjusted and adjusted for military occupation were performed.

Four models were examined for each covariate. Additional details regarding dioxin measurements are given in Chapter 2, Dioxin Assay, and Chapter 7, Statistical Methods. Model 1 examined the relation of an individual covariate with group (Ranch Hand or Comparison). In this model, exposure was defined as “yes” for Ranch Hands and “no” for Comparisons without regard to the magnitude of the exposure. Model 2 explored the relation between the covariate and an extrapolated initial dioxin measure for Ranch Hands who had a 1987 dioxin measurement greater than 10 parts per trillion (ppt). If a participant did not have a 1987 dioxin level, the 1992 level was used to estimate the initial dioxin level. If a participant did not have a 1987 or a 1992 dioxin level, the 1997 level was used to estimate the initial dioxin level.

Model 3 divided the Ranch Hands examined in Model 2 into two categories based on their initial dioxin measures. These two categories are referred to in the tables as “Low Ranch Hand” if the initial dioxin level was greater than 10 ppt and less than or equal to 94 ppt and “High Ranch Hand” if the initial dioxin level was greater than 94 ppt. Two additional categories, Ranch Hands with 1987 serum dioxin levels at or below 10 ppt and Comparisons with 1987 serum dioxin levels at or below 10 ppt, were created. Ranch Hands with 1987 serum dioxin levels at or below 10 ppt are referred to in the tables as the “Background Ranch Hand” category. Dioxin levels in 1992 were used if the 1987 level was not available, and dioxin levels in 1997 were used if the 1987 and 1992 levels were not available. Comparisons with 1987 dioxin levels greater than 10 ppt were excluded. Covariate means or covariate category percentages in the three Ranch Hand categories and the Comparison category were contrasted.

Model 4 examined the relation between the covariate and 1987 dioxin levels in all Ranch Hands with a dioxin measurement. If a participant did not have a 1987 dioxin measurement, the 1992 measurement was used in determining the dioxin level. If a participant did not have a 1987 or a 1992 dioxin measurement, the 1997 measurement was used in determining the dioxin level.

The summary statistics listed in the tables in this chapter are percentages, correlation coefficients (r), or means. For Models 1 and 3, if a covariate is discrete, the percentage of participants in each of the Ranch

Hand or Comparison categories is shown for each of the covariate categories. If a covariate is continuous, the mean of the covariate is given for each Ranch Hand and Comparison category. Because the measure of dioxin is continuous for the analyses of Models 2 and 4, if a covariate is also continuous, a correlation coefficient between initial dioxin and the covariate is provided. If a covariate is discrete, dioxin means for each of the covariate categories are displayed. Consistent with the methodology used in each of the clinical chapters, the means presented in the tables were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2, and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

8.2 MATCHING DEMOGRAPHIC VARIABLES (AGE, RACE, AND MILITARY OCCUPATION)

Age, race, and military occupation were used in the design of the Air Force Health Study to match Ranch Hand participants with Comparisons to reduce the association between these variables and group status. It was impossible, however, to eliminate the possible confounding effect of these variables with serum dioxin in Models 2 through 4 through study design. Results of tests of association between age, race, and military occupation and the four estimates of dioxin exposure are given in Table 8-1.

Examining the association between age and dioxin revealed significant relations in the unadjusted analyses of Models 2, 3, and 4 for age in its continuous form (p<0.001 for each model). After adjusting for military occupation, however, the association was not significant in Models 2 or 4 (p=0.266 and p=0.564, respectively) but was significant in Model 3 (p=0.016). The highest mean age (60.0 years) was observed in the low Ranch Hand dioxin category, and youngest average age was observed for Ranch Hands in the high dioxin category, with a mean age of 55.8 years.

Dichotomized age (i.e., born before 1942, born in or after 1942) showed a significant relation (p<0.001) with dioxin exposure in Models 2, 3, and 4. When the relation was adjusted for military occupation, however, it was not significant in any of these models (p>0.07 for all three models).

Marginally significant unadjusted associations were observed between race and dioxin levels in Models 2 and 3 (p=0.054 and p=0.089, respectively). The unadjusted association in Model 4 was not significant (p=0.587). These effects were significant for Models 2, 3, and 4, however, when adjusting for military occupation (p<0.001, p=0.015, and p=0.002, respectively). Blacks had lower mean initial and 1987 dioxin levels than did non-Blacks in Models 2 and 4. In Model 3, the percentage of Blacks varied among Comparisons (5.8%), Ranch Hands in the background dioxin category (5.0%), Ranch Hands in the low dioxin category (9.6%), and Ranch Hands in the high dioxin category (5.4%).

Similar to the relation between age and dioxin, a significant association was found between military occupation and dioxin in Models 2, 3, and 4 (p<0.001 for each model). In Models 2 and 4, the mean dioxin levels were lowest among officers, followed by enlisted flyers and enlisted groundcrew. As expected, the percentages of officers, enlisted flyers, and enlisted groundcrew were similar between Ranch Hands and Comparisons in Model 1 (p=0.302), but the percentages varied considerably among the three Ranch Hand dioxin categories in Model 3. In Model 3, 61.4 percent of Ranch Hands in the background dioxin category were officers, but only 40.2 percent of Ranch Hands in the low dioxin category and 2.9 percent of Ranch Hands in the high dioxin category were officers.

Table 8-1. Associations Between Matching Demographic Variables (Age, Race, and Military Occupation) and Estimates of Herbicide or Dioxin Exposure

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Age (continuous) (years)	n	870	1,251			482		
		$\bar{x}$ = 58.5	$\bar{x}$ = 58.4	0.677	0.924	r=–0.285	<0.001	0.266
(discrete)	Born <1942	495 (56.9)	693 (55.4)	0.522	0.745	$\bar{x}$ = 83.9 (n=250)	<0.001	0.075
	Born ≥1942	375 (43.1)	558 (44.6)			$\bar{x}$ = 144.9 (n=232)		
Race	n	870	1,251			482		
	Black	55 (6.3)	73 (5.8)	0.711	0.604	$\bar{x}$ = 82.3 (n=36)	0.054	<0.001
	Non-Black	815 (93.7)	1,178 (94.2)			$\bar{x}$ = 111.7 (n=446)		
Occupation	n	870	1,251			482		
	Officer	341 (39.2)	494 (39.5)	0.302	--	$\bar{x}$ = 50.0 (n=103)	<0.001	--
	Enlisted Flyer	151 (17.4)	187 (15.0)			$\bar{x}$ = 97.9 (n=103)		
	Enlisted Groundcrew	378 (43.5)	570 (45.6)			$\bar{x}$ = 152.1 (n=276)		

Table 8-1. Associations Between Matching Demographic Variables (Age, Race, and Military Occupation) and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	Covariate Category	Comparison Mean or n (%)	Background Ranch Hand Mean or n (%)	Low Ranch Hand Mean or n (%)	High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Age	n	1,213	381	239	243		
(continuous) (years)		$\bar{x}$ = 58.4	$\bar{x}$ = 59.4	$\bar{x}$ = 60.0	$\bar{x}$ = 55.8	<0.001	0.016
(discrete)	Born <1942	671 (55.3)	242 (63.5)	155 (64.9)	95 (39.1)	<0.001	0.101
	Born ≥1942	542 (44.7)	139 (36.5)	84 (35.1)	148 (60.9)		
Race	n	1,213	381	239	243		
	Black	70 (5.8)	19 (5.0)	23 (9.6)	13 (5.4)	0.089	0.015
	Non-Black	1,143 (94.2)	362 (95.0)	216 (90.4)	230 (94.7)		
Occupation	n	1,213	381	239	243		
	Officer	478 (39.4)	234 (61.4)	96 (40.2)	7 (2.9)	<0.001	--
	Enlisted Flyer	185 (15.3)	48 (12.6)	51 (21.3)	52 (21.4)		
	Enlisted Groundcrew	550 (45.3)	99 (26.0)	92 (38.5)	184 (75.7)		

Table 8-1. Associations Between Matching Demographic Variables (Age, Race, and Military Occupation) and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Age	n	863		
(continuous) (years)		r=–0.197	<0.001	0.564
(discrete)	Born <1942	$\bar{x}$ = 11.4 (n=492)	<0.001	0.542
	Born ≥1942	$\bar{x}$ = 18.2 (n=371)		
Race	n	863		
	Black	$\bar{x}$ = 12.9 (n=55)	0.587	0.002
	Non-Black	$\bar{x}$ = 14.1 (n=808)		
Occupation	n	863		
	Officer	$\bar{x}$ = 7.4 (n=337)	<0.001	--
	Enlisted Flyer	$\bar{x}$ = 15.4 (n=151)		
	Enlisted Groundcrew	$\bar{x}$ = 23.4 (n=375)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

8.3 ALCOHOL USE

Results of tests of association between alcohol use and the estimates of dioxin exposure are shown in Table 8-2. No significant association was found between dioxin and current alcohol use for Models 2, 3, and 4 using the discrete or the continuous form of alcohol use for unadjusted or adjusted analyses ($p>0.19$ for all analyses). Model 1 analyses showed a significant association between the discrete form of current alcohol use and group ($p=0.040$, unadjusted; $p=0.037$, adjusted). A greater percentage of Comparisons than Ranch Hands were light and heavy current drinkers (in terms of drinks per day), whereas a greater percentage of Ranch Hands than Comparisons were moderate current drinkers.

The adjusted and unadjusted associations between lifetime alcohol history and dioxin exposure were not significant in Models 1, 3, and 4 for either the continuous or discrete forms of alcohol history. Model 2 showed a significant association between lifetime alcohol history and initial dioxin in the adjusted model of the continuous form ($p=0.041$) and a marginally significant association with the discrete form ($p=0.078$).

Statistically significant and marginally significant associations were found in the unadjusted analysis of dioxin and current wine use for Model 2 ($p=0.038$, continuous; $p=0.004$, discrete), Model 3 ($p<0.001$ for both continuous and discrete), and Model 4 ($p<0.001$ for both continuous and discrete). None of these associations, however, was significant when the models were adjusted for military occupation ($p>0.63$ for all analyses).

Lifetime wine history, in the continuous form, differed significantly between Ranch Hands and Comparisons ($p=0.028$, unadjusted; $p=0.022$, adjusted for military occupation) and was marginally significant in the discrete form ($p=0.082$, unadjusted). Ranch Hands had a higher mean wine-years than Comparisons (3.86 wine-years vs. 3.03 wine-years), but a greater percentage of Comparisons than Ranch Hands (73.4% vs. 69.9%) had a history of wine use. Lifetime wine history showed significant inverse associations with dioxin in the unadjusted Model 2 ($p<0.001$ for continuous and discrete forms) and Model 4 ($p<0.001$ for continuous and discrete forms) analyses. When adjusting for military occupation, the associations between lifetime wine history and dioxin levels were no longer statistically significant ($p>0.12$ for all analyses). In Model 3, the unadjusted association between lifetime wine history and dioxin levels was significant ($p<0.001$ for the continuous and discrete forms of lifetime wine history). These results were marginally significant when adjusting for military occupation ($p=0.076$, continuous; $p=0.061$, discrete). The mean wine-years for Comparisons, Ranch Hands in the background dioxin category, Ranch Hands in the low dioxin category, and Ranch Hands in the high dioxin category for Model 3 were 3.07, 4.80, 4.55, and 1.73, respectively.

8.4 CIGARETTE SMOKING

Results of tests of association between cigarette smoking and the estimates of dioxin exposure are given in Table 8-3. No significant associations were observed between both current or lifetime cigarette smoking and group in Model 1 for adjusted or unadjusted analyses ($p>0.31$ for all analyses). No significant associations between the cigarette smoking covariates and initial dioxin were observed in Model 2 analyses ($p>0.20$ for all analyses). In Models 3 and 4, the unadjusted analyses showed no significant association between dioxin levels and current cigarette smoking or lifetime smoking habits ($p>0.17$ for all analyses); however, when adjusting for military occupation in Model 4, both the continuous and discrete forms of current and lifetime smoking showed significant associations with 1987

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure

Covariate	Covariate Category	Model 1: Ranch Hand Mean or n (%)	Model 1: Comparison Mean or n (%)	Model 1: p-Value: Unadjusted	Model 1: p-Value: Adjusted[a]	Model 2: Initial Dioxin (ppt) Correlation or Mean (n)	Model 2: p-Value: Unadjusted	Model 2: p-Value: Adjusted[a]
Current Alcohol Use (drinks/day)	n	869	1,251			482		
(continuous)		$\bar{x}$ = 0.68	$\bar{x}$ = 0.72	0.553	0.515	r=–0.058	0.207	0.793
(discrete)	0-1	684 (78.7)	1,015 (81.1)	0.040	0.037	$\bar{x}$ = 111.5 (n=385)	0.593	0.853
	>1-4	170 (19.6)	201 (16.1)			$\bar{x}$ = 100.4 (n=89)		
	>4	15 (1.7)	35 (2.8)			$\bar{x}$ = 98.8 (n=8)		
Lifetime Alcohol History (drink-years)	n	864	1,249			479		
(continuous)		$\bar{x}$ = 36.9	$\bar{x}$ = 37.0	0.970	0.918	r=0.074	0.104	0.041
(discrete)	0	54 (6.3)	64 (5.1)	0.393	0.349	$\bar{x}$ = 143.2 (n=34)	0.198	0.078
	>0-40	568 (65.7)	811 (64.9)			$\bar{x}$ = 106.8 (n=307)		
	>40	242 (28.0)	374 (29.9)			$\bar{x}$ = 106.8 (n=138)		

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Current Wine Use (drinks/day)	n	869	1,251			482		
(continuous)		$\bar{x}$ = 0.15	$\bar{x}$ = 0.14	0.297	0.267	r=–0.095	0.038	0.701
(discrete)	0	503 (57.9)	717 (57.3)	0.829	0.793	$\bar{x}$ = 119.0 (n=316)	0.004	0.895
	>0	366 (42.1)	534 (42.7)			$\bar{x}$ = 92.6 (n=166)		
Lifetime Wine History (wine-years)	n	866	1,249			480		
(continuous)		$\bar{x}$ = 3.86	$\bar{x}$ = 3.03	0.028	0.022	r=–0.159	<0.001	0.121
(discrete)	0	261 (30.1)	332 (26.6)	0.082	0.056	$\bar{x}$ = 133.1 (n=166)	<0.001	0.265
	>0	605 (69.9)	917 (73.4)			$\bar{x}$ = 98.3 (n=314)		

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	Covariate Category	Comparison Mean or n (%)	Background Ranch Hand Mean or n (%)	Low Ranch Hand Mean or n (%)	High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Current Alcohol Use (drinks/day)	n	1,213	380	239	243		
(continuous)		$\bar{x}$ = 0.72	$\bar{x}$ = 0.73	$\bar{x}$ = 0.66	$\bar{x}$ = 0.59	0.570	0.862
(discrete)	0-1	985 (81.2)	296 (77.9)	189 (79.1)	196 (80.7)	0.279	0.252
	>1-4	194 (16.0)	78 (20.5)	46 (19.3)	43 (17.7)		
	>4	34 (2.8)	6 (1.6)	4 (1.7)	4 (1.7)		
Lifetime Alcohol History (drink-years)	n	1,212	378	238	241		
(continuous)		$\bar{x}$ = 37.1	$\bar{x}$ = 34.7	$\bar{x}$ = 35.6	$\bar{x}$ = 40.3	0.602	0.808
(discrete)	0	62 (5.1)	20 (5.3)	13 (5.5)	21 (8.7)	0.338	0.458
	>0-40	786 (64.9)	258 (68.3)	155 (65.1)	152 (63.1)		
	>40	364 (30.0)	100 (26.5)	70 (29.4)	68 (28.2)		
Current Wine Use (drinks/day)	n	1,213	380	239	243		
(continuous)		$\bar{x}$ = 0.14	$\bar{x}$ = 0.21	$\bar{x}$ = 0.15	$\bar{x}$ = 0.07	<0.001	0.756
(discrete)	0	694 (57.2)	184 (48.4)	143 (59.8)	173 (71.2)	<0.001	0.803
	>0	519 (42.8)	196 (51.6)	96 (40.2)	70 (28.8)		

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Lifetime Wine History (wine-years)	n	1,212	379	238	242		
(continuous)		$\bar{x}$ = 3.07	$\bar{x}$ = 4.80	$\bar{x}$ = 4.55	$\bar{x}$ = 1.73	<0.001	0.076
(discrete)	0	320 (26.4)	93 (24.5)	76 (31.9)	90 (37.2)	<0.001	0.061
	>0	892 (73.6)	286 (75.5)	162 (68.1)	152 (62.8)		

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 4: 1987 Dioxin (ppt) Correlation or Mean (n)	Model 4: p-Value: Unadjusted	Model 4: p-Value: Adjusted[a]
Current Alcohol Use (drinks/day)	n	862		
(continuous)		r=–0.044	0.197	0.920
(discrete)	0-1	$\bar{x}$ = 14.3 (n=681)	0.497	0.932
	>1-4	$\bar{x}$ = 12.8 (n=167)		
	>4	$\bar{x}$ = 13.4 (n=14)		
Lifetime Alcohol History (drink-years)	n	857		
(continuous)		r=0.053	0.122	0.237
(discrete)	0	$\bar{x}$ = 17.8 (n=54)	0.223	0.353
	>0-40	$\bar{x}$ = 13.6 (n=565)		
	>40	$\bar{x}$ = 14.1 (n=238)		
Current Wine Use (drinks/day)	n	862		
(continuous)		r=–0.126	<0.001	0.741
(discrete)	0	$\bar{x}$ = 16.5 (n=500)	<0.001	0.631
	>0	$\bar{x}$ = 11.2 (n=362)		

Table 8-2. Associations Between Alcohol Use and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	Covariate Category	1987 Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Lifetime Wine History (wine-years)	n	859		
(continuous)		r=–0.118	<0.001	0.616
(discrete)	0	$\bar{x}$ = 17.6 (n=259)	<0.001	0.566
	>0	$\bar{x}$ = 12.6 (n=600)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

Table 8-3. Associations Between Cigarette Smoking and Estimates of Herbicide or Dioxin Exposure

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Current Cigarette Smoking (cigarettes/day)	n	869	1,251			482		
(continuous)		$\bar{x}$ = 4.4	$\bar{x}$ = 4.0	0.311	0.325	r=0.045	0.328	0.450
(discrete)	0 (Never Smoked)	240 (27.6)	355 (28.4)	0.829	0.826	$\bar{x}$ = 110.9 (n=131)	0.775	0.388
	0 (Former Smoker)	453 (52.1)	663 (53.0)			$\bar{x}$ = 105.2 (n=252)		
	0-20	117 (13.5)	155 (12.4)			$\bar{x}$ = 117.8 (n=64)		
	>20	59 (6.8)	78 (6.2)			$\bar{x}$ = 117.2 (n=35)		
Lifetime Cigarette Smoking) (pack-years)	n	868	1,250			481		
(continuous)		$\bar{x}$ = 17.3	$\bar{x}$ = 16.5	0.434	0.519	r=–0.040	0.377	0.203
(discrete)	0	240 (27.7)	355 (28.4)	0.886	0.869	$\bar{x}$ = 110.9 (n=131)	0.498	0.203
	>0-10	233 (26.8)	325 (26.0)			$\bar{x}$ = 117.2 (n=129)		
	>10	395 (45.5)	570 (45.6)			$\bar{x}$ = 104.1 (n=221)		

Table 8-3. Associations Between Cigarette Smoking and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Current Cigarette Smoking (cigarettes/day)	n	1,213	380	239	243		
(continuous)		$\bar{x}$ = 3.98	$\bar{x}$ = 4.43	$\bar{x}$ = 4.04	$\bar{x}$ = 4.96	0.518	0.047
(discrete)	0 (Never Smoked)	344 (28.4)	106 (27.9)	65 (27.2)	66 (27.2)	0.835	0.090
	0 (Former Smoker)	644 (53.1)	198 (52.1)	131 (54.8)	121 (49.8)		
	0-20	152 (12.5)	52 (13.7)	25 (10.5)	39 (16.1)		
	>20	73 (6.0)	24 (6.3)	18 (7.5)	17 (7.0)		
Lifetime Cigarette Smoking (pack-years)	n	1,212	380	238	243		
(continuous)		$\bar{x}$ = 16.4	$\bar{x}$ = 16.1	$\bar{x}$ = 19.7	$\bar{x}$ = 17.0	0.172	0.156
(discrete)	0	344 (28.4)	106 (27.9)	65 (27.3)	66 (27.2)	0.767	0.067
	>0-10	315 (26.0)	102 (26.8)	56 (23.5)	73 (30.0)		
	>10	553 (45.6)	172 (45.3)	117 (49.2)	104 (42.8)		

Table 8-3. Associations Between Cigarette Smoking and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Current Cigarette Smoking (cigarettes/day)	n	862		
(continuous)		r=–0.014	0.679	<0.001
(discrete)	0 (Never Smoked)	$\bar{x}$ = 14.5 (n=237)	0.889	<0.001
	0 (Former Smoker)	$\bar{x}$ = 13.9 (n=450)		
	0-20	$\bar{x}$ = 13.2 (n=116)		
	>20	$\bar{x}$ = 14.2 (n=59)		
Lifetime Cigarette Smoking (pack-years)	n	861		
(continuous)		r=–0.006	0.861	0.039
(discrete)	0	$\bar{x}$ = 14.5 (n=237)	0.434	<0.001
	>0-10	$\bar{x}$ = 14.8 (n=231)		
	>10	$\bar{x}$ = 13.3 (n=393)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

dioxin ($p=0.039$ for lifetime cigarette smoking in its continuous form; $p<0.001$ for all other analyses). The mean 1987 dioxin for those participants with more than 10 pack-years was lower (13.3 ppt) than participants with no smoking history (14.5 ppt) or smokers with no more than 10 pack-years (14.8 ppt). The adjusted analysis of Model 3 showed marginally significant results for the discrete forms of current smoking habits ($p=0.090$) and lifetime smoking history ($p=0.067$).

8.5 EXPOSURE TO CARCINOGENS

Results of tests of association between reported exposure to ionizing radiation, industrial chemicals, herbicides, insecticides, and degreasing chemicals and the estimates of dioxin exposure are presented in Table 8-4. These variables were constructed based on responses given by participants and were intended to indicate only post-Southeast Asia (SEA) exposures to these suspected carcinogens.

The association between reported degreasing chemical exposure and dioxin was significant in the analysis of Models 2, 3, and 4 ($p<0.001$ for each model); however, after adjusting for military occupation, the association between reported degreasing chemical exposure and dioxin levels was not significant in any of those three models ($p>0.27$ for all analyses).

Significant associations between group or dioxin levels and reported exposure to herbicides were revealed in Models 1, 3, and 4 ($p<0.001$, $p<0.001$, $p=0.013$, respectively). These associations were significant after adjustment for military occupation ($p<0.001$ for all analyses). In Model 1, more Ranch Hands (96.9%) than Comparisons (40.9%) reported herbicide exposure. Model 3 analyses showed a similar relation between Ranch Hands and Comparisons. In Model 4, Ranch Hands who reported exposure to herbicides had a mean 1987 dioxin level of 14.2 ppt, as compared to a mean 1987 dioxin level of 8.2 ppt for Ranch Hands who did not report exposure to herbicides. In Model 2, unadjusted and adjusted analysis showed no significant association between reported herbicide exposure and initial dioxin levels ($p>0.39$ for both analyses).

The association between industrial chemical exposure and dioxin was significant in the analysis of Models 2, 3, and 4 ($p=0.030$ for Model 2 and $p<0.001$ for Models 3 and 4); however, after adjusting for military occupation, these associations were no longer significant ($p>0.46$ for all analyses). Participants who reported exposure to industrial chemicals had higher mean dioxin levels in Models 2 and 4 than those participants who did not report exposure. In Model 3, the percentage of Ranch Hands reporting exposure to industrial chemicals increased with increasing dioxin levels. For Ranch Hands in the background dioxin category, 52.5 percent of participants reported exposure to industrial chemicals. For Ranch Hands in the low dioxin category, 65.7 percent reported exposure to industrial chemicals. For Ranch Hands in the high dioxin category, 74.5 percent reported exposure to industrial chemicals.

Significant associations were observed between insecticide exposure and group in Model 1 ($p<0.001$, unadjusted and adjusted), as well as between insecticide exposure and categorized dioxin in Model 3 ($p<0.001$, unadjusted and adjusted). In Model 1, 80.5 percent of Ranch Hands and 63.9 percent of Comparisons were exposed to insecticides. In Model 3, the percentage of participants exposed to insecticides was 64.0 among Comparisons, 79.5 among Ranch Hands in the background dioxin category, 82.0 among Ranch Hands in the low dioxin category, and 80.3 among Ranch Hands in the high dioxin category.

Table 8-4. Associations Between Exposure to Carcinogens and Estimates of Herbicide or Dioxin Exposure

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Degreasing Chemical Exposure	n	870	1,251			482		
	Yes	571 (65.6)	795 (63.6)	0.348	0.299	$\bar{x}$ = 120.3 (n=360)	<0.001	0.922
	No	299 (34.4)	456 (36.5)			$\bar{x}$ = 81.9 (n=122)		
Herbicide Exposure	n	870	1,251			482		
	Yes	843 (96.9)	511 (40.9)	<0.001	<0.001	$\bar{x}$ = 108.7 (n=474)	0.399	0.781
	No	27 (3.1)	740 (59.2)			$\bar{x}$ = 143.1 (n=8)		
Industrial Chemical Exposure	n	870	1,251			482		
	Yes	541 (62.2)	776 (62.0)	0.979	0.934	$\bar{x}$ = 115.8 (n=338)	0.030	0.605
	No	329 (37.8)	475 (38.0)			$\bar{x}$ = 95.0 (n=144)		
Insecticide Exposure	n	870	1,251			482		
	Yes	700 (80.5)	799 (63.9)	<0.001	<0.001	$\bar{x}$ = 106.6 (n=391)	0.231	0.162
	No	170 (19.5)	452 (36.1)			$\bar{x}$ = 121.0 (n=91)		

Table 8-4. Associations Between Exposure to Carcinogens and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Ionizing Radiation Exposure	n	870	1,251			482		
	Yes	194 (22.3)	344 (27.5)	0.008	0.005	$\bar{x}$ = 96.5 (n=109)	0.108	0.280
	No	676 (77.7)	907 (72.5)			$\bar{x}$ = 113.2 (n=373)		

Table 8-4. Associations Between Exposure to Carcinogens and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value Unadjusted**	**p-Value: Adjusted[a]**
Degreasing Chemical Exposure	n	1,213	381	239	243		
	Yes	780 (64.3)	209 (54.9)	158 (66.1)	202 (83.1)	<0.001	0.310
	No	433 (35.7)	172 (45.1)	81 (33.9)	41 (16.9)		
Herbicide Exposure	n	1,213	381	239	243		
	Yes	500 (41.2)	363 (95.3)	236 (98.7)	238 (97.9)	<0.001	<0.001
	No	713 (58.8)	18 (4.7)	3 (1.3)	5 (2.1)		
Industrial Chemical Exposure	n	1,213	381	239	243		
	Yes	758 (62.5)	200 (52.5)	157 (65.7)	181 (74.5)	<0.001	0.465
	No	455 (37.5)	181 (47.5)	82 (34.3)	62 (25.5)		
Insecticide Exposure	n	1,213	381	239	243		
	Yes	776 (64.0)	303 (79.5)	196 (82.0)	195 (80.3)	<0.001	<0.001
	No	437 (36.0)	78 (20.5)	43 (18.0)	48 (19.8)		
Ionizing Radiation Exposure	n	1,213	381	239	243		
	Yes	334 (27.5)	82 (21.5)	63 (26.4)	46 (18.9)	0.010	0.013
	No	879 (72.5)	299 (78.5)	176 (73.6)	197 (81.1)		

Table 8-4. Associations Between Exposure to Carcinogens and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 4: 1987 Dioxin (ppt) Correlation or Mean (n)	Model 4: p-Value: Unadjusted	Model 4: p-Value: Adjusted[a]
Degreasing Chemical Exposure	n	863		
	Yes	$\bar{x}$ = 16.9 (n=569)	<0.001	0.279
	No	$\bar{x}$ = 9.6 (n=294)		
Herbicide Exposure	n	863		
	Yes	$\bar{x}$ = 14.2 (n=837)	0.013	<0.001
	No	$\bar{x}$ = 8.2 (n=26)		
Industrial Chemical Exposure	n	863		
	Yes	$\bar{x}$ = 16.3 (n=538)	<0.001	0.633
	No	$\bar{x}$ = 10.8 (n=325)		
Insecticide Exposure	n	863		
	Yes	$\bar{x}$ = 14.0 (n=694)	0.967	0.583
	No	$\bar{x}$ = 14.0 (n=169)		

Table 8-4. Associations Between Exposure to Carcinogens and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Ionizing Radiation Exposure	n	863		
	Yes	$\bar{x}$ = 12.9 (n=191)	0.261	0.546
	No	$\bar{x}$ = 14.3 (n=672)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

The Models 1 and 3 analyses showed significant associations between group and exposure to ionizing radiation for unadjusted and adjusted analysis. A significant difference between the percentage of participants who have been exposed to ionizing radiation was seen between Ranch Hands (22.3%) and Comparisons (27.5%) in Model 1 (p=0.008, unadjusted; p=0.005, adjusted). In Model 3, a significant difference in the percentage of participants who were exposed to ionizing radiation was seen among Comparisons (27.5%), Ranch Hands in the background dioxin category (21.5%), Ranch Hands in the low dioxin category (26.4%), and Ranch Hands in the high dioxin category (18.9%) (p=0.010, unadjusted; p=0.013, adjusted, for military occupation). No significant associations were seen between mean initial or 1987 dioxin levels and ionizing radiation exposure in Models 2 and 4 in the adjusted or unadjusted models (p>0.10 for all analyses).

8.6 HEALTH VARIABLES

Results of tests of association between numerous measures related to a participant's health and the estimates of dioxin exposure are presented in Table 8-5. In Model 1 analyses, both unadjusted and adjusted for military occupation, all associations between health variables and group were nonsignificant (p>0.22 for all analyses).

Statistically significant associations were found between the continuous and discrete forms of the body fat measurement and dioxin for Model 3 (p<0.001) and Model 4 (p<0.001) for both unadjusted and adjusted analyses. In Model 3, the mean body fat was 22.9 percent for Comparisons, 21.2 percent for Ranch Hands in the background dioxin category, 23.8 percent for Ranch Hands in the low dioxin category, and 24.3 percent for Ranch Hands in the high dioxin category. The association between body fat and 1987 dioxin was positive. For the continuous form of the body fat measurement, the unadjusted Model 2 analysis showed no significant association with initial dioxin (p=0.106); however, the results adjusted for military occupation were statistically significant (p=0.048), with a positive association between body fat and initial dioxin.

The association between the continuous form of cholesterol and initial dioxin was significant for Model 2 in the unadjusted analysis (p=0.005) and in the analysis adjusted for military occupation (p=0.042). Cholesterol increased as initial dioxin increased. The association between cholesterol and dioxin levels was significant or marginally significant in both the continuous and discrete forms for Models 3 and 4. When the analysis was adjusted for military occupation, the association was no longer significant in Model 3 (p=0.176, continuous; p=0.293, discrete). The positive association between cholesterol and 1987 dioxin based on the adjusted Model 4 analysis was marginally significant for the continuous form of cholesterol (p=0.099) and nonsignificant for the discrete form of Model 4 (p=0.446).

High-density lipoprotein (HDL) cholesterol in its continuous form showed significant or marginally significant associations with dioxin in Model 2 (p=0.065), Model 3 (p=0.002), and Model 4 (p<0.001). When adjusting for military occupation, the association became nonsignificant in Model 2 (p=0.274) and Model 3 (p=0.188). The adjusted association remained significant in Model 4 (p=0.013), with HDL levels decreasing as the mean dioxin levels increased. Stratifying participants into less than or equal to 35 mg/dl HDL or greater than 35 mg/dl HDL revealed no significant associations with dioxin levels in Models 2 through 4 for the adjusted or unadjusted analyses (p>0.18 for all analyses).

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure

		Model 1				Model 2		
Covariate	**Covariate Category**	**Ranch Hand Mean or n (%)**	**Comparison Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**	**Initial Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Body Fat (percent)	n	870	1,251			482		
(continuous)		$\bar{x}$ = 22.8	$\bar{x}$ = 23.0	0.544	0.580	r=0.074	0.106	0.048
(discrete)	Lean or Normal (≤25%)	626 (72.0)	875 (69.9)	0.341	0.338	$\bar{x}$ = 109.2 (n=314)	0.989	0.952
	Obese (>25%)	244 (28.0)	376 (30.1)			$\bar{x}$ = 109.1 (n=168)		
Cholesterol (mg/dl)	n	870	1,251			482		
(continuous)		$\bar{x}$ = 212.6	$\bar{x}$ = 213.2	0.745	0.705	r=0.129	0.005	0.042
(discrete)	0-200	336 (38.6)	467 (37.3)	0.753	0.714	$\bar{x}$ = 100.3 (n=175)	0.211	0.520
	>200-239	345 (39.7)	516 (41.3)			$\bar{x}$ = 110.5 (n=190)		
	>239	189 (21.7)	268 (21.4)			$\bar{x}$ = 121.4 (n=117)		
HDL (mg/dl)	n	869	1,250			481		
(continuous)		$\bar{x}$ = 46.6	$\bar{x}$ = 46.4	0.679	0.688	r=–0.084	0.065	0.274
(discrete)	0-35	164 (18.9)	210 (16.8)	0.241	0.221	$\bar{x}$ = 108.2 (n=100)	0.898	0.270
	>35	705 (81.1)	1,040 (83.2)			$\bar{x}$ = 109.7 (n=381)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Cholesterol-HDL Ratio	n	869	1,250			481		
(continuous)		$\bar{x}$ = 4.85	$\bar{x}$ = 4.85	0.961	0.945	r=0.143	0.002	0.100
(discrete)	0-5	510 (58.7)	738 (59.0)	0.907	0.847	$\bar{x}$ = 95.5 (n=263)	<0.001	0.038
	>5	359 (41.3)	512 (41.0)			$\bar{x}$ = 128.8 (n=218)		
Physical Activity Index	n	864	1,243			480		
	Sedentary	475 (55.0)	646 (52.0)	0.256	0.265	$\bar{x}$ = 121.1 (n=268)	0.001	0.022
	Moderate	157 (18.2)	259 (20.8)			$\bar{x}$ = 115.3 (n=86)		
	Very Active	232 (26.9)	338 (27.2)			$\bar{x}$ = 84.5 (n=126)		
Diabetic Class[b]	n	861	1,233	0.997	0.999	477	0.135	0.004
	Normal	601 (69.8)	862 (69.9)			$\bar{x}$ = 106.5 (n=303)		
	Impaired	113 (13.1)	161 (13.1)			$\bar{x}$ = 98.4 (n=66)		
	Diabetic	147 (17.1)	210 (17.0)			$\bar{x}$ = 127.0 (n=108)		
Family History of Diabetes	n	863	1,239			478		
	Yes	221 (25.6)	338 (27.3)	0.422	0.387	$\bar{x}$ = 116.4 (n=133)	0.368	0.353
	No	642 (74.4)	901 (72.7)			$\bar{x}$ = 107.0 (n=345)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 1				Model 2		
Covariate	**Covariate Category**	**Ranch Hand Mean or n (%)**	**Comparison Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**	**Initial Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Family History of Heart Disease	n	860	1,245			477		
	Yes	526 (61.2)	756 (60.7)	0.875	0.812	$\bar{x}$ = 111.6 (n=292)	0.599	0.429
	No	334 (38.8)	489 (39.3)			$\bar{x}$ = 106.7 (n=185)		
Family History of Heart Disease Before Age 45	n	848	1,229			471		
	Yes	107 (12.6)	146 (11.9)	0.662	0.617	$\bar{x}$ = 124.2 (n=63)	0.266	0.876
	No	741 (87.4)	1,083 (88.1)			$\bar{x}$ = 108.2 (n=408)		
Currently Taking Blood Pressure Medication	n	870	1,251			482		
	Yes	265 (30.5)	364 (29.1)	0.530	0.544	$\bar{x}$ = 107.1 (n=161)	0.748	0.838
	No	605 (69.5)	887 (70.9)			$\bar{x}$ = 110.2 (n=321)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	Covariate Category	Comparison Mean or n (%)	Background Ranch Hand Mean or n (%)	Low Ranch Hand Mean or n (%)	High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Body Fat (percent)	n	1,213	381	239	243		
(continuous)		$\bar{x}$ = 22.9	$\bar{x}$ = 21.2	$\bar{x}$ = 23.8	$\bar{x}$ = 24.3	<0.001	<0.001
(discrete)	Lean or Normal (≤25%)	852 (70.2)	308 (80.8)	154 (64.4)	160 (65.8)	<0.001	<0.001
	Obese (>25%)	361 (29.8)	73 (19.2)	85 (35.6)	83 (34.2)		
Cholesterol (mg/dl)	n	1,213	381	239	243		
(continuous)		$\bar{x}$ = 213.2	$\bar{x}$ = 210.4	$\bar{x}$ = 210.3	$\bar{x}$ = 218.4	0.045	0.176
(discrete)	0-200	451 (37.2)	159 (41.7)	94 (39.3)	81 (33.3)	0.097	0.293
	>200-239	502 (41.4)	151 (39.6)	97 (40.6)	93 (38.3)		
	>239	260 (21.4)	71 (18.6)	48 (20.1)	69 (28.4)		
HDL (mg/dl)	n	1,212	381	238	243		
(continuous)		$\bar{x}$ = 46.3	$\bar{x}$ = 48.0	$\bar{x}$ = 46.8	$\bar{x}$ = 44.1	0.002	0.188
(discrete)	0-35	207 (17.1)	62 (16.3)	49 (20.6)	51 (21.0)	0.262	0.585
	>35	1,005 (82.9)	319 (83.7)	189 (79.4)	192 (79.0)		
Cholesterol-HDL Ratio	n	1,212	381	238	243		
(continuous)		$\bar{x}$ = 4.86	$\bar{x}$ = 4.68	$\bar{x}$ = 4.77	$\bar{x}$ = 5.18	<0.001	0.103
(discrete)	0-5	713 (58.8)	244 (64.0)	152 (63.9)	111 (45.7)	<0.001	0.028
	>5	499 (41.2)	137 (36.0)	86 (36.1)	132 (54.3)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 3 Comparison Mean or n (%)	Background Ranch Hand Mean or n (%)	Low Ranch Hand Mean or n (%)	High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Physical Activity Index	n	1,205	377	238	242		
	Sedentary	623 (51.7)	200 (53.1)	121 (50.8)	147 (60.7)	0.075	0.309
	Moderate	255 (21.2)	71 (18.8)	41 (17.2)	45 (18.6)		
	Very Active	327 (27.1)	106 (28.1)	76 (31.9)	50 (20.7)		
Diabetic Class[b]	n	1,196	379	236	241		
	Normal	841 (70.3)	295 (77.8)	151 (64.0)	152 (63.1)	<0.001	<0.001
	Impaired	155 (13.0)	47 (12.4)	35 (14.8)	31 (12.9)		
	Diabetic	200 (16.7)	37 (9.8)	50 (21.2)	58 (24.1)		
Family History of Diabetes	n	1,201	378	236	242		
	Yes	321 (26.7)	87 (23.0)	58 (24.6)	75 (31.0)	0.149	0.761
	No	880 (73.3)	291 (77.0)	178 (75.4)	167 (69.0)		
Family History of Heart Disease	n	1,207	376	235	242		
	Yes	729 (60.4)	230 (61.2)	141 (60.0)	151 (62.4)	0.936	0.565
	No	478 (39.6)	146 (38.8)	94 (40.0)	91 (37.6)		
Family History of Heart Disease Before Age 45	n	1,192	370	230	241		
	Yes	137 (11.5)	44 (11.9)	24 (10.4)	39 (16.2)	0.186	0.444
	No	1,055 (88.5)	326 (88.1)	206 (89.6)	202 (83.8)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	Covariate Category	Comparison Mean or n (%)	Background Ranch Hand Mean or n (%)	Low Ranch Hand Mean or n (%)	High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Currently Taking Blood Pressure Medication	n	1,213	381	239	243		
	Yes	353 (29.1)	99 (26.0)	77 (32.2)	84 (34.6)	0.102	0.070
	No	860 (70.9)	282 (74.0)	162 (67.8)	159 (65.4)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Body Fat (percent)	n	863		
(continuous)		r=0.257	<0.001	<0.001
(discrete)	Lean or Normal (≤25%)	$\bar{x}$ = 12.6 (n=622)	<0.001	<0.001
	Obese (>25%)	$\bar{x}$ = 18.4 (n=241)		
Cholesterol (mg/dl)	n	863		
(continuous)		r=0.097	0.004	0.099
(discrete)	0-200	$\bar{x}$ = 12.7 (n=334)	0.040	0.446
	>200-239	$\bar{x}$ = 14.1 (n=341)		
	>239	$\bar{x}$ = 16.4 (n=188)		
HDL (mg/dl)	n	862		
(continuous)		r=–0.131	<0.001	0.013
(discrete)	0-35	$\bar{x}$ = 15.5 (n=162)	0.188	0.621
	>35	$\bar{x}$ = 13.7 (n=700)		
Cholesterol-HDL Ratio	n	862		
(continuous)		r=0.152	<0.001	0.021
(discrete)	0-5	$\bar{x}$ = 12.2 (n=507)	<0.001	0.010
	>5	$\bar{x}$ = 16.9 (n=355)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Physical Activity Index	n	857		
	Sedentary	$\bar{x}$ = 15.1 (n=468)	0.026	0.408
	Moderate	$\bar{x}$ = 14.5 (n=157)		
	Very Active	$\bar{x}$ = 11.9 (n=232)		
Diabetic Class[b]	n	856	<0.001	<0.001
	Normal	$\bar{x}$ = 12.7 (n=598)		
	Impaired	$\bar{x}$ = 13.9 (n=113)		
	Diabetic	$\bar{x}$ = 21.2 (n=145)		
Family History of Diabetes	n	856	0.065	0.198
	Yes	$\bar{x}$ = 15.8 (n=220)		
	No	$\bar{x}$ = 13.5 (n=636)		
Family History of Heart Disease	n	853		
	Yes	$\bar{x}$ = 14.3 (n=522)	0.580	0.177
	No	$\bar{x}$ = 13.7 (n=331)		

Table 8-5. Associations Between Health Variables and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Family History of Heart Disease Before Age 45	n	841		
	Yes	$\bar{x}$ = 16.3 (n=107)	0.148	0.979
	No	$\bar{x}$ = 13.8 (n=734)		
Currently Taking Blood Pressure Medication	n	863		
	Yes	$\bar{x}$ = 15.6 (n=260)	0.057	0.013
	No	$\bar{x}$ = 13.3 (n=603)		

[a] Adjusted for occupation.
[b] Diabetic Class: Normal: <140 mg/dl 2-hour postprandial glucose
Impaired: ≥140-<200 mg/dl 2-hour postprandial glucose
Diabetic: Verified past history of diabetes or ≥200 mg/dl 2-hour postprandial glucose.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

Statistically significant unadjusted associations were found between the cholesterol-HDL ratio and dioxin for Model 2 (p=0.002), Model 3 (p<0.001), and Model 4 (p<0.001). In Models 2 and 3, the association was not significant when adjusting for military occupation (p=0.100 for Model 2; p=0.103 for Model 3). In Model 4, the association between 1987 dioxin and the cholesterol-HDL ratio remained significant after adjusting for military occupation (p=0.021). As 1987 dioxin levels increased, the cholesterol-HDL ratio increased.

Dichotomizing the cholesterol-HDL ratio using a cutpoint of 5.0 revealed significant associations with dioxin for Models 2, 3, and 4 (p<0.001 for these models). The associations between the categorized cholesterol-HDL ratio and dioxin levels remained significant after adjusted for military occupation (p<0.04 for all analyses). The mean dioxin levels were greater for participants with a higher cholesterol-HDL ratio in Models 2 and 4. In Model 3, a significant difference between the percentage of participants with a ratio less than 5.0 was seen among Comparisons (58.8%), Ranch Hands in the background dioxin category (64.0%), Ranch Hands in the low dioxin category (63.9%), and Ranch Hands in the high dioxin category (45.7%).

The examination of the physical activity index showed a significant association with dioxin in Model 2 (p=0.001) and Model 4 (p=0.026), and a marginally significant relation in Model 3 (p=0.075) in the unadjusted analysis. In Models 2 and 4, the mean dioxin levels were decreased as activity levels increased. When adjusting for military occupation, the associations seen in Models 3 and 4 were no longer significant (p=0.309 for Model 3; p=0.408 for Model 4). Model 2 analysis showed a significant association between physical activity and initial dioxin levels after adjusting for military occupation (p=0.022).

A significant association between diabetic class and dioxin was revealed in Models 3 and 4 (p<0.001 for both models), and the results remained significant (p<0.001) after adjusting for military occupation. In Model 3, a significant difference between the percentage of participants classified as normal, impaired, and diabetic was seen among Comparisons, Ranch Hands in the background dioxin category, Ranch Hands in the low dioxin category, and Ranch Hands in the high dioxin category. More participants were classified as diabetic as the dioxin levels increased. For Ranch Hands in the background dioxin category, 9.8 percent of participants were classified as diabetic. For Ranch Hands in the low dioxin category, 21.2 percent were classified as diabetic, and 24.1 percent of Ranch Hands in the high dioxin category were classified as diabetic. In Model 4, participants classified as diabetic had higher mean 1987 dioxin levels than participants classified as impaired or normal. Model 2 showed a significant association between diabetic class and initial dioxin levels only when adjusting for military occupation (p=0.004).

The analysis of family history of diabetes revealed no significant associations with dioxin levels in Models 1, 2, and 3 in the unadjusted or adjusted analyses. Model 4 showed a marginally significant association in the unadjusted model only (p=0.065).

No significant associations were observed between family history of heart disease or family history of heart disease before age 45 and any of the estimates of herbicide or dioxin exposure (p>0.14 for all analyses).

When examining the relation between current blood pressure medication use and dioxin exposure, no significant relation was observed in Model 2, whether or not adjustment was made for military occupation (p>0.74 for both analyses). In Model 3, the unadjusted analysis showed no significant association (p=0.102), but the adjusted showed a marginally significant association (p=0.070). In Model 4, the unadjusted analysis was marginally significant (p=0.057), and the adjusted analysis showed a significant association (p=0.013). Mean 1987 dioxin levels were higher in those participants currently taking medication for high blood pressure (15.6 ppt) than for those not taking the medication (13.3 ppt).

8.7 SUN EXPOSURE VARIABLES

Results of tests of association between a participant's reaction to sun exposure and the estimates of dioxin exposure are shown in Table 8-6. These statistics are based on non-Black participants, because the sun exposure covariates were used in adjusted analyses of skin neoplasms only, and Blacks were excluded from the skin neoplasm analyses.

Unadjusted analysis of the relation between skin color and dioxin exposure showed no significant associations (p≥0.12 for all unadjusted analyses). When the associations were tested adjusting for military occupation, Models 3 and 4 showed a significant association (p=0.050 for Model 3; p=0.006 for Model 4). The highest percentage of participants with peach skin color was for Ranch Hands in the low dioxin category (82.4%). Participants with peach skin color had a higher mean 1987 dioxin level than participants with non-peach skin color (14.5 ppt vs. 12.5 ppt; p=0.006, adjusted for military occupation).

A significant association between hair color and dioxin levels was observed in Model 2 (p<0.001) and Model 3 (p=0.006), and a marginally significant association was seen in Model 4 (p=0.055). The association was no longer significant when adjusting for military occupation in Model 2 (p=0.155) or Model 4 (p=0.715), but remained significant in Model 3 (p=0.048). The percentage of participants with black or dark brown hair varied among the Comparisons (69.0%), Ranch Hands in the background dioxin category (66.9%), Ranch Hands in the low dioxin category (59.7%), and Ranch Hands in the high dioxin category (74.8%).

Significant associations were observed between eye color and dioxin exposure in the unadjusted analysis of all four models (p<0.04 for all unadjusted analyses). These results remained significant (p<0.04) after adjusting for military occupation in all models except Model 3, which still showed a marginally significant association (p=0.088). In Model 2 and Model 4, participants with brown eyes had higher initial and 1987 dioxin levels than participants with other eye colors.

Unadjusted analysis of average lifetime residential latitude revealed significant associations with dioxin exposure in Model 1 (p=0.004), Model 2 (p=0.032), and Model 3 (p=0.011). In Model 1, a significant difference between the percentage of participants living, on average, closer to the equator (less than 37 degrees latitude) was seen between Ranch Hands (46.5%) and Comparisons (53.2%). In Model 2, the mean initial dioxin levels were greater for participants living closer to the equator. In Model 3, a significant difference between the percentage of participants living, on average, closer to the equator was seen among Comparisons (52.9%), Ranch Hands in the background dioxin category (46.4%), Ranch Hands in the low dioxin category (42.1%), and Ranch Hands in the high dioxin category (50.0%). Analyses of the relation between group or dioxin and average lifetime residential latitude also was significant after adjustment for the effects of military occupation in Models 1, 2, and 3 (p=0.002, p=0.028, and p=0.007, respectively). While no significant association was seen in the unadjusted analysis of Model 4 (p=0.152), the association between latitude was significant when adjusting for military occupation (p=0.021).

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only)

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Skin Color	n	815	1,178			446		
	Peach	637 (78.2)	897 (76.2)	0.319	0.308	$\bar{x}$ = 111.3 (n=360)	0.884	0.789
	Non-Peach	178 (21.8)	281 (23.9)			$\bar{x}$ = 113.2 (n=86)		
Hair Color	n	815	1,176			446		
	Black, Dark Brown	549 (67.4)	810 (68.9)	0.506	0.497	$\bar{x}$ = 123.7 (n=301)	<0.001	0.155
	Light Brown, Blonde, Red, Bald	266 (32.6)	366 (31.1)			$\bar{x}$ = 90.4 (n=145)		
Eye Color	n	815	1,178			446		
	Brown	229 (28.1)	383 (32.5)	0.016	0.015	$\bar{x}$ = 135.3 (n=132)	0.014	0.023
	Hazel, Green	242 (29.7)	287 (24.4)			$\bar{x}$ = 98.7 (n=133)		
	Gray, Blue	344 (42.2)	508 (43.1)			$\bar{x}$ = 106.3 (n=181)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

		Model 1				Model 2		
Covariate	**Covariate Category**	**Ranch Hand Mean or n (%)**	**Comparison Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**	**Initial Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Reaction of Skin to Sun After at Least 2 Hours	n	814	1,178			446		
	No Reaction	294 (36.1)	427 (36.3)	0.859	0.855	$\bar{x}$ = 122.5 (n=169)	0.221	0.243
	Becomes Red	322 (39.6)	481 (40.8)			$\bar{x}$ = 109.7 (n=176)		
	Burns	127 (15.6)	178 (15.1)			$\bar{x}$ = 93.0 (n=68)		
	Painfully Burns	71 (8.7)	92 (7.8)			$\bar{x}$ = 111.8 (n=33)		
Reaction of Skin to Sun After Repeated Exposure	n	814	1,178			446		
	Tans Dark Brown	225 (27.6)	331 (28.1)	0.978	0.976	$\bar{x}$ = 116.6 (n=131)	0.417	0.485
	Tans Moderately	409 (50.3)	580 (49.2)			$\bar{x}$ = 109.0 (n=218)		
	Tans Mildly	151 (18.6)	224 (19.0)			$\bar{x}$ = 119.6 (n=78)		
	Freckles with No Tan	29 (3.6)	43 (3.7)			$\bar{x}$ = 82.7 (n=19)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

		Model 1				Model 2		
Covariate	**Covariate Category**	**Ranch Hand Mean or n (%)**	**Comparison Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**	**Initial Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Composite Sun-Reaction Index	n	814	1,178			446		
	High	91 (11.2)	110 (9.3)	0.330	0.333	$\bar{x}$ = 103.6 (n=45)	0.820	0.871
	Medium	187 (23.0)	291 (24.7)			$\bar{x}$ = 110.3 (n=102)		
	Low	536 (65.9)	777 (66.0)			$\bar{x}$ = 113.4 (n=299)		
Average Lifetime Residential Latitude	n	815	1,178			446		
	<37°	379 (46.5)	627 (53.2)	0.004	0.002	$\bar{x}$ = 123.6 (n=206)	0.032	0.028
	≥37°	436 (53.5)	551 (46.8)			$\bar{x}$ = 102.4 (n=240)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Skin Color	n	1,143	362	216	230		
	Peach	873 (76.4)	273 (75.4)	178 (82.4)	182 (79.1)	0.179	0.050
	Non-Peach	270 (23.6)	89 (24.6)	38 (17.6)	48 (20.9)		
Hair Color	n	1,141	362	216	230		
	Black, Dark Brown	787 (69.0)	242 (66.9)	129 (59.7)	172 (74.8)	0.006	0.048
	Light Brown, Blonde, Red, Bald	354 (31.0)	120 (33.1)	87 (40.3)	58 (25.2)		
Eye Color	n	1,143	362	216	230		
	Brown	366 (32.0)	95 (26.2)	53 (24.5)	79 (34.4)	0.039	0.088
	Hazel, Green	283 (24.8)	106 (29.3)	70 (32.4)	63 (27.4)		
	Gray, Blue	494 (43.2)	161 (44.5)	93 (43.1)	88 (38.3)		
Reaction of Skin to Sun After at Least 2 Hours	n	1,143	361	216	230		
	No Reaction	410 (35.9)	122 (33.8)	74 (34.3)	95 (41.3)	0.644	0.994
	Becomes Red	471 (41.2)	144 (39.9)	89 (41.2)	87 (37.8)		
	Burns	174 (15.2)	57 (15.8)	35 (16.2)	33 (14.4)		
	Painfully Burns	88 (7.7)	38 (10.5)	18 (8.3)	15 (6.5)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Reaction of Skin to Sun After Repeated Exposure	n	1,143	361	216	230		
	Tans Dark Brown	315 (27.6)	90 (24.9)	60 (27.8)	71 (30.9)	0.533	0.768
	Tans Moderately	571 (50.0)	188 (52.1)	106 (49.1)	112 (48.7)		
	Tans Mildly	217 (19.0)	73 (20.2)	37 (17.1)	41 (17.8)		
	Freckles with No Tan	40 (3.5)	10 (2.8)	13 (6.0)	6 (2.6)		
Composite Sun-Reaction Index	n	1,143	361	216	230		
	High	105 (9.2)	46 (12.7)	25 (11.6)	20 (8.7)	0.480	0.815
	Medium	285 (24.9)	83 (23.0)	48 (22.2)	54 (23.5)		
	Low	753 (65.9)	232 (64.3)	143 (66.2)	156 (67.8)		
Average Lifetime Residential Latitude	n	1,143	362	216	230		
	<37°	605 (52.9)	168 (46.4)	91 (42.1)	115 (50.0)	0.011	0.007
	≥37°	538 (47.1)	194 (53.6)	125 (57.9)	115 (50.0)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

Covariate	Covariate Category	Model 4: 1987 Dioxin (ppt) Correlation or Mean (n)	Model 4: p-Value: Unadjusted	Model 4: p-Value: Adjusted[a]
Skin Color	n	808		
	Peach	$\bar{x}$ = 14.5 (n=633)	0.120	0.006
	Non-Peach	$\bar{x}$ = 12.5 (n=175)		
Hair Color	n	808		
	Black, Dark Brown	$\bar{x}$ = 14.8 (n=543)	0.055	0.715
	Light Brown, Blonde, Red, Bald	$\bar{x}$ = 12.6 (n=265)		
Eye Color	n	808		
	Brown	$\bar{x}$ = 16.8 (n=227)	0.015	0.037
	Hazel, Green	$\bar{x}$ = 13.1 (n=239)		
	Gray, Blue	$\bar{x}$ = 13.1 (n=342)		
Reaction of Skin to Sun After at Least 2 Hours	n	807		
	No Reaction	$\bar{x}$ = 15.3 (n=291)	0.229	0.694
	Becomes Red	$\bar{x}$ = 14.1 (n=320)		
	Burns	$\bar{x}$ = 12.7 (n=125)		
	Painfully Burns	$\bar{x}$ = 12.0 (n=71)		

Table 8-6. Associations Between Sun Exposure Variables and Estimates of Herbicide or Dioxin Exposure (Non-Blacks Only) (Continued)

Covariate	Covariate Category	Model 4: 1987 Dioxin (ppt) Correlation or Mean (n)	Model 4: p-Value: Unadjusted	Model 4: p-Value: Adjusted[a]
Reaction of Skin to Sun After Repeated Exposure	n	807		
	Tans Dark Brown	$\bar{x}$ = 15.6 (n=221)	0.463	0.822
	Tans Moderately	$\bar{x}$ = 13.5 (n=406)		
	Tans Mildly	$\bar{x}$ = 13.7 (n=151)		
	Freckles with No Tan	$\bar{x}$ = 14.2 (n=29)		
Composite Sun-Reaction Index	n	807		
	High	$\bar{x}$ = 12.2 (n=91)	0.419	0.837
	Medium	$\bar{x}$ = 14.1 (n=185)		
	Low	$\bar{x}$ = 14.4 (n=531)		
Average Lifetime Residential Latitude	n	808		
	<37°	$\bar{x}$ = 14.9 (n=374)	0.152	0.021
	≥37°	$\bar{x}$ = 13.4 (n=434)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

No significant associations were observed between group or dioxin levels and reaction of skin to sun after at least 2 hours, reaction of skin to sun after repeated exposures, or a composite sun-reaction index for either the adjusted or unadjusted analyses (p>0.22 for all analyses).

8.8 OTHER MISCELLANEOUS COVARIATES

Results of tests of association between other miscellaneous covariates and the estimates of dioxin exposure are shown in Table 8-7. Examining the association between current total household income in both its continuous and discrete forms and dioxin revealed significant relations in the analysis of Models 2 through 4. By adjusting for military occupation, the association between income and dioxin levels was not significant (p>0.08) for continuous or discrete forms of income or for any of the models.

No significant associations were seen between group or dioxin levels and personality type, either unadjusted or adjusted for military occupation (p>0.14 for all analyses).

The relation between education and group was nonsignificant (p=0.339, unadjusted; p=0.270, adjusted, for military occupation). A significant relation between education and dioxin was revealed for Models 2 through 4 (p≤0.001 for each model); however, after adjusting for military occupation, no significant relations were observed in Models 2, 3, or 4 (p>0.20 for all analyses).

The relation between current employment status and dioxin exposure mirrored the relation between education and dioxin exposure. Significant relations were seen in Models 2, 3, and 4 in the unadjusted analysis, but the relations were no longer significant when adjusted for military occupation (p>0.39 for all analyses).

In the analysis of current marital status and dioxin exposure, a marginally significant association was seen in Model 2 (p=0.082), and a significant relation was seen in Model 3 (p=0.033). After adjusting for military occupation, however, these associations were no longer significant (p=0.282 for Model 2; p=0.635 for Model 3).

Current parental status (having a child younger than 18 years old) was shown to have a marginally significant relation with dioxin in Model 2 (p=0.066) and Model 3 (p=0.069), and a significant relation with dioxin in Model 4 (p=0.014). Similar to current marital status, these relations were no longer significant when adjusting for military occupation (p=0.979, p=0.644, and p=0.961 for Models 2, 3, and 4, respectively).

The analysis of participants who reported having worked with vibrating power equipment or tools for 30 days or more revealed a significant association with initial dioxin (p=0.033) in Model 2 and with 1987 dioxin (p=0.013) in Model 4. Participants who worked with vibrating power equipment or tools had greater average initial and 1987 dioxin levels than participants who did not report having worked with vibrating power equipment or tools. After adjustment for military occupation, these associations became nonsignificant (p=0.537 for Model 2; p=0.394 for Model 4). All tests of association in Models 1 and 3 were nonsignificant for this covariate (p>0.14 for each analysis).

Tests of the association between reported exposure to heavy metals (worked for 30 days or more with lead, mercury, chromium, nickel, copper, cadmium, manganese, arsenic, selenium, or molybdenum) and

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure

		Model 1				Model 2		
Covariate	Covariate Category	Ranch Hand Mean or n (%)	Comparison Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]	Initial Dioxin (ppt) Correlation or Mean (n)	p-Value: Unadjusted	p-Value: Adjusted[a]
Current Total Household Income (dollars)	n	861	1,236			478		
(continuous)		$\bar{x}$ = $66,013	$\bar{x}$ = $65,546	0.697	0.666	r=–0.187	<0.001	0.367
(discrete)	≤ $65,000	438 (50.9)	628 (50.8)	0.999	0.956	$\bar{x}$ = 121.3 (n=267)	0.003	0.771
	> $65,000	423 (49.1)	608 (49.2)			$\bar{x}$ = 94.7 (n=211)		
Personality Type	n	867	1,251			481		
	Type A	351 (40.5)	469 (37.5)	0.178	0.148	$\bar{x}$ = 106.0 (n=184)	0.590	0.740
	Type B	516 (59.5)	782 (62.5)			$\bar{x}$ = 111.1 (n=297)		
Education	n	869	1,251			482		
	High School	456 (52.5)	684 (54.7)	0.339	0.270	$\bar{x}$ = 93.1 (n=201)	0.001	0.261
	College	413 (47.5)	567 (45.3)			$\bar{x}$ = 122.3 (n=281)		
Current Employment Status	n	869	1,251			482		
	Yes	564 (64.9)	825 (66.0)	0.652	0.719	$\bar{x}$ = 116.6 (n=319)	0.027	0.836
	No	305 (35.1)	426 (34.1)			$\bar{x}$ = 96.0 (n=163)		

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 1: Ranch Hand Mean or n (%)	Model 1: Comparison Mean or n (%)	Model 1: p-Value: Unadjusted	Model 1: p-Value: Adjusted[a]	Model 2: Initial Dioxin (ppt) Correlation or Mean (n)	Model 2: p-Value: Unadjusted	Model 2: p-Value: Adjusted[a]
Current Marital Status	n	869	1,251			482		
	Married	714 (82.2)	1,031 (82.4)	0.928	0.823	$\bar{x}$ = 105.3 (n=386)	0.082	0.282
	Not Married	155 (17.8)	220 (17.6)			$\bar{x}$ = 126.2 (n=96)		
Current Parental Status (Child Younger than 18 Years of Age)	n	869	1,251			482		
	Yes	110 (12.7)	181 (14.5)	0.260	0.301	$\bar{x}$ = 132.1 (n=67)	0.066	0.979
	No	759 (87.3)	1,070 (85.5)			$\bar{x}$ = 105.9 (n=415)		
Worked with Vibrating Power Equipment or Tools	n	869	1,249			482		
	Yes	246 (28.3)	328 (26.3)	0.321	0.287	$\bar{x}$ = 124.5 (n=150)	0.033	0.537
	No	623 (71.7)	921 (73.7)			$\bar{x}$ = 102.9 (n=332)		
Composite Exposure to Heavy Metals	n	869	1,251			482		
	Yes	110 (12.7)	178 (14.2)	0.330	0.288	$\bar{x}$ = 116.0 (n=77)	0.522	0.401
	No	759 (87.3)	1,073 (85.8)			$\bar{x}$ = 107.9 (n=405)		

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 3					
Covariate	**Covariate Category**	**Comparison Mean or n (%)**	**Background Ranch Hand Mean or n (%)**	**Low Ranch Hand Mean or n (%)**	**High Ranch Hand Mean or n (%)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Current Total Household Income (dollars)	n	1,199	376	237	241		
(continuous)		$\bar{x}$ = $65,894	$\bar{x}$ = $70,625	$\bar{x}$ = $66,698	$\bar{x}$ = $58,081	<0.001	0.835
(discrete)	≤ $65,000	603 (50.3)	167 (44.4)	114 (48.1)	153 (63.5)	<0.001	0.692
	> $65,000	596 (49.7)	209 (55.6)	123 (51.9)	88 (36.5)		
Personality Type	n	1,213	379	239	242		
	Type A	457 (37.7)	164 (43.3)	87 (36.4)	97 (40.1)	0.205	0.264
	Type B	756 (62.3)	215 (56.7)	152 (63.6)	145 (59.9)		
Education	n	1,213	380	239	243		
	High School	549 (45.3)	130 (34.2)	119 (49.8)	162 (66.7)	<0.001	0.357
	College	664 (54.7)	250 (65.8)	120 (50.2)	81 (33.3)		
Current Employment Status	n	1,213	380	239	243		
	Yes	806 (66.5)	240 (63.2)	144 (60.3)	175 (72.0)	0.031	0.398
	No	407 (33.6)	140 (36.8)	95 (39.8)	68 (28.0)		
Current Marital Status	n	1,213	380	239	243		
	Married	1,006 (82.9)	322 (84.7)	201 (84.1)	185 (76.1)	0.033	0.635
	Not Married	207 (7.1)	58 (15.3)	38 (15.9)	58 (23.9)		

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 3: Comparison Mean or n (%)	Model 3: Background Ranch Hand Mean or n (%)	Model 3: Low Ranch Hand Mean or n (%)	Model 3: High Ranch Hand Mean or n (%)	p-Value: Unadjusted	p-Value: Adjusted[a]
Current Parental Status (Child Younger than 18 Years of Age)	n	1,213	380	239	243		
	Yes	176 (14.5)	41 (10.8)	26 (10.9)	41 (16.9)	0.069	0.644
	No	1,037 (85.5)	339 (89.2)	213 (89.1)	202 (83.1)		
Worked with Vibrating Power Equipment or Tools	n	1,211	380	239	243		
	Yes	318 (26.3)	95 (25.0)	72 (30.1)	78 (32.1)	0.142	0.242
	No	893 (73.7)	285 (75.0)	167 (69.9)	165 (67.9)		
Composite Exposure to Heavy Metals	n	1,213	380	239	243		
	Yes	174 (14.3)	33 (8.7)	35 (14.6)	42 (17.3)	0.010	0.347
	No	1,039 (85.7)	347 (91.3)	204 (85.4)	201 (82.7)		

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure (Continued)

		Model 4		
Covariate	**Covariate Category**	**1987 Dioxin (ppt) Correlation or Mean (n)**	**p-Value: Unadjusted**	**p-Value: Adjusted[a]**
Current Total Household Income (dollars)	n	854		
(continuous)		r=–0.169	<0.001	0.185
(discrete)	≤ $65,000	$\bar{x}$ = 15.9 (n=434)	<0.001	0.083
	> $65,000	$\bar{x}$ = 12.3 (n=420)		
Personality Type	n	860		
	Type A	$\bar{x}$ = 13.4 (n=348)	0.314	0.671
	Type B	$\bar{x}$ = 14.5 (n=512)		
Education	n	862		
	High School	$\bar{x}$ = 18.2 (n=411)	<0.001	0.203
	College	$\bar{x}$ = 11.0 (n=451)		
Current Employment Status	n	862		
	Yes	$\bar{x}$ = 15.0 (n=559)	0.013	0.878
	No	$\bar{x}$ = 12.4 (n=303)		
Current Marital Status	n	862		
	Married	$\bar{x}$ = 13.6 (n=708)	0.119	0.794
	Not Married	$\bar{x}$ = 15.9 (n=154)		

Table 8-7. Associations Between Other Miscellaneous Covariates and Estimates of Herbicide or Dioxin Exposure (Continued)

Covariate	Covariate Category	Model 4: 1987 Dioxin (ppt) Correlation or Mean (n)	Model 4: p-Value: Unadjusted	Model 4: p-Value: Adjusted[a]
Current Parental Status (Child Younger than 18 Years of Age)	n	862		
	Yes	$\bar{x}$ = 17.8 (n=108)	0.014	0.961
	No	$\bar{x}$ = 13.5 (n=754)		
Worked with Vibrating Power Equipment or Tools	n	862		
	Yes	$\bar{x}$ = 16.2 (n=245)	0.013	0.394
	No	$\bar{x}$ = 13.2 (n=617)		
Composite Exposure to Heavy Metals	n	862		
	Yes	$\bar{x}$ = 18.1 (n=110)	0.007	0.854
	No	$\bar{x}$ = 13.5 (n=752)		

[a] Adjusted for occupation.

Note: Means for discrete covariates were transformed from the logarithmic (base 2) scale for initial dioxin in Model 2 and from the ($\log_2$ (X+1)) scale for 1987 dioxin in Model 4.

dioxin were significant for categorized dioxin in Model 3 (p=0.010) and 1987 dioxin in Model 4 (p=0.007). The percentage of Ranch Hands exposed to heavy metals increased as dioxin increased in Model 3 analyses (8.7% for Ranch Hands in the background dioxin category, 14.6% for Ranch Hands in the low dioxin category, and 17.3% for Ranch Hands in the high dioxin category). After adjustment for occupation, the association was nonsignificant (p=0.347). In Model 4, average 1987 dioxin levels were greater for participants reporting exposure to heavy metals than for participants not reporting exposure to heavy metals. The association between exposure to heavy metals and 1987 dioxin was nonsignificant after adjustment for military occupation (p=0.854). All tests of association between reported exposure to heavy metals and group in Model 1 were nonsignificant (p>0.28 for both analyses). Tests of association between reported exposure to heavy metals and initial dioxin in Model 2 also were nonsignificant (p>0.40 for both analyses).

8.9 SUMMARY

The purpose of this chapter was to determine whether the covariates used throughout this report were associated with the estimates of herbicide or dioxin exposure. Military occupation, being associated with education, may have influenced the associations between covariates and dioxin estimates. Therefore, associations between covariates and the estimates of exposure in this chapter were adjusted for military occupation but not for other known or suspected confounders. Associations between covariates and dioxin estimates should be interpreted with caution and do not necessarily reflect a causal relation.

The demographic variables of age, race, and military occupation were used as matching variables in the original study design. As expected because of the matching, there were no significant differences between Ranch Hands and Comparisons for these three variables. As exhibited in previous reports, dioxin was significantly associated with military occupation. Officers had the lowest levels, followed by enlisted flyers and enlisted groundcrew. Because the Ranch Hand enlisted groundcrew tended to be younger on average than the Ranch Hand officers and enlisted flyers, a strong negative association also was seen between dioxin levels and age. When military occupation was taken into consideration, however, dioxin exposure estimates did not appear to be related to age. Race exhibited significant associations with dioxin in that Black participants appeared to have lower dioxin levels than non-Black participants. The effect of race on dioxin levels was strengthened when military occupation was considered.

Few significant associations were seen between current alcohol use or lifetime alcohol history and group or dioxin. Wine use appeared to affect dioxin exposure estimates significantly. Lower dioxin levels were associated with more wine use, both current and lifetime. As suspected in previous reports, this phenomenon appears to be related to military occupation as officers may have consumed more wine than did enlisted personnel. When adjusting for military occupation, the association between wine use and dioxin exposure was not significant.

Significant associations were observed between current cigarette smoking and lifetime cigarette smoking history and 1987 dioxin after adjustment for military occupation.

Questions posed to the participants regarding exposure to known carcinogens were intended to indicate post-SEA exposures; however, the data suggest that the participants may have included SEA exposures as well. Significant associations were seen between dioxin and both degreasing chemicals and industrial chemicals. Adjusted analysis showed that these associations were related to military occupation. It is believed that fewer officers were exposed to industrial chemicals and degreasing chemicals than enlisted personnel. The percentage of Comparisons exposed to ionizing radiation was larger than the percentage of Ranch Hands exposed; however, a greater percentage of Ranch Hands was exposed to herbicides and insecticides and may indicate that Ranch Hands were more likely to report SEA or pre-SEA exposures as well.

The significant associations between dioxin and health measurements, such as cholesterol, HDL, the cholesterol-HDL ratio, physical activity level, and diabetic class, are likely to be explained by body fat. Higher body fat measurements are known to correspond to higher dioxin levels, lower levels of HDL cholesterol, and higher cholesterol-HDL ratios, as well as diabetes. Also, higher body fat is more likely to occur with sedentary lifestyles.

Of covariates related to sun exposure, Ranch Hands with darker hair tended to have higher levels of initial dioxin than those with lighter-colored hair. The relation between dioxin and hair color was explained by military occupation. Dioxin estimates appeared to differ with eye color in that those with brown eyes tended to have higher dioxin levels. Although eye and hair color are related, from the adjusted analysis, it did not appear that the relation between eye color and dioxin could be explained by military occupation. A larger percentage of Ranch Hands lived in latitudes farther from the equator than did Comparisons, and higher levels of dioxin were seen for those participants who live in more southerly latitudes. No significant associations were observed with the reaction to sun exposure covariates.

The relations between dioxin and current total household income, education, current employment status, current marital status, and having a child younger than 18 years old appear to be directly related to military occupation. Participants who were officers at the time of service in SEA have larger current incomes than participants who were enlisted at the time of service in SEA. Officers have the lowest dioxin levels (Table 2-8); consequently, there was a negative association between income and dioxin. A larger percentage of Ranch Hand officers tended to be college graduates than enlisted personnel, and, consequently, college graduates had lower dioxin levels than high school graduates. Differences in current employment may be due to age, income, and level of education. Current marital and parental status may be related to military occupation directly or indirectly through the relation between military occupation and socioeconomic factors.

8.10 CONCLUSION

The purpose of this chapter was to determine whether the covariates used throughout this report were associated with the estimates of dioxin exposure and, therefore, could potentially be confounding variables in subsequent statistical analyses in this report. Military occupation, being associated with education, may have influenced the associations between covariates and dioxin estimates. The associations between covariates and the estimates of dioxin exposure in this chapter were adjusted for military occupation, but not for other known or suspected confounders. Therefore, associations between covariates and dioxin estimates should be interpreted with caution.

In general, the Ranch Hand and Comparison groups were similar for the majority of the covariates; however, exceptions included reported herbicide exposure, insecticide exposure, and average lifetime latitude. A greater percentage of Ranch Hands than Comparisons reported herbicide exposure. Although the questionnaire had been structured to indicate post-SEA exposure only, a possible explanation for this association between group and herbicide exposure may have been the tendency of Ranch Hands to report their exposure to dioxin during their time of duty in SEA. A greater percentage of Ranch Hands reported exposure to insecticides than did Comparisons. More Comparisons than Ranch Hands lived in the more southerly latitudes. Ranch Hands who lived in the more southerly latitudes had a higher average initial and 1987 dioxin level than Ranch Hands living in the more northerly latitudes.

Most of the significant associations between dioxin and the covariates in the Ranch Hand group can be explained at least partially by the effects of military occupation or body fat. Of the three occupational cohorts, enlisted groundcrew had the highest levels of 1987 and initial dioxin. Adjusted analyses in the clinical chapters fully account for group, age, occupation, and other potential confounders to further investigate significant associations between covariates and dioxin. Body fat and the half-life of dioxin were known to be related, and the Models 2 and 3 analyses in the clinical chapters adjusted for body fat. In addition, body fat was used as a risk factor where appropriate. The reader is referred to these chapters for a more complete assessment of the effect of dioxin on the relevant medical endpoints.