

## CHAPTER 9

### GENERAL HEALTH ASSESSMENT

#### INTRODUCTION

##### Background

Though the potentially lethal consequences of acute phenoxy herbicide intoxication have been well documented (1-3), the long-term effects of herbicide exposure on human health remain undefined. Epidemiologic studies published in the scientific literature have focused on specific clinical endpoints, particularly malignancy, and have been based on cohorts of Vietnam veterans (4-9) and on civilian populations exposed to trichlorophenols by occupation (10-18) or as a consequence of industrial accidents (19-23). These studies and others have been addressed in several recent review articles (24-31).

In laboratory animals, dioxin toxicity is species- and strain-specific and appears to correlate with the presence of a stereospecific protein receptor, aryl hydrocarbon (Ah) receptor found in the cytosol of selected organs and capable of binding aromatic hydrocarbons (32-36). Research into the molecular and cellular mechanisms of dioxin toxicity has been summarized in the recent comprehensive literature reviews of the Veterans Health Services and Research Administration (37-39). Although Ah receptors have been isolated in the tissue of several human organs (40-45), the relevance of these observations to dioxin toxicity remains to be proven (46). Epidemiologic studies have focused on biologic endpoints defined in animal models including immunotoxicity, carcinogenicity, genetic and reproductive outcomes, hepatotoxicity, and neurotoxicity. In the chapters that follow, each of these endpoints will be considered in detail.

Common to all of the early epidemiologic studies of the effects of herbicides on human health was the inability to estimate dioxin exposure accurately. Currently available techniques permit the accurate detection (in parts per quadrillion [ppq]) of dioxin in human adipose tissue and in blood (47-49). In a preliminary study, based on serum levels in 36 subjects, a dioxin half-life of 7.1 years was derived (50). The extent of past exposure now can be derived objectively. More recent studies have established that obese subjects have longer dioxin half-lives than lean subjects (51,52), a finding that may prove relevant to the development of clinical endpoints related to obesity.

The importance of the serum dioxin assay to the credibility of this and other epidemiologic studies on the effects of dioxin on human health cannot be overemphasized. The Centers for Disease Control (CDC) study of serum dioxin levels demonstrated that all estimates of exposure employed previously in Vietnam veterans were imprecise, and that there was no significant difference in the current body burden of dioxin between most Vietnam and non-Vietnam veterans of the same era (53,54). Published reports leave no doubt that, of the approximately 3 million members of the Armed Forces who served in Southeast Asia (SEA), the 1,300 Air Force Ranch Hand personnel were among those most highly exposed to dioxin, and that, within this group, the enlisted groundcrew responsible for

handling the herbicide and for maintaining the herbicide spray equipment were at greatest risk (4,55).

Apart from the current study, a few other published reports on exposed populations include information on serum dioxin levels. These include occupational exposure occurring in the manufacture of dioxin-contaminated chemicals in the United States (10,56-58) and Germany (21,59) and civilians exposed as a consequence of an industrial explosion in Seveso, Italy (20,60). As the only other longitudinal epidemiologic studies that correlate clinical endpoints with the proven body burden of dioxin, these will receive special attention in the chapters that follow.

Finally, as will be discussed below, the Air Force Health Study (AFHS) has incorporated five variables into the current analyses including self-perception of health, appearance of illness or distress during the examination, relative age, percent body fat, and erythrocyte sedimentation rate. In the most recent Serum Dioxin Analysis Report (61), the first to correlate these indices with serum 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD, or dioxin) levels, positive associations were noted with the perception of ill health and the percent body fat. Furthermore, a slight but statistically significant increase in the sedimentation rate was noted as initial dioxin levels increased. These results have raised the possibility of an occult dioxin-induced disease process and point to the need for surveillance in this and subsequent examination cycles.

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

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

Five general health variables were included in the 1982 Baseline examination: self-perception of health, appearance of illness or distress, relative age, percent body fat, and sedimentation rate. In the analysis of the Baseline examination data, a statistically significant difference in self-perception of health was found between the Ranch Hand and Comparison groups, with a greater percentage of Ranch Hands reporting their health as fair or poor than Comparisons (20.6% vs. 14.2%). This was true in both the younger and older age groups (Est. RR=1.82,  $p=0.017$  for individuals 40 or younger and Est. RR=1.35,  $p=0.025$  for individuals older than 40). Since only 9 of 1,811 individuals were reported by the examining physician as appearing ill or distressed, this designation was apparently reserved for only very ill or distressed individuals. Nevertheless, eight of the nine individuals were Ranch Hands, the difference being of marginal significance ( $p=0.056$ ). Conversely, more Ranch Hands than Comparisons were reported by the examiners as appearing younger than their actual ages (4.9% vs. 2.5%,  $p=0.029$ ). No overall differences in percent body fat or sedimentation rate were found, although a significant interaction between group and age for sedimentation rate was noted; younger Ranch Hands had fewer sedimentation rate abnormalities than did Comparisons, whereas no difference was found in participants older than 40.

### ***1985 Followup Study Summary Results***

General physical health was evaluated by the same five measures used in the Baseline examination (self-perception of health, appearance of illness or distress, relative age, percent body fat, and sedimentation rate). The Ranch Hands again rated their health as fair or poor more often than the Comparisons (9.1% vs. 7.3% respectively), although this difference was not statistically significant. However, further analysis revealed a significant group-by-occupation interaction. Differences were largely confined to the enlisted groundcrew category where the adjusted relative risk was 1.90 ( $p=0.003$ ).

Ten individuals were reported as appearing acutely ill or distressed at the 1985 followup examination. In contrast to the Baseline examination, four were Ranch Hands and six were Comparisons; thus, no group difference was suggested. Relative age, as determined by the examining physician, was not significantly different in the two groups.

The (geometric) mean sedimentation rates did not differ significantly, either unadjusted or after adjustment for age, race, occupation, personality score, and an age-by-personality score interaction. However, in the discrete analysis, 5.8 percent of the Ranch Hands had sedimentation rate abnormalities ( $>20$  mm/hr), contrasted to 3.6 percent in the Comparison group. This difference was significant both unadjusted ( $p=0.013$ ) and adjusted for age and personality score ( $p=0.011$ ).

The mean percent body fat of the Ranch Hands was significantly lower than the Comparisons (21.10 vs. 21.54,  $p=0.037$ ), and the difference was of nearly the same magnitude after adjustment for age, race, and occupation.

Longitudinal differences between the 1982 Baseline and the 1985 followup examination were assessed by analyses of two discrete variables: self-perception of health and sedimentation rate. Analysis of self-perception of health showed no significant group differences in the change over time, with the Ranch Hand and Comparison groups reporting symmetrical improvements in their perceptions over the 3-year period. The sedimentation rate analysis, however, revealed a highly significant group difference ( $p=0.002$ ), due to a reversal of findings between examinations (i.e., a significant detriment in the [younger] Comparisons at the Baseline examination versus a significant detriment in the Ranch Hands at the followup examination).

### ***1987 Followup Study Summary Results***

The general health in the Ranch Hand and Comparison groups was assessed by five measures: self-perception of health, appearance of illness or distress, relative age, percent body fat, and sedimentation rate. There were no significant group differences, either unadjusted or adjusted for covariates (age, race, occupation, and, in the case of self-perception of health and sedimentation rate, personality type), nor were there any significant group-by-covariate interactions for self-perception of health, appearance of illness or distress, relative age, or percent body fat. There was little difference in the geometric mean values of sedimentation rate in the two groups, but Ranch Hands had a significantly higher percentage of individuals with an abnormal sedimentation rate ( $>20$  mm/hr) than Comparisons.

However, only three participants (two Ranch Hands and one Comparison) were found to have rates in excess of 100 mm/hr; one of these (a Comparison) proved to have lung cancer and died in early 1989. No diagnosis was established for either of the two Ranch Hands during the course of the 1987 examination. Longitudinal analyses revealed a similar decline in both groups over time in the percentage of individuals reporting their health as fair or poor. For sedimentation rate, there was a significant difference between groups in the change from Baseline to the 1987 followup examination, with a relatively greater number of Ranch Hands than Comparisons shifting from normal at Baseline to abnormal at the followup examination.

### ***Serum Dioxin Analysis of 1987 Followup Study Summary Results***

In general, percent body fat and sedimentation rate exhibited significant positive associations with initial dioxin. The other variables exhibited positive but nonsignificant associations with initial dioxin. The unadjusted and adjusted analyses of relative age exhibited significant interactions between current dioxin and time since tour of duty. For Ranch Hands with 18.6 years or less since the end of duty in SEA, the associations between relative age and current dioxin were positive and at least marginally significant for each analysis type and assumption. For the other variables, the current dioxin-by-time analyses generally displayed nonsignificant but positive associations with current dioxin.

In general, the unadjusted and adjusted analyses for the four current dioxin categories overall exhibited significant contrasts for percent body fat and sedimentation rate, and the high versus background contrast and the low versus background contrast were significant with the Ranch Hands exceeding Comparisons. The percent body fat results for the four current dioxin categories displayed an increasing association with dioxin within the Ranch Hands (i.e., unknown, low, and high categories); however, the background category for Comparisons exceeded the unknown category for Ranch Hands.

The longitudinal analyses of self-perception of health demonstrated significant positive associations with initial dioxin and current dioxin. However, the percentage of participants who reported fair or poor health decreased by more than 50 percent from 1982 to 1987. In the longitudinal analyses of sedimentation rate, the percentages of abnormalities in 1987 differed significantly among the current dioxin categories.

In summary, with the exception of the sedimentation rate, the data analyzed in the General Health Assessment did not reveal any health detriment consequent to herbicide exposure or to the current body burden of dioxin.

### **Parameters for the General Health Assessment**

#### ***Dependent Variables***

The General Health Assessment was based on data from the 1992 questionnaire, physical examination, and laboratory examination data.

## Questionnaire Data

During the health interview administered through the 1992 National Opinion Research Center (NORC) Questionnaire, each study participant was asked, "Compared to other people your age, would you say your health is excellent, good, fair, or poor?" This self-reported perception was analyzed as a measure of the general health status of each participant, although it was recognized that the perception was susceptible to varying degrees of conscious and subconscious bias (most participants were aware of their serum dioxin levels). This variable was dichotomized as "excellent or good" and "fair or poor" for statistical analyses. No participants were excluded for medical reasons from the analysis of this variable.

## Physical Examination Data

Three variables derived from the 1992 Scripps Clinic and Research Foundation (SCRF) physical examination were analyzed in the assessment of general health. For the first variable, the physician at the examination recorded the appearance of illness or distress (yes, no) of the study participant. For the second variable, the physician noted the appearance of the subject as younger than, older than, or the same as his stated age. This variable was dichotomized as "older than" and "same as or younger than" for statistical analyses. To the degree that the examining physicians are kept blind to the participant's group membership, these assessments were less subject to bias than the self-perception of health.

The third variable, body fat, was a measure of the relative body mass of an individual and was calculated from height (in meters) and weight (in kilograms) recorded at the physical examination. Non-ambulatory participants were weighed on a Scale-Tronix® 6006, which allowed a participant to be weighed in a wheelchair, if necessary. Body fat was calculated from a metric body mass index (62); the formula is

$$\text{Body Fat (in percent)} = \frac{\text{Weight (kg)}}{[\text{Height (m)}]^2} \cdot 1.264 - 13.305.$$

This variable was analyzed in both the discrete and continuous forms. A natural logarithmic transformation was used to enhance normality. For purposes of discrete analyses, body fat was dichotomized as "lean or normal" ( $\leq 25$  percent) and "obese" ( $> 25$  percent). Lean participants (less than 10 percent body fat) were categorized with normal participants because few of the people in this study fit this definition (2 Ranch Hands and 4 Comparisons). This variable did not reflect changes in weight since time of duty in SEA.

To examine the association between body fat and exposure independent of the effects of diet, body fat also was analyzed adjusting for the covariate caloric intake. Caloric intake was not removed from the analysis during stepwise model reduction procedures; consequently, these results differed from the analysis results that do not consider caloric intake a covariate. This analysis is a further study motivated by the results observed from

the serum dioxin analysis of the 1987 followup examination data. No participants were excluded for medical reasons from the analyses of these three variables.

### **Laboratory Examination Data**

The erythrocyte sedimentation rate (mm/hr), measured at the laboratory examination, was analyzed. Although nonspecific, a high sedimentation rate is a generally accepted indicator of an ongoing disease process. A natural logarithmic transformation was used to enhance normality. This variable was analyzed in both the discrete and continuous forms. Additionally, 0.1 was added to each measurement before the transformation due to the presence of zeros. No participants were excluded for medical reasons from the analysis of this variable.

### ***Covariates***

The effects of the covariates age, race (Black, non-Black), military occupation (officer, enlisted flyer, enlisted groundcrew), personality type (Type A, Type B), and caloric intake were examined in the assessment of general health in adjusted statistical analyses. Age, race, and occupation were used for analyses with all dependent variables. Age was used in its continuous form for all adjusted analyses. Personality type was used in the analysis of self-perception of health and sedimentation rate only. Personality type was determined from the Jenkins Activity Survey administered during the 1992 followup examination. This variable was derived from a discriminant-function equation based on questions that best discriminate men judged to be Type A from those judged to be Type B (63). Positive scores reflected the Type A direction; negative scores reflected the Type B direction. Personality type was dichotomized as Type A or Type B for all analyses of self-perception of health and sedimentation rate.

As mentioned above, body fat also was analyzed adjusting for the covariate caloric intake to examine the association between body fat and exposure independent of the effects of diet. The caloric intake variable was based on responses to the Diet Assessment Questionnaire administered along with the 1992 NORC Questionnaire. A measurement combining components of the Diet Assessment Questionnaire, based on a review of existing literature, was used to construct a caloric intake index (64).

### **Statistical Methods**

Chapter 7, Statistical Methods, describes the basic statistical methods used throughout this report. Table 9-1 summarizes the statistical analyses performed for the General Health Assessment. The first part of this table describes the dependent variables and identifies the candidate covariates and the statistical methods. The second part of the table further describes the candidate covariates. The abbreviations used in the body of the table are defined at the end of the table. Table 9-2 provides participants with missing dependent variable and covariate data.

Cutpoints for sedimentation rate are age-dependent. Consequently, normal and abnormal levels for sedimentation rate are constructed according to a participant's laboratory

**Table 9-1.**  
**Statistical Analyses for the General Health Assessment**

**Dependent Variables**

<b>Variable (Units)</b>	<b>Data Source</b>	<b>Data Form</b>	<b>Cutpoints</b>	<b>Candidate Covariates</b>	<b>Statistical Analysis</b>
Self-Perception of Health	Q-SR	D	Fair or Poor Excellent or Good	AGE,RACE, OCC,PERS	U:LR,CS A:LR L:LR
Appearance of Illness or Distress as Assessed by Physician	PE	D	Yes No	AGE,RACE, OCC	U:LR,CS A:LR L:LR
Relative Age Appearance as Assessed by Physician	PE	D	Older Same or Younger	AGE,RACE, OCC	U:LR,CS A:LR L:LR
Body Fat (percent)	PE	D/C	Obese: >25% Lean or Normal: ≤25%	AGE,RACE, OCC,CAL	U:LR,CS, GLM,TT A:LR,GLM L:LR,GLM
Sedimentation Rate (mm/hr)	LAB	D/C	Abnormal: >15 (40-49) >20 (≥50) Normal: ≤15 (40-49) ≤20 (≥50)	AGE,RACE, OCC,PERS	U:LR,CS, GLM,TT A:LR,GLM L:LR,GLM

**Covariates**

<b>Variable (Abbreviation)</b>	<b>Data Source</b>	<b>Data Form</b>	<b>Cutpoints</b>
Age (AGE)	MIL	D/C	Born ≥ 1942 Born < 1942
Race (RACE)	MIL	D	Black Non-Black
Occupation (OCC)	MIL	D	Officer Enlisted Flyer Enlisted Groundcrew
Personality Type (PERS)	PE	D	A Direction B Direction
Caloric Intake (CALINT) (kcal/day)	Q-SR	D/C	≤2,000 >2,000

**Table 9-1. (Continued)  
Statistical Analyses for the General Health Assessment**

**Abbreviations**

Data Source:	LAB = 1992 laboratory results
	MIL = Air Force military records
	PE = 1992 physical examination
	Q-SR = 1992 health questionnaire (self-reported)
Data Form:	D = Discrete analysis only
	D/C = Discrete and continuous analysis for dependent variables; appropriate form for analysis (either discrete or continuous) for covariates
Statistical Analyses:	U = Unadjusted analyses
	A = Adjusted analyses
	L = Longitudinal analyses
Statistical Methods:	CS = Chi-square contingency table analysis (continuity-adjusted for 2 x 2 tables)
	GLM = General linear models analysis
	LR = Logistic regression analysis
	TT = Two-sample t-test

**Table 9-2.  
Number of Participants with Missing Data for the General Health Assessment**

Variable	Variable Use	Group		Dioxin (Ranch Hands Only)		Categorized Dioxin	
		Ranch Hand	Comparison	Initial	Current	Ranch Hand	Comparison
Self-Perception of Health	DEP	0	2	0	0	0	2
Sedimentation Rate	DEP	0	1	0	0	0	0
Caloric Intake	COV	2	2	2	2	2	2
Personality Type	COV	1	1	1	1	1	1

Abbreviations: DEP = Dependent variable.  
COV = Covariate.

Note: 952 Ranch Hands and 1,281 Comparisons;  
520 Ranch Hands for initial dioxin; 894 Ranch Hands for current dioxin;  
894 Ranch Hands and 1,063 Comparisons for categorized dioxin.

One Ranch Hand missing total lipids for current dioxin.

value and age at the physical examination. The age-specific cutpoints also are listed in Table 9-1, and the reference ages for these cutpoints are given in parentheses following the cutpoints.

Analyses of data collected at the 1987 followup study indicated that dioxin was associated with military occupation. In general, enlisted personnel had higher levels of dioxin than officers, with enlisted groundcrew having higher levels than enlisted flyers. Consequently, adjustment for military occupation in statistical models using dioxin as a measure of exposure may improperly mask an actual dioxin effect. However, occupation also can be a surrogate for socioeconomic effects. Failure to adjust for occupation could overlook important risk factors related to lifestyle. If occupation was found to be significantly associated with a dependent variable in the 1992 followup analyses and was retained in the final statistical models using dioxin as a measure of exposure, the dioxin effect was evaluated in the context of two models. Analyses were performed with and without occupation in the final models to investigate whether conclusions regarding the association between the health endpoint and dioxin differed.

The results of the analyses without occupation are presented in Appendix E-3 and are only discussed in the text if the level of significance differs from the original final adjusted model (significant versus nonsignificant).

### ***Longitudinal Analysis***

Longitudinal analyses on all of the variables described above (self-perception of health, appearance of illness or distress by the physician, relative age, body fat, and sedimentation rate) were conducted to evaluate the changes between the 1982 Baseline examination and the 1992 followup examination. Longitudinal analyses were conducted on body fat in the continuous and discrete forms but without adjustment for caloric intake. The absence of information on caloric intake from 1982 precludes this adjustment.

The sedimentation rate abnormal cutpoints differ by examination date and age. For the 1982 Baseline examination, the cutpoint was 12 mm/hr for all participants (that is, sedimentation rates greater than 12 mm/hr were considered abnormal). For the 1985, 1987, and 1992 followup examinations, the cutpoint was 15 mm/hr for participants younger than 50 and 20 mm/hr for participants at least 50 years old at the time of the examination. A participant is considered to be normal or abnormal based on his age and the cutpoint at the given examination for discrete analyses. Methods of compensation for the change in cutpoints over time for the continuous analyses include the use of age and the measurement in 1982 as covariates (see Chapter 7, Statistical Methods, for a further discussion of methods used in longitudinal analyses).

## **RESULTS**

### **Dependent Variable-Covariate Associations**

The covariate tests of association for self-perception of health showed that occupation and age were both significant covariates (Appendix Table E-1-1:  $p=0.001$  and  $p=0.082$

respectively). The percentages of officers, enlisted flyers, and enlisted groundcrew who perceived their health as fair or poor were 5.9, 11.2, and 10.2 respectively. Of the participants born before 1942, 9.6 percent reported their health as fair or poor in comparison to 7.4 percent of the participants born in or after 1942.

For appearance of illness or distress, tests of covariate association found age to be a significant covariate (Appendix Table E-1-1:  $p=0.041$ ). For participants born before 1942, 2.4 percent appeared ill or distressed at the physical examination, whereas for participants born in or after 1942, 1.2 percent appeared ill or distressed.

Tests of covariate association found a high association between relative age appearance and both occupation ( $p=0.001$ ) and race ( $p=0.045$ ). The analysis of occupation revealed that 3.6 percent of the officers appeared older than their age, while 8.0 percent of the enlisted flyers and 7.2 percent of the enlisted groundcrew looked older than their actual age. The percentages of abnormalities for the Black and non-Black categories were 1.5 percent and 6.2 percent respectively.

The results of the tests of covariate association for body fat (discrete) revealed that occupation and caloric intake were statistically significant ( $p=0.005$  and  $p=0.048$  respectively). For the occupation analysis, the percentages of participants with body fat above 25 percent were 22.7 percent for officers, 23.3 percent for enlisted flyers, and 28.8 percent for enlisted groundcrew. The caloric intake analysis showed that 27.1 percent of the participants who consumed no more than 2,000 calories per day were obese, while 23.3 percent of the participants who consumed more than 2,000 calories per day were obese.

For body fat (continuous), tests of covariate association were significant for occupation ( $p=0.039$ ) and caloric intake ( $p=0.001$ ). Mean body fat was 21.64 percent in the officer category and 21.65 percent in the enlisted flyer category. For enlisted groundcrew, average body fat was 22.20 percent. For the caloric intake analysis, the correlation coefficient between body fat and caloric intake was  $-0.070$ .

The tests of covariate association for sedimentation rate (discrete) showed that both occupation and personality type were significant covariates ( $p=0.001$  and  $p=0.005$  respectively). The percentages of abnormalities for officers, enlisted flyers, and enlisted groundcrew were 14.0, 22.3, and 18.9 respectively. For those participants with a Type A personality, 14.9 percent had an abnormal sedimentation rate as compared to 19.5 percent of participants with a Type B personality.

In the covariate analysis of sedimentation rate (continuous), occupation, personality type, and age were statistically significant ( $p=0.002$ ,  $p<0.001$ , and  $p<0.001$  respectively). Average sedimentation rate was 7.64 mm/hr for officers, 9.27 mm/hr for enlisted flyers, and 8.15 mm/hr for enlisted groundcrew. In the analysis of personality type, the mean sedimentation rate was 7.46 mm/hr for Type A participants and 8.63 mm/hr for Type B participants. The test of covariate association for sedimentation rate and age revealed a statistically significant positive correlation between the two variables ( $r=0.214$ ).

## **Exposure Analysis**

The following section presents results of the statistical analyses of the dependent variables shown in Table 9-1. Dependent variables are grouped into three sections: those derived from the questionnaire administered in the 1992 followup examination, data obtained during the 1992 physical examination, and data derived from the laboratory portion of the 1992 followup examination.

Unadjusted and adjusted analyses of six models are presented for each variable. Model 1 examines the relationship between the dependent variable and group (Ranch Hand or Comparison). Model 2 explores the relationship between the dependent variable and an extrapolated initial dioxin measure for Ranch Hands who had a 1987 dioxin measurement greater than 10 ppt. If a participant did not have a 1987 dioxin level, a 1992 level was used. A statistical adjustment for the percent of body fat at the participant's time of duty in SEA and the change in the percent of body fat from the time of duty in SEA to the date of the blood draw for dioxin is included in this model to account for body-fat-related differences in elimination rate (51). Model 3 dichotomies the Ranch Hands in Model 2 based on their initial dioxin measures; these two categories of Ranch Hands are referred to as the "low Ranch Hand" category and the "high Ranch Hand" category. These participants are added to Ranch Hands and Comparisons with current serum dioxin levels (1987, if available; 1992, if the 1987 level was not available) at or below 10 ppt to create a total of four categories. Ranch Hands with current serum dioxin levels at or below 10 ppt are referred to as the "background Ranch Hand" category. The relationship between the dependent variable in each of the three Ranch Hand categories and the dependent variable in the "Comparison" category is examined. A fourth contrast, exploring the relationship of the dependent variable in the low Ranch Hand category and the high Ranch Hand category combined, also is conducted. This combination is referred to in the text and tables as the "low plus high Ranch Hand" category. As in Model 2, a statistical adjustment is made for the percent of body fat at the participant's time of duty in SEA and the change in the percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

Models 4, 5, and 6 examine the relationship between the dependent variable and 1987 dioxin levels in all Ranch Hands with a dioxin measurement. If a participant did not have a 1987 dioxin measurement, a 1992 measurement was utilized in determining the current dioxin level. The measure of dioxin in Model 4 is lipid-adjusted, whereas whole-weight current dioxin is used in Models 5 and 6. Model 6 differs from Model 5 in that a statistical adjustment for total lipids is included in Model 6. Further details on dioxin and the modeling strategy are found in Chapters 2 and 7 respectively.

Results of investigations for group-by-covariate and dioxin-by-covariate interactions are referenced in the text, and tabular results are presented in Appendix E-2. As described previously, additional analyses were performed when occupation was retained in the final models for Models 2 through 6. Results excluding occupation from these models are tabled in Appendix E-3. Results from analyses excluding occupation are discussed in the text only if a meaningful change in the results occurred (that is, changes between significant results, marginally significant results, and nonsignificant results).

## *Questionnaire Variable*

### **Self-Perception of Health**

In the Model 1 unadjusted analysis of self-perception of health, a significant group difference existed between Ranch Hands and Comparisons (Table 9-3(a):  $p=0.017$ , Est. RR=1.45), with 10.4 percent of Ranch Hands and 7.4 percent of Comparisons reporting their health as fair or poor. Stratification by occupation revealed a significant estimated relative risk for enlisted groundcrew ( $p=0.031$ , Est. RR=1.60) but nonsignificant relative risks for officers and enlisted flyers. For the enlisted groundcrew stratum, 12.8 percent of the Ranch Hands perceived their health as fair or poor compared to 8.4 percent of the Comparisons. The Model 1 results of the adjusted analysis closely parallel those of the unadjusted analysis. The relative risk for Ranch Hands versus Comparisons was significant (Table 9-3(b):  $p=0.016$ , Adj. RR=1.44) and, of the three occupational strata, only enlisted groundcrew exhibited a significant adjusted relative risk ( $p=0.023$ , Adj. RR=1.62). Significant covariates included occupation and age.

The unadjusted analysis of self-perception of health for Model 2 uncovered a significant association with initial dioxin (Table 9-3(c):  $p=0.049$ , Est. RR=1.21). For the low, medium, and high initial dioxin categories, the percentages of Ranch Hands who reported their health as poor or fair were 10.3, 13.9, and 13.9 respectively. Although the relative risk was nonsignificant in the adjusted analysis (adjusted for age and occupation) (Table 9-3(d):  $p=0.120$ ), removal of occupation from the final model caused the initial dioxin effect to become significant (Appendix Table E-3-1:  $p=0.010$ , Adj. RR=1.30).

In the unadjusted analysis for Model 3, the percentage of participants who perceived their health as fair or poor was significantly higher in both the high Ranch Hand dioxin category (15.0%) and low plus high Ranch Hand dioxin category (12.7%) than in the Comparison dioxin category (7.0%) (Table 9-3(e): high Ranch Hands vs. Comparisons: Est. RR=2.20,  $p<0.001$ , low plus high Ranch Hands vs. Comparisons: Est. RR=1.82,  $p=0.001$ ). The adjusted analysis also uncovered significant differences between high Ranch Hands and Comparisons (Table 9-3(f): Adj. RR=1.84,  $p=0.005$ ) as well as between low plus high Ranch Hands and Comparisons (Adj. RR=1.65,  $p=0.006$ ). Age and occupation were significant covariates retained in the categorized dioxin adjusted analyses. In addition, the contrast involving low Ranch Hands and Comparisons became marginally significant after removing occupation from the final model (Appendix Table E-3-1:  $p=0.090$ , Adj. RR=1.50).

Each of the unadjusted analyses for Models 4, 5, and 6 revealed a significant relationship between self-perception of health and current dioxin (Table 9-3(g):  $p=0.002$ ,  $p<0.001$ , and  $p=0.018$  respectively). The current dioxin-by-age interaction was significant in all three adjusted analyses for Models 4, 5, and 6 (Table 9-3(h):  $p=0.039$ ,  $p=0.021$ , and  $p=0.016$  respectively), and occupation was also included in the final models. Appendix Table E-2-1 displays results stratified by age. After removing this interaction from the final models, current dioxin was marginally significant in Model 4 (Adj. RR=1.17,  $p=0.065$ ) and significant in Model 5 (Adj. RR=1.18,  $p=0.024$ ), but nonsignificant in Model 6 ( $p=0.291$ ). In addition, once occupation was removed from each of the final models, the interaction of

**Table 9-3.**  
**Analysis of Self-Perception of Health**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Fair or Poor</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>10.4</i>	<i>1.45 (1.08,1.94)</i>	<i>0.017</i>
	<i>Comparison</i>	<i>1,279</i>	<i>7.4</i>		
Officer	Ranch Hand	367	6.0	1.04 (0.59,1.84)	0.999
	Comparison	502	5.8		
Enlisted Flyer	Ranch Hand	162	14.2	1.70 (0.88,3.27)	0.151
	Comparison	203	8.9		
Enlisted Groundcrew	Ranch Hand	423	12.8	1.60 (1.06,2.42)	0.031
	Comparison	574	8.4		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>1.44 (1.07,1.94)</i>	<i>0.016</i>	OCC (p < 0.001) AGE (p < 0.001)
Officer	1.03 (0.38,1.82)	0.926	
Enlisted Flyer	1.68 (0.87,3.25)	0.121	
Enlisted Groundcrew	1.62 (1.07,2.45)	0.023	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-3. (Continued)  
Analysis of Self-Perception of Health**

<b>c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Fair or Poor</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	10.3	1.21 (1.00,1.46)	0.049
Medium	173	13.9		
High	173	13.9		

<b>d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>			
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
520	1.19 (0.96,1.47)	0.120	OCC (p=0.099) AGE (p=0.012)

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-3. (Continued)**  
**Analysis of Self-Perception of Health**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY -- UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Fair or Poor</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,061	7.0		
Background RH	374	6.7	1.06 (0.66,1.70)	0.815
Low RH	260	10.4	1.47 (0.92,2.34)	0.107
High RH	260	15.0	2.20 (1.45,3.34)	<0.001
Low plus High RH	520	12.7	1.82 (1.28,2.60)	0.001

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY -- ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>ac</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,061			AGE (p<0.001) OCC (p<0.001)
Background RH	374	1.29 (0.79,2.11)	0.302	
Low RH	260	1.44 (0.90,2.31)	0.131	
High RH	260	1.84 (1.20,2.84)	0.005	
Low plus High RH	520	1.65 (1.15,2.36)	0.006	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-3. (Continued)**  
**Analysis of Self-Perception of Health**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Fair or Poor/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	6.8 (295)	9.3 (300)	14.4 (299)	1.26 (1.09,1.45)	0.002
5	6.3 (300)	10.1 (297)	14.1 (297)	1.26 (1.11,1.43)	<0.001
6 <sup>c</sup>	6.4 (299)	10.1 (297)	14.1 (297)	1.18 (1.03,1.36)	0.018

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>n</b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			<b>Covariate Remarks</b>
		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>		
4	894	1.17 (0.99,1.38)**	0.065**		CURR*AGE (p=0.039) OCC (p<0.001)
5	894	1.18 (1.02,1.37)**	0.024**		CURR*AGE (p=0.021) OCC (p<0.001)
6 <sup>d</sup>	893	1.09 (0.93,1.27)**	0.291**		CURR*AGE (p=0.016) OCC (p<0.001)

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted relative risk, confidence interval, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-1 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.  
 CURR = Log<sub>2</sub> (current dioxin + 1).

current dioxin and age became nonsignificant and was therefore removed from the supplemental model. In doing so, current dioxin was significant (Appendix Table E-3-1:  $p \leq 0.003$  for Models 4 through 6).

### ***Physical Examination Variables***

#### **Appearance of Illness or Distress**

As shown in Table 9-4(a), the Model 1 unadjusted analysis of the physician's assessment as to whether the study participant displayed illness or distress at the physical examination uncovered no significant differences between Ranch Hands and Comparisons ( $p > 0.25$  for all analyses). In the adjusted analysis, a marginally significant overall difference was detected between the two groups (Table 9-4(b): Adj. RR=1.44,  $p=0.093$ ); however, this difference was not significant when examined within each of the three occupational strata. Interactions between age and race and between occupation and race were significant.

For Models 2 and 3, the results from the analysis of appearance of illness or distress are shown in Table 9-4(c-f). Neither the unadjusted or adjusted analyses detected any significant associations between initial or categorized dioxin and appearance of illness or distress ( $p > 0.39$  for all analyses). The interaction of age and race was significant in the Model 2 adjusted analysis. In the Model 3 adjusted analysis, age was significant.

In each of the three unadjusted analyses for Models 4, 5, and 6, current dioxin was not significantly associated with appearance of illness or distress (Table 9-4(g):  $p > 0.26$  for all analyses). The adjusted analyses uncovered a significant interaction effect between current dioxin and age for Models 4, 5, and 6 (Table 9-4(h):  $p=0.039$ ,  $p=0.027$ , and  $p=0.028$  respectively). The results stratified by each age category are shown in Appendix Table E-2-2. Removal of the interaction from the final models did not lead to a significant current dioxin effect ( $p > 0.48$  for all models).

#### **Relative Age Appearance**

Table 9-5(a,b) displays the results from the analysis of relative age appearance for Model 1. No statistically significant group differences were detected in either the unadjusted or adjusted analyses ( $p > 0.26$  for all analyses). Occupation and race were significant in the adjusted analysis.

The unadjusted analyses for Model 2 revealed a marginally significant association between initial dioxin and relative age appearance (Table 9-5(c): Est. RR=1.29,  $p=0.070$ ). After adjusting for occupation, however, no statistically significant results were evident (Table 9-5(d):  $p=0.209$ ). For Model 3, the relationship between categorized dioxin and relative age appearance was nonsignificant for both the unadjusted and adjusted analyses (Table 9-5(e,f):  $p > 0.17$  for all contrasts). Significant covariates uncovered in the Model 3 adjusted analysis included race and occupation.

**Table 9-4.**  
**Analysis of Appearance of Illness or Distress**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Yes</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>2.3</i>	<i>1.49 (0.81,2.75)</i>	<i>0.258</i>
	<i>Comparison</i>	<i>1,281</i>	<i>1.6</i>		
Officer	Ranch Hand	367	2.5	2.08 (0.73,5.89)	0.254
	Comparison	502	1.2		
Enlisted Flyer	Ranch Hand	162	3.1	3.20 (0.61,16.72)	0.285
	Comparison	203	1.0		
Enlisted Groundcrew	Ranch Hand	423	1.9	0.91 (0.37,2.34)	0.999
	Comparison	576	2.1		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>1.44 (0.77,2.68)</i>	<i>0.093</i>	AGE*RACE (p<0.001) OCC*RACE (p=0.006)
Officer	1.85 (0.64,5.37)	0.258	
Enlisted Flyer	3.10 (0.60,16.07)	0.178	
Enlisted Groundcrew	0.91 (0.36,2.28)	0.841	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-4. (Continued)  
Analysis of Appearance of Illness or Distress**

<b>c) MODEL 2: RANCH HANDS — INITIAL DIOXIN — UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Yes</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	1.7	0.90 (0.57,1.43)	0.648
Medium	173	2.3		
High	173	1.7		

<b>d) MODEL 2: RANCH HANDS — INITIAL DIOXIN — ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>			
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
520	0.93 (0.56,1.54)	0.762	AGE*RACE (p=0.010)

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-4. (Continued)**  
**Analysis of Appearance of Illness or Distress**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY -- UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Yes</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,063	1.5		
Background RH	374	2.1	1.46 (0.61,3.47)	0.394
Low RH	260	2.3	1.41 (0.54,3.66)	0.482
High RH	260	1.5	0.95 (0.31,2.92)	0.924
Low plus High RH	520	1.9	1.18 (0.53,2.66)	0.685

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY -- ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,063			AGE (p=0.021)
Background RH	374	1.38 (0.58,3.28)	0.473	
Low RH	260	1.32 (0.51,3.46)	0.570	
High RH	260	1.11 (0.36,3.44)	0.854	
Low plus High RH	520	1.23 (0.55,2.77)	0.618	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): Current Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): Current Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  143 ppt.

High (Ranch Hand): Current Dioxin  $>$  10 ppt, Initial Dioxin  $>$  143 ppt.

**Table 9-4. (Continued)**  
**Analysis of Appearance of Illness or Distress**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Yes/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	2.4 (295)	1.3 (300)	2.3 (299)	0.89 (0.63,1.24)	0.469
5	2.3 (300)	1.7 (297)	2.0 (297)	0.88 (0.67,1.16)	0.372
6 <sup>c</sup>	2.3 (299)	1.7 (297)	2.0 (297)	0.89 (0.63,1.24)	0.268

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>n</b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			<b>Covariate Remarks</b>
		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>		
4	894	0.95 (0.66,1.36)**	0.779**	CURR*AGE (p=0.039)	
5	894	0.92 (0.69,1.24)**	0.596**	CURR*AGE (p=0.027)	
6 <sup>d</sup>	893	0.89 (0.65,1.22)**	0.484**	CURR*AGE (p=0.028)	

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted relative risk, confidence interval, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-2 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

**Table 9-5.**  
**Analysis of Relative Age Appearance**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS -- UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Older</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>5.5</i>	<i>0.87 (0.61,1.24)</i>	<i>0.493</i>
	<i>Comparison</i>	<i>1,281</i>	<i>6.3</i>		
Officer	Ranch Hand	367	3.0	0.75 (0.35,1.57)	0.556
	Comparison	502	4.0		
Enlisted Flyer	Ranch Hand	162	9.3	1.38 (0.65,2.94)	0.526
	Comparison	203	6.9		
Enlisted Groundcrew	Ranch Hand	423	6.2	0.76 (0.46,1.24)	0.324
	Comparison	576	8.0		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS -- ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>0.86 (0.60,1.23)</i>	<i>0.416</i>	OCC (p<0.001) RACE (p=0.002)
Officer	0.75 (0.35,1.58)	0.449	
Enlisted Flyer	1.36 (0.64,2.92)	0.425	
Enlisted Groundcrew	0.75 (0.46,1.24)	0.264	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-5. (Continued)**  
**Analysis of Relative Age Appearance**

<b>c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Older</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	4.6	1.29 (0.98,1.68)	0.070
Medium	173	6.4		
High	173	6.9		

<b>d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>			
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
520	1.22 (0.90,1.65)	0.209	OCC (p=0.129)

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-5. (Continued)**  
**Analysis of Relative Age Appearance**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Older</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,063	6.2		
Background RH	374	4.3	0.71 (0.40,1.24)	0.229
Low RH	260	4.2	0.64 (0.33,1.23)	0.177
High RH	260	7.7	1.22 (0.22,2.06)	0.460
Low plus High RH	520	6.0	0.92 (0.59,1.43)	0.710

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,063			OCC (p=0.002) RACE (p=0.004)
Background RH	374	0.86 (0.48,1.53)	0.600	
Low RH	260	0.66 (0.34,1.27)	0.212	
High RH	260	0.97 (0.57,1.67)	0.925	
Low plus High RH	520	0.83 (0.53,1.30)	0.408	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-5. (Continued)**  
**Analysis of Relative Age Appearance**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Older(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	5.4 (295)	2.7 (300)	7.7 (299)	1.08 (0.89,1.32)	0.430
5	5.3 (300)	3.0 (297)	7.4 (297)	1.04 (0.88,1.24)	0.618
6 <sup>c</sup>	5.0 (299)	3.0 (297)	7.4 (297)	1.05 (0.87,1.27)	0.605

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>				
<b>Model<sup>a</sup></b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			
	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
4	894	0.97 (0.78,1.21)**	0.785**	CURR*OCC (p=0.043)
5	894	0.95 (0.79,1.14)	0.591	OCC (p=0.010)
6 <sup>d</sup>	893	0.95 (0.77,1.16)	0.599	OCC (p=0.023)

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted relative risk, confidence interval, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-3 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

As shown in Table 9-5(g), none of the unadjusted analyses for Models 4 through 6 uncovered a significant current dioxin effect in relation to the participant's relative age appearance ( $p > 0.43$  for all analyses). The adjusted analysis for Model 4 displayed a significant interaction between current dioxin and occupation (Table 9-5(h):  $p = 0.043$ ; see Appendix Table E-2-3 for the stratified results of this interaction). Analysis with the interaction removed did not reveal a significant association between current dioxin and relative age appearance ( $p = 0.785$ ). The adjusted analyses of Models 5 and 6 led to nonsignificant results ( $p > 0.59$ ). In both Models 5 and 6, occupation was significant.

### **Body Fat (Continuous)**

The results of the group analysis of body fat for Model 1 are shown in Table 9-6(a,b). The unadjusted and adjusted analyses did not reveal any significant differences in mean body fat between Ranch Hands and Comparisons ( $p > 0.13$  for all analyses). The age-by-occupation interaction was significant in the adjusted analysis.

No significant associations were detected between body fat and initial dioxin from the unadjusted or adjusted Model 2 analyses (Table 9-6(c,d):  $p > 0.12$  for all analyses). It is noted that the high  $R^2$  values in these analyses ( $R^2 > 0.72$ ) are due to the use of body fat at the time of duty in SEA and change in body fat from the time of duty in SEA to the date of the blood draw for dioxin as covariates in the analysis of this current body fat measure. For the Model 3 unadjusted analysis, a marginally significant relationship between categorized dioxin and body fat was evident from the contrast involving background Ranch Hands (21.76 percent) versus Comparisons (22.01 percent) (Table 9-6(e): difference = -0.25,  $p = 0.085$ ). However, no significant differences were revealed between the low Ranch Hands, the high Ranch Hands, or the low plus high Ranch Hands contrasts. After adjusting the Model 3 analysis for significant covariates, the difference between background Ranch Hands and Comparisons became nonsignificant (Table 9-6(f):  $p = 0.194$ ), but the difference between high Ranch Hands and Comparisons became marginally significant (difference = -0.30,  $p = 0.064$ ). Significant differences between low Ranch Hands and Comparisons and between low plus high Ranch Hands and Comparisons were not evident from this analysis ( $p > 0.40$ ). Age was a significant covariate retained in both adjusted analyses.

Highly significant positive associations between current dioxin and body fat were uncovered in the unadjusted analyses of Models 4 through 6 (Table 9-6(g): slope = 0.05,  $p < 0.001$  for Model 4 and slope = 0.04,  $p < 0.001$  for Models 5 and 6). The adjusted analysis of Model 4 detected a significant current dioxin-by-occupation interaction (Table 9-6(h):  $p = 0.023$ ). The stratified results of this interaction are shown in Appendix Table E-2-4. After deleting the interaction from the final model, a highly significant relationship still existed between current dioxin and body fat (Adj. slope = 0.06,  $p = 0.001$ ). Analogous to the Model 5 and Model 6 unadjusted results, both adjusted analyses of Models 5 and 6 revealed highly significant associations between current dioxin and body fat (Adj. slope = 0.05,  $p < 0.001$  for both models). The interaction of age and occupation was retained in both Models 4 and 5, while Model 6 adjusted only for occupation.

**Table 9-6.**  
**Analysis of Body Fat (Percent)**  
**(Continuous)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
Occupational Category	Group	n	Mean <sup>a</sup>	Difference of Means (95% C.I.) <sup>b</sup>	p-Value
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>21.79</i>	<i>-0.17 --</i>	<i>0.448</i>
	<i>Comparison</i>	<i>1,281</i>	<i>21.96</i>		
Officer	Ranch Hand	367	21.78	0.25 --	0.432
	Comparison	502	21.54		
Enlisted Flyer	Ranch Hand	162	21.52	-0.24 --	0.656
	Comparison	203	21.76		
Enlisted Groundcrew	Ranch Hand	423	21.91	-0.50 --	0.159
	Comparison	576	22.41		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>						
Occupational Category	Group	n	Adjusted Mean <sup>a</sup>	Difference of Adj. Means (95% C.I.) <sup>b</sup>	p-Value	Covariate Remarks <sup>c</sup>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>21.75</i>	<i>-0.16 --</i>	<i>0.449</i>	<i>AGE*OCC (p=0.012)</i>
	<i>Comparison</i>	<i>1,281</i>	<i>21.91</i>			
Officer	Ranch Hand	367	21.61	0.23 --	0.511	
	Comparison	502	21.38			
Enlisted Flyer	Ranch Hand	162	21.71	-0.21 --	0.699	
	Comparison	203	21.91			
Enlisted Groundcrew	Ranch Hand	423	21.94	-0.50 --	0.131	
	Comparison	576	22.44			

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

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

<sup>c</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-6. (Continued)**  
**Analysis of Body Fat (Percent)**  
**(Continuous)**

<b>c) MODEL 2: RANCH HANDS -- INITIAL DIOXIN -- UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
Low	174	22.71	23.20	0.726	-0.0028 (0.0040)	0.484
Medium	173	22.55	22.83			
High	173	23.54	22.76			

<b>d) MODEL 2: RANCH HANDS -- INITIAL DIOXIN -- ADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>d</sup></b>			
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Low	174	23.34	0.731	-0.0065 (0.0042)	0.123	AGE (p=0.004)
Medium	173	22.85				
High	173	22.60				

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-6. (Continued)  
Analysis of Body Fat (Percent)  
(Continuous)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>
Comparison	1,063	22.05	22.01		
Background RH	374	20.36	21.76	-0.25 --	0.085
Low RH	260	22.69	22.09	0.08 --	0.616
High RH	260	23.17	21.82	-0.19 --	0.263
Low plus High RH	520	22.93	21.96	-0.05 --	0.691

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>e</sup></b>	<b>Covariate Remarks</b>
Comparison	1,063	22.01			AGE (p < 0.001)
Background RH	374	21.82	-0.19 --	0.194	
Low RH	260	22.14	0.13 --	0.415	
High RH	260	21.70	-0.30 --	0.064	
Low plus High RH	520	21.92	-0.08 --	0.509	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

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

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-6. (Continued)  
Analysis of Body Fat (Percent)  
(Continuous)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>						
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>		
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
4	20.09 (295)	22.34 (300)	23.12 (299)	0.086	0.0471 (0.0051)	<0.001
5	20.01 (300)	22.34 (297)	23.26 (297)	0.096	0.0427 (0.0044)	<0.001
6 <sup>d</sup>	20.11 (299)	22.34 (297)	23.17 (297)	0.092	0.0412 (0.0047)	<0.001

<b>b) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>							
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Adjusted Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
4	19.68** (295)	22.23** (300)	23.72** (299)	0.114	0.0619 (0.0059)**	0.001**	CURR*OCC (p=0.023) AGE*OCC (p=0.028)
5	19.63 (300)	22.25 (297)	23.84 (297)	0.123	0.0541 (0.0049)	<0.001	AGE*OCC (p=0.047)
6 <sup>e</sup>	19.68 (299)	22.15 (297)	23.57 (297)	0.111	0.0521 (0.0053)	<0.001	OCC (p<0.001)

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

<sup>b</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).

Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).

Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

<sup>c</sup> Slope and standard error based on natural logarithm of body fat versus log<sub>2</sub> (current dioxin + 1).

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>e</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted mean, adjusted slope, standard error, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-4 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.

Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

## **Body Fat (Continuous)—Adjusted for Caloric Intake**

A second adjusted analysis of body fat was performed in which individual caloric intake was included as an additional covariate. This allowed the relationships between body fat and group and between body fat and dioxin to be explored independently of the effects of diet. The unadjusted analysis was not affected, thus unadjusted results in Table 9-7 are identical to those in Table 9-6. Adjusted results in Table 9-7 include caloric intake as a covariate.

In the Model 1 adjusted analysis of body fat, with adjustment for caloric intake, no significant differences, either overall or within occupation, were detected between Ranch Hands and Comparisons (Table 9-7(b):  $p \geq 0.11$  for all contrasts). An age-by-occupation interaction and caloric intake were significant in the adjusted analysis.

The adjusted analysis of Model 2 did not show a significant relationship between body fat and initial dioxin (Table 9-7(d):  $p=0.135$ ). In the adjusted analysis of body fat for Model 3, a highly significant categorized dioxin-by-caloric intake interaction was displayed (Table 9-7(f):  $p=0.001$ ). Appendix Table E-2-5 shows the results from further exploration of this interaction. Analysis after removal of the interaction from the model showed a nonsignificant difference between background Ranch Hands and Comparisons ( $p=0.183$ ), in contrast to the marginally significant unadjusted analysis. However, a marginally significant association between categorized dioxin and body fat was present for the participants in the high Ranch Hand category versus Comparison dioxin categories (difference=-0.29,  $p=0.076$ ). Age was a significant covariate in both Model 2 and 3 adjusted analyses, and caloric intake was also significant in Model 2.

A significant interaction between current lipid-adjusted dioxin and occupation was uncovered in the adjusted analysis of body fat for Model 4 (Table 9-7(h):  $p=0.013$ ). The results from analyzing the occupational levels separately are seen in Appendix Table E-2-5. Dropping the interaction from the final model resulted in a significant current lipid-adjusted dioxin effect (Adj. slope=0.06,  $p=0.001$ ). The Models 5 and 6 current whole-weight dioxin adjusted analyses yielded very similar results. Highly significant results were evident in the results of both analyses (Table 9-7(h): Adj. slope=0.05,  $p < 0.001$  for both models). The age-by-occupation, age-by-caloric intake, and caloric intake-by-occupation interactions were significant in all three models.

## **Body Fat (Discrete)**

For Model 1, the unadjusted analysis of the frequencies of obese Ranch Hands versus Comparisons did not reveal a significant difference between the two groups (Table 9-8(a):  $p=0.960$ ). Likewise, no significant associations were found to exist between obesity and group after adjusting for covariate information (Table 9-8(b):  $p > 0.55$  for all analyses). The interaction of occupation and age was significant in the adjusted analysis.

Initial dioxin and categorized dioxin were nonsignificant when examined in relation to body fat in both unadjusted and adjusted analyses for Models 2 and 3 (Table 9-8(c-f):  $p \geq 0.30$  for all analyses). Age was a significant covariate retained in both adjusted analyses.

**Table 9-7.**  
**Analysis of Body Fat (Percent) with Adjustment for Caloric Intake**  
**(Continuous)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>21.79</i>	<i>-0.17 --</i>	<i>0.448</i>
	<i>Comparison</i>	<i>1,281</i>	<i>21.96</i>		
Officer	Ranch Hand	367	21.78	0.25 --	0.432
	Comparison	502	21.54		
Enlisted Flyer	Ranch Hand	162	21.52	-0.24 --	0.656
	Comparison	203	21.76		
Enlisted Groundcrew	Ranch Hand	423	21.91	-0.50 --	0.159
	Comparison	576	22.41		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>						
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Adjusted Mean<sup>a</sup></b>	<b>Difference of Adj. Means (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	<i>950</i>	<i>21.72</i>	<i>-0.18 --</i>	<i>0.400</i>	AGE*OCC (p=0.012) CALINT (p<0.001)
	<i>Comparison</i>	<i>1,279</i>	<i>21.90</i>			
Officer	Ranch Hand	367	21.63	0.23 --	0.495	
	Comparison	502	21.39			
Enlisted Flyer	Ranch Hand	161	21.62	-0.26 --	0.626	
	Comparison	203	21.87			
Enlisted Groundcrew	Ranch Hand	422	21.94	-0.53 --	0.110	
	Comparison	574	22.46			

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

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

<sup>c</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-7. (Continued)**  
**Analysis of Body Fat (Percent) with Adjustment for Caloric Intake**  
**(Continuous)**

<b>c) MODEL 2: RANCH HANDS — INITIAL DIOXIN — UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
Low	174	22.71	23.20	0.726	-0.0028 (0.0040)	0.484
Medium	173	22.55	22.83			
High	173	23.54	22.76			

<b>d) MODEL 2: RANCH HANDS — INITIAL DIOXIN — ADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>d</sup></b>			
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Low	174	23.33	0.734	-0.0062 (0.0042)	0.135	AGE (p=0.003) CALINT (p=0.019)
Medium	173	22.83				
High	171	22.63				

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-7. (Continued)**  
**Analysis of Body Fat (Percent) with Adjustment for Caloric Intake**  
**(Continuous)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>
Comparison	1,063	22.01	22.01		
Background RH	374	20.36	21.76	-0.25 --	0.085
Low RH	260	22.69	22.09	0.08 --	0.616
High RH	260	23.17	21.82	-0.19 --	0.293
Low plus High RH	520	22.93	21.96	-0.05 --	0.691

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>c</sup></b>	<b>Covariate Remarks</b>
Comparison	1,061	22.01**			DXCAT*CALINT (p=0.001) AGE (p<0.001)
Background RH	374	21.82**	-0.19 ---**	0.183**	
Low RH	260	22.14**	0.13 ---**	0.446**	
High RH	258	21.72**	-0.29 ---**	0.076**	
Low plus High RH	518	21.93**	-0.08 ---**	0.520**	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

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

\*\* Categorized dioxin-by-covariate interaction ( $p \leq 0.05$ ); adjusted mean, difference of adjusted means, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-5 for further analysis of this interaction.

Note: RH = Ranch Hand.

Comparison: Current Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): Current Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): Current Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  143 ppt.

High (Ranch Hand): Current Dioxin  $>$  10 ppt, Initial Dioxin  $>$  143 ppt.

DXCAT = Categorized dioxin.

**Table 9-7. (Continued)**  
**Analysis of Body Fat (Percent) with Adjustment for Caloric Intake**  
**(Continuous)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>						
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>		
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
4	20.09 (295)	22.34 (300)	23.12 (299)	0.086	0.0471 (0.0051)	<0.001
5	20.11 (300)	22.34 (297)	23.26 (297)	0.096	0.0427 (0.0044)	<0.001
6 <sup>d</sup>	20.01 (299)	22.34 (297)	23.17 (297)	0.092	0.0412 (0.0047)	<0.001

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>							
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Adjusted Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
4	19.73** (295)	22.67** (300)	23.61** (297)	0.132	0.0604 (0.0059)**	0.001**	CURR*OCC (p=0.013) AGE*OCC (p=0.015) AGE*CALINT (p=0.001) CALINT*OCC (p=0.002)
5	19.67 (300)	22.32 (297)	23.71 (295)	0.140	0.0528 (0.0049)	<0.001	AGE*OCC (p=0.028) AGE*CALINT (p=0.003) CALINT*OCC (p=0.003)
6 <sup>e</sup>	19.75 (299)	22.34 (297)	23.67 (295)	0.135	0.0527 (0.0050)	<0.001	AGE*OCC (p=0.032) AGE*CALINT (p=0.003) CALINT*OCC (p=0.003)

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

<sup>b</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

<sup>c</sup> Slope and standard error based on natural logarithm of body fat versus log<sub>2</sub> (current dioxin + 1).

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>e</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted mean, adjusted slope, standard error, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-5 for additional details of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

**Table 9-8.  
Analysis of Body Fat  
(Discrete)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Obese</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>25.4</i>	<i>0.99 (0.82,1.20)</i>	<i>0.960</i>
	<i>Comparison</i>	<i>1,281</i>	<i>25.6</i>		
Officer	Ranch Hand	367	22.3	0.97 (0.70,1.34)	0.909
	Comparison	502	22.9		
Enlisted Flyer	Ranch Hand	162	23.5	1.02 (0.62,1.66)	0.999
	Comparison	203	23.2		
Enlisted Groundcrew	Ranch Hand	423	28.8	1.00 (0.76,1.32)	0.999
	Comparison	576	28.8		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>0.99 (0.82,1.20)</i>	<i>0.927</i>	OCC*AGE (p=0.030)
Officer	1.04 (0.75,1.44)	0.805	
Enlisted Flyer	1.12 (0.68,1.83)	0.655	
Enlisted Groundcrew	1.09 (0.82,1.43)	0.558	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-8. (Continued)  
Analysis of Body Fat  
(Discrete)**

<b>c) MODEL 2: RANCH HANDS — INITIAL DIOXIN — UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Obese</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	28.2	0.99 (0.80,1.24)	0.950
Medium	173	34.1		
High	173	37.0		

<b>d) MODEL 2: RANCH HANDS — INITIAL DIOXIN — ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>			
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
520	0.91 (0.72,1.16)	0.437	AGE (p=0.026)

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-8. (Continued)  
Analysis of Body Fat  
(Discrete)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Obese</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,063	26.3		
Background RH	374	14.2	0.82 (0.49,1.35)	0.427
Low RH	260	30.4	1.19 (0.75,1.90)	0.464
High RH	260	35.8	1.23 (0.78,1.94)	0.377
Low plus High RH	520	33.1	1.21 (0.84,1.73)	0.300

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,063			AGE (p < 0.001)
Background RH	374	0.88 (0.53,1.46)	0.623	
Low RH	260	1.24 (0.77,1.98)	0.374	
High RH	260	1.08 (0.68,1.72)	0.754	
Low plus High RH	520	1.15 (0.80,1.66)	0.442	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-8. (Continued)  
Analysis of Body Fat  
(Discrete)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Obese/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	11.9 (295)	27.0 (300)	36.5 (299)	1.41 (1.26,1.56)	<0.001
5	12.3 (300)	27.3 (297)	36.0 (297)	1.37 (1.25,1.51)	<0.001
6 <sup>c</sup>	12.4 (299)	27.3 (297)	36.0 (297)	1.35 (1.22,1.50)	<0.001

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>n</b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			<b>Covariate Remarks</b>
		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>		
4	894	1.45 (1.28,1.65)**	<0.001**	CURR*OCC (p=0.015) AGE*RACE (p=0.029)	
5	894	1.37 (1.25,1.51)	<0.001		
6 <sup>d</sup>	893	1.36 (1.22,1.51)	<0.001	AGE*RACE (p=0.049)	

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted relative risk, confidence interval, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-6 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

Each of the three unadjusted analyses for Models 4 through 6 detected a highly significant relationship between current dioxin and body fat (Table 9-8(g):  $p < 0.001$  for all unadjusted analyses). In the Model 4 adjusted analysis, the interaction of current dioxin and occupation was significant (Table 9-8(h):  $p = 0.015$ ). The results of further exploration of this interaction are shown in Appendix Table E-2-6. Deleting this interaction from the final model revealed a highly significant association between current dioxin and body fat (Table 9-8(h): Adj. RR=1.45,  $p < 0.001$ ). Likewise, current dioxin was significant in relation to body fat after adjusting for covariate information in the Model 6 analysis (Adj. RR=1.36,  $p < 0.001$ ). In both Model 4 and Model 6, the interaction of age and race was significant. In the Model 5 adjusted analysis, none of the candidate covariates were significant, and none were retained in the model; therefore, the results from this analysis are identical to those of the unadjusted Model 5 analysis.

### **Body Fat (Discrete)—Adjusted for Caloric Intake**

A second adjusted analysis of body fat was performed in which individual caloric intake was included as an additional covariate. This allowed the relationships between body fat and group and between body fat and dioxin to be explored independently of the effects of diet. The unadjusted analysis was not affected, thus the unadjusted results in Table 9-9 are identical to those in Table 9-8. Adjusted results in Table 9-9 include caloric intake as a covariate.

For Model 1, adjusting for caloric intake in addition to the original covariates, age, race, and occupation, did not uncover any significant differences between Ranch Hands and Comparisons (Table 9-9(b):  $p > 0.79$  for all analyses). Caloric intake-by-race, age-by-race, and occupation-by-race interactions were significant in the adjusted analysis.

Examination of the adjusted results of body fat for Model 2 did not show any statistically significant associations between initial dioxin and body fat (Table 9-9(d):  $p = 0.460$ ). In the Model 3 adjusted analysis, no significant associations were seen between the percentage of obese Ranch Hands and the percentage in the Comparison category (Table 9-9(f):  $p > 0.44$  for all analyses). Model 2 analyses were adjusted for age and caloric intake. In Model 3, the adjusted analysis uncovered significant interactions between age and race and between race and caloric intake.

The results from investigating the relationship between body fat and current dioxin (Models 4 through 6) are displayed in Table 9-9(h). The current lipid adjusted dioxin-by-occupation interaction was significant in the Model 4 analysis ( $p = 0.021$ ; see Appendix Table E-2-7 for stratified results of the dioxin-by-occupation interaction). Deletion of this interaction from the final model found that current lipid-adjusted dioxin was significantly related to body fat (Adj. RR=1.44,  $p < 0.001$ ). Current whole-weight dioxin and body fat were also strongly associated for both Models 5 and 6 (Adj. RR=1.37,  $p < 0.001$  and Adj. RR=1.35,  $p < 0.001$  respectively). Caloric intake was included as a covariate in each of the Models 4 through 6 adjusted analysis. Also for Model 4, adjusting for covariate information revealed a significant interaction between age and race.

**Table 9-9.**  
**Analysis of Body Fat with Adjustment for Caloric Intake**  
**(Discrete)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS – UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Obese</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>25.4</i>	<i>0.99 (0.82,1.20)</i>	<i>0.960</i>
	<i>Comparison</i>	<i>1,281</i>	<i>25.6</i>		
Officer	Ranch Hand	367	22.3	0.97 (0.70,1.34)	0.909
	Comparison	502	22.9		
Enlisted Flyer	Ranch Hand	162	23.5	1.02 (0.62,1.66)	0.999
	Comparison	203	23.2		
Enlisted Groundcrew	Ranch Hand	423	28.8	1.00 (0.76,1.32)	0.999
	Comparison	576	28.8		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS – ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>0.99 (0.82,1.21)</i>	<i>0.952</i>	CALINT*RACE (p=0.037) AGE*RACE (p=0.024) OCC*AGE (p=0.016)
Officer	0.96 (0.69,1.32)	0.792	
Enlisted Flyer	1.04 (0.64,1.70)	0.877	
Enlisted Groundcrew	1.01 (0.77,1.34)	0.926	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-9. (Continued)**  
**Analysis of Body Fat with Adjustment for Caloric Intake**  
**(Discrete)**

<b>c) MODEL 2: RANCH HANDS — INITIAL DIOXIN — UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Obese</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	28.2	0.99 (0.80,1.24)	0.950
Medium	173	34.1		
High	173	37.0		

<b>d) MODEL 2: RANCH HANDS — INITIAL DIOXIN — ADJUSTED</b>			
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>			
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
518	0.91 (0.72,1.16)	0.460	AGE (p=0.027) CALINT (p=0.816)

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-9. (Continued)**  
**Analysis of Body Fat with Adjustment for Caloric Intake**  
**(Discrete)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Obese</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,063	26.3		
Background RH	374	14.2	0.82 (0.49,1.35)	0.427
Low RH	260	30.4	1.19 (0.75,1.90)	0.464
High RH	260	35.8	1.23 (0.78,1.94)	0.377
Low plus High RH	520	33.1	1.21 (0.84,1.73)	0.300

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,061			AGE*RACE (p=0.026) RACE*CALINT (p=0.010)
Background RH	374	0.91 (0.55,1.51)	0.707	
Low RH	260	1.20 (0.75,1.94)	0.441	
High RH	258	1.06 (0.66,1.69)	0.816	
Low plus High RH	518	1.13 (0.78,1.63)	0.521	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-9. (Continued)**  
**Analysis of Body Fat with Adjustment for Caloric Intake**  
**(Discrete)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Obese/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	11.9 (295)	27.0 (300)	36.5 (299)	1.41 (1.26,1.56)	<0.001
5	12.3 (300)	27.3 (297)	36.0 (297)	1.37 (1.25,1.51)	<0.001
6 <sup>c</sup>	12.4 (299)	27.3 (297)	36.0 (297)	1.35 (1.22,1.50)	<0.001

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>				
<b>Model<sup>a</sup></b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			
	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
4	892	1.44 (1.27,1.64)**	<0.001**	CURR*OCC (p=0.021) AGE*RACE (p=0.031) CALINT (p=0.335)
5	892	1.37 (1.24,1.50)	<0.001	CALINT (p=0.388)
6 <sup>d</sup>	891	1.35 (1.22,1.49)	<0.001	CALINT (p=0.384)

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

\*\* Log<sub>2</sub> (current dioxin + 1)-by-covariate interaction (0.01 < p ≤ 0.05); adjusted relative risk, confidence interval, and p-value derived from a model fitted after deletion of this interaction; refer to Appendix Table E-2-7 for further analysis of this interaction.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

## **Laboratory Examination Variable**

### **Sedimentation Rate (Continuous)**

In the Model 1 unadjusted analysis of sedimentation rate in its continuous form, the differences in means between Ranch Hands and Comparisons, overall and within occupations, were nonsignificant (Table 9-10(a):  $p > 0.10$  for all analyses). Although the adjusted analysis of sedimentation rate revealed no significant overall group difference (Table 9-10(b):  $p = 0.232$ ), stratification across occupation led to a marginally significant difference in adjusted means for enlisted groundcrew (Table 9-10(b): difference = 0.84,  $p = 0.078$ ). After adjusting for covariate information, the interactions between occupation and personality type and between age and personality type were significant.

A significant association between initial dioxin and sedimentation rate was not evident from the results of the Model 2 unadjusted analysis (Table 9-10(c):  $p = 0.732$ ). However, the adjusted analysis uncovered a marginally significant relationship between initial dioxin and sedimentation rate (Table 9-10(d): Adj. slope = 0.051,  $p = 0.089$ ). Age and personality type were retained in the Model 2 adjusted analysis.

The unadjusted categorized dioxin analysis of Model 3 detected marginally significant differences in means for low Ranch Hands versus Comparisons (Table 9-10(e): difference = 0.85,  $p = 0.093$ ) and low plus high Ranch Hands versus Comparisons (difference = 0.75,  $p = 0.057$ ). In the adjusted Model 3 analysis, the contrast involving low plus high Ranch Hands and Comparisons contained a marginally significant difference in adjusted means (Table 9-10(f): difference = 0.71,  $p = 0.064$ ). Age-by-personality type and occupation-by-personality type interactions were retained in the Model 3 adjusted analysis. Once occupation was removed from the final model, significant differences in adjusted means were seen between high Ranch Hands and Comparisons and between low plus high Ranch Hands and Comparisons (Appendix Table E-3-8:  $p = 0.019$  and  $p = 0.017$  respectively).

The unadjusted current dioxin analyses of Models 4, 5, and 6 each revealed a statistically significant, or marginally significant, association between sedimentation rate and the current dioxin measurement (Table 9-10(g):  $p \leq 0.09$  for all unadjusted analyses). In the Model 4 adjusted analysis, sedimentation rate was significant in relation to dioxin (Table 9-10(h): Adj. slope = 0.044,  $p = 0.045$ ). The Models 5 and 6 adjusted analyses led to conflicting results regarding the relationship between current whole-weight dioxin and sedimentation rate. For Model 5, the analysis uncovered a significant association between sedimentation rate and current whole-weight dioxin (Adj. slope = 0.051,  $p = 0.006$ ), whereas for Model 6, which adjusts for total lipids, the relationship was nonsignificant (Adj. slope = 0.027,  $p = 0.180$ ). Occupation was a covariate retained in each of the three adjusted analyses for Models 4, 5, and 6. Removing occupation from the final models did not change the status of the dioxin effects for Models 4 and 5, where dioxin was initially significant. However, in Model 6 the dioxin effect, originally nonsignificant, became significant once occupation was removed (Appendix Table E-3-7:  $p = 0.004$ ). Age, occupation, and personality were covariates retained in each of the current dioxin adjusted analyses.

**Table 9-10.**  
**Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Means (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	952	8.32	0.35 --	0.248
	<i>Comparison</i>	1,280	7.97		
Officer	Ranch Hand	367	7.63	-0.01 --	0.989
	Comparison	502	7.64		
Enlisted Flyer	Ranch Hand	162	9.31	0.07 --	0.939
	Comparison	202	9.24		
Enlisted Groundcrew	Ranch Hand	423	8.59	0.75 --	0.109
	Comparison	576	7.84		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>						
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Difference of Adj. Means (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks<sup>c</sup></b>
<i>All</i>	<i>Ranch Hand</i>	951	8.31	0.35 --	0.232	OCC*PERS (p=0.034) AGE*PERS (p=0.001)
	<i>Comparison</i>	1,279	7.96			
Officer	Ranch Hand	367	6.93	0.02 --	0.946	
	Comparison	502	6.91			
Enlisted Flyer	Ranch Hand	161	8.75	-0.05 --	0.945	
	Comparison	202	8.80			
Enlisted Groundcrew	Ranch Hand	423	9.27	0.84 --	0.078	
	Comparison	575	8.43			

<sup>a</sup> Transformed from natural logarithm scale of sedimentation rate + 0.1.

<sup>b</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale of sedimentation rate + 0.1.

<sup>c</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-10. (Continued)**  
**Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>				<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>		
<b>Initial Dioxin</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
Low	174	8.51	8.56	0.007	0.0070 (0.0099)	0.732
Medium	173	9.86	9.92			
High	173	8.77	8.67			

<b>d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>						
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>d</sup></b>			
<b>Initial Dioxin</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Low	173	7.97	0.071	0.0506 (0.0297)	0.089	AGE (p<0.001)
Medium	173	9.62				PERS (p=0.017)
High	173	9.16				

<sup>a</sup> Transformed from natural logarithm scale of sedimentation rate of + 0.1.

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Slope and standard error based on natural logarithm of sedimentation rate + 0.1 versus log<sub>2</sub> (initial dioxin).

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-10. (Continued)**  
**Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Mean<sup>a</sup></b>	<b>Adj. Mean<sup>ab</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value</b>
Comparison	1,063	8.06	8.05		
Background RH	374	7.60	7.89	-0.16 --	0.697
Low RH	260	9.09	8.91	0.85 --	0.093
High RH	260	8.97	8.70	0.64 --	0.203
Low plus High RH	520	9.03	8.80	0.75 --	0.057

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>					
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Mean<sup>ad</sup></b>	<b>Difference of Adj. Mean vs. Comparisons (95% C.I.)<sup>c</sup></b>	<b>p-Value<sup>c</sup></b>	<b>Covariate Remarks</b>
Comparison	1,062	8.02			AGE*PERS (p=0.002) OCC*PERS (p=0.027)
Background RH	374	8.01	-0.01 --	0.980	
Low RH	259	8.70	0.68 --	0.163	
High RH	260	8.76	0.74 --	0.145	
Low plus High RH	519	8.73	0.71 --	0.064	

<sup>a</sup> Transformed from natural logarithm scale of sedimentation rate + 0.1.

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Difference of means after transformation to original scale; confidence interval on difference of means not presented because analysis was performed on natural logarithm scale of sedimentation rate + 0.1.

<sup>d</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

<sup>e</sup> P-value is based on difference of means on natural logarithm scale of sedimentation rate + 0.1.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

**Table 9-10. (Continued)**  
**Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>						
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>		
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>
4	7.52 (295)	8.69 (300)	9.06 (299)	0.007	0.0490 (0.0199)	0.014
5	7.47 (300)	8.68 (297)	9.16 (297)	0.011	0.0541 (0.0170)	0.001
6 <sup>d</sup>	7.84 (299)	8.72 (297)	8.65 (297)	0.029	0.0309 (0.0182)	0.090

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>							
<b>Model<sup>b</sup></b>	<b>Current Dioxin Category Adjusted Mean<sup>a</sup>/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>R<sup>2</sup></b>	<b>Adj. Slope (Std. Error)<sup>c</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
4	7.68 (295)	8.38 (299)	8.93 (299)	0.077	0.0443 (0.0220)	0.045	AGE (p<0.001) OCC (p=0.009) PERS (p=0.020)
5	7.58 (300)	8.40 (296)	9.03 (297)	0.081	0.0507 (0.0186)	0.006	AGE (p<0.001) OCC (p=0.017) PERS (p=0.019)
6 <sup>e</sup>	7.98 (299)	8.47 (296)	8.48 (297)	0.095	0.0269 (0.0200)	0.180	AGE (p<0.001) OCC (p=0.011) PERS (p=0.009)

<sup>a</sup> Transformed from natural logarithm scale of sedimentation rate + 0.1.

<sup>b</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

<sup>c</sup> Slope and standard error based on natural logarithm of sedimentation rate + 0.1 versus log<sub>2</sub> (current dioxin + 1).

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>e</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

## **Sedimentation Rate (Discrete)**

For Model 1, neither the unadjusted nor the adjusted group analyses of sedimentation rate detected any significant differences between Ranch Hands and Comparisons (Table 9-11(a,b):  $p > 0.78$  for all analyses). Occupation and the interaction of age and personality type were significant in the adjusted analysis.

Models 2 and 3 examined the association between initial and categorized dioxin and sedimentation rate. No significant results were uncovered in the unadjusted or adjusted analyses of each model (Table 9-11(c-f):  $p > 0.12$  for all analyses). Age and personality type were included in the final Model 2 adjusted analysis. In Model 3, occupation and the interaction of age and personality type were retained in the adjusted analysis. However, removal of occupation from the final Model 3 adjusted analysis revealed a marginally significant association between sedimentation rate and initial dioxin for the low plus high Ranch Hand category versus the Comparison category (Appendix Table E-3-8:  $p = 0.086$ ).

Each of the unadjusted analyses of Models 4 through 6 detected a significant, or marginally significant, current dioxin effect in relation to sedimentation rate. For Model 4, where current dioxin is lipid-adjusted, the estimated relative risk was 1.15 (Table 9-11(g):  $p = 0.019$ ). Sedimentation rate and current whole-weight dioxin were associated in both the Model 5 and Model 6 unadjusted analyses. The respective estimated relative risks were 1.15 ( $p = 0.009$ ) and 1.10 ( $p = 0.082$ ). In the Model 4 adjusted analyses of sedimentation rate, a marginally significant relationship was seen between current lipid-adjusted dioxin and sedimentation rate (Table 9-11(h): Adj. RR=1.12,  $p = 0.090$ ). Although the adjusted analyses of Model 5 uncovered a statistically significant adjusted relative risk (Adj. RR=1.19,  $p = 0.001$ ), examination of the results of the Model 6 analysis showed that additionally adjusting for total lipids led to nonsignificant results (Adj. RR=1.08,  $p = 0.223$ ). Also, in the Model 6 adjusted analysis, occupation was retained in the final model. The deletion of this variable from the final model caused current whole-weight dioxin to become significant (Appendix Table E-3-8: Adj. RR=1.15,  $p = 0.021$ ). Age was retained in each of the adjusted analyses of Models 4 through 6 as a significant covariate. Additionally, in Models 5 and 6, race was included.

## **Longitudinal Analysis**

Longitudinal analyses were conducted on five variables—self-perception of health, appearance of illness or distress, relative age, body fat, and sedimentation rate—to examine whether changes across time differed with respect to group membership (Model 1), initial dioxin (Model 2), and categorized dioxin (Model 3). Models 4, 5, and 6 were not examined in longitudinal analyses because current dioxin, the measure of exposure in these models, changes over time and is not available for all participants for 1982 or 1992. Discrete analyses were performed for all variables, and continuous analyses were performed for body fat and sedimentation rate. The longitudinal analyses for all of these variables investigated the difference between the 1982 examination and the 1992 examination. Participants considered abnormal in 1982 were not included. These analyses were used to investigate the temporal effects of dioxin during the 10-year period between 1982 and 1992. Participants considered abnormal in 1982 were already abnormal before this period; consequently, only

**Table 9-11.**  
**Analysis of Sedimentation Rate**  
**(Discrete)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS — UNADJUSTED</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>n</b>	<b>Percent Abnormal</b>	<b>Est. Relative Risk (95% C.I.)</b>	<b>p-Value</b>
<i>All</i>	<i>Ranch Hand</i>	<i>952</i>	<i>17.8</i>	<i>1.02 (0.82,1.28)</i>	<i>0.883</i>
	<i>Comparison</i>	<i>1,280</i>	<i>17.4</i>		
Officer	Ranch Hand	367	14.2	1.02 (0.69,1.50)	0.999
	Comparison	502	13.9		
Enlisted Flyer	Ranch Hand	162	22.2	1.00 (0.61,1.64)	0.999
	Comparison	202	22.3		
Enlisted Groundcrew	Ranch Hand	423	19.2	1.03 (0.75,1.41)	0.938
	Comparison	576	18.8		

<b>b) MODEL 1: RANCH HANDS VS. COMPARISONS — ADJUSTED</b>			
<b>Occupational Category</b>	<b>Adj. Relative Risk (95% C.I.)</b>	<b>p-Value</b>	<b>Covariate Remarks<sup>a</sup></b>
<i>All</i>	<i>1.02 (0.82,1.28)</i>	<i>0.839</i>	OCC (p<0.001) AGE*PERS (p=0.008)
Officer	1.06 (0.71,1.56)	0.782	
Enlisted Flyer	0.96 (0.58,1.58)	0.859	
Enlisted Groundcrew	1.03 (0.75,1.42)	0.859	

<sup>a</sup> Covariates and associated p-values correspond to final model based on all participants with available data.

**Table 9-11. (Continued)**  
**Analysis of Sedimentation Rate**  
**(Discrete)**

<b>c) MODEL 2: RANCH HANDS – INITIAL DIOXIN – UNADJUSTED</b>				
<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>n</b>	<b>Percent Abnormal</b>	<b>Estimated Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
Low	174	19.5	1.02 (0.87,1.19)	0.835
Medium	173	23.1		
High	173	20.2		

<b>d) MODEL 2: RANCH HANDS – INITIAL DIOXIN – ADJUSTED</b>				
<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>c</sup></b>				
<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>	
519	1.06 (0.89,1.25)	0.509	AGE (p=0.048) PERS (p=0.136)	

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

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

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

**Table 9-11. (Continued)**  
**Analysis of Sedimentation Rate**  
**(Discrete)**

<b>e) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — UNADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Percent Abnormal</b>	<b>Est. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value</b>
Comparison	1,063	17.2		
Background RH	374	13.4	0.79 (0.56,1.11)	0.174
Low RH	260	21.5	1.29 (0.92,1.81)	0.136
High RH	260	20.4	1.17 (0.83,1.65)	0.373
Low plus High RH	520	21.0	1.23 (0.94,1.61)	0.128

<b>f) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY — ADJUSTED</b>				
<b>Dioxin Category</b>	<b>n</b>	<b>Adj. Relative Risk (95% C.I.)<sup>ac</sup></b>	<b>p-Value</b>	<b>Covariate Remarks</b>
Comparison	1,062			OCC (p=0.004) AGE*PERS (p=0.007)
Background RH	374	0.87 (0.61,1.23)	0.423	
Low RH	259	1.27 (0.90,1.79)	0.169	
High RH	260	1.10 (0.77,1.57)	0.616	
Low plus High RH	519	1.18 (0.90,1.56)	0.224	

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA and change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin.

<sup>c</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and covariates specified under "Covariate Remarks" column.

Note: RH = Ranch Hand.

Comparison: Current Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): Current Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): Current Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  143 ppt.

High (Ranch Hand): Current Dioxin  $>$  10 ppt, Initial Dioxin  $>$  143 ppt.

**Table 9-11. (Continued)  
Analysis of Sedimentation Rate  
(Discrete)**

<b>g) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — UNADJUSTED</b>					
<b>Model<sup>a</sup></b>	<b>Current Dioxin Category Percent Abnormal/(n)</b>			<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>	
	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Est. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
4	12.5 (295)	20.3 (300)	20.4 (299)	1.15 (1.02,1.29)	0.019
5	13.0 (300)	19.2 (297)	21.2 (297)	1.15 (1.03,1.27)	0.009
6 <sup>c</sup>	13.0 (299)	19.2 (297)	21.2 (297)	1.10 (0.99,1.23)	0.082

<b>h) MODELS 4, 5, AND 6: RANCH HANDS — CURRENT DIOXIN — ADJUSTED</b>				
<b>Model<sup>a</sup></b>	<b>n</b>	<b>Analysis Results for Log<sub>2</sub> (Current Dioxin + 1)</b>		<b>Covariate Remarks</b>
		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>	
4	894	1.12 (0.98,1.28)	0.090	OCC (p=0.109) AGE (p<0.001)
5	894	1.19 (1.07,1.33)	0.001	AGE (p=0.002) RACE (p=0.086)
6 <sup>d</sup>	893	1.08 (0.95,1.21)	0.223	AGE (p=0.001) OCC (p=0.114) RACE (p=0.118)

<sup>a</sup> Model 4: Log<sub>2</sub> (lipid-adjusted current dioxin + 1).  
 Model 5: Log<sub>2</sub> (whole-weight current dioxin + 1).  
 Model 6: Log<sub>2</sub> (whole-weight current dioxin + 1), adjusted for log<sub>2</sub> total lipids.

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

<sup>c</sup> Adjusted for log<sub>2</sub> total lipids.

<sup>d</sup> Adjusted for log<sub>2</sub> total lipids in addition to covariates specified under "Covariate Remarks" column.

Note: Model 4: Low = ≤ 8.1 ppt; Medium = >8.1-20.5 ppt; High = >20.5 ppt.  
 Models 5 and 6: Low = ≤ 46 ppq; Medium = >46-128 ppq; High = >128 ppq.

participants normal at the 1982 examination were considered to be at risk when the effects of dioxin over this period of time are explored. The rate of abnormalities under this restriction approximates an incidence rate between 1982 and 1992. Summary statistics are provided for reference purposes for the 1985 and 1987 examinations.

The longitudinal analyses for the discrete variables examined relative risks at the 1992 exam for participants who were classified as normal at the 1982 exam. The adjusted relative risks estimated from each of the three models were used to investigate the change in the dependent variable over time. All three models were adjusted for age; Models 2 and 3 were also adjusted for percent body fat at the tour of duty and change in percent body fat from the tour of duty to the date of the blood draw for dioxin.

The longitudinal analysis for the two continuous variables examined the paired difference between the measurements from 1982 and 1992. These paired differences measured the change in body fat or sedimentation rate over time. Each of the three models used in the longitudinal analysis were adjusted for age and the dependent variable as measured in 1982 (see Statistical Methods, Chapter 7). The analyses of Models 2 and 3 were also adjusted for percent body fat at the tour of duty and change in percent body fat from the tour of duty to the date of the blood draw for dioxin. A logarithmic transformation was applied to both of these variables for analytic purposes.

The cutpoints for abnormal sedimentation rate differ by examination data and age. For the 1982 Baseline examination, the cutpoint was 12 mm/hr for all participants. For the 1985, 1987, and 1992 followup examinations, the cutpoint was 15 mm/hr for participants younger than 50 and 20 mm/hr for participants at least 50 years old at the time of the examination.

### *Questionnaire Variable*

#### **Self-Perception of Health**

Percentages of participants who reported their health as fair or poor for the 1992 examination were examined longitudinally for an association with group and current and initial dioxin levels. Only those participants who reported a good or excellent perception of health in 1982 were included in the longitudinal study. The results of this analysis are shown in Table 9-12.

In the Model 1 analyses, overall and occupationally-stratified longitudinal analyses of participants with good or excellent health in 1982 showed that the percentage of Ranch Hands who reported their health as fair or poor in the 1992 examination did not differ significantly from the percentage of Comparisons (Table 9-12(a):  $p > 0.14$  for each analysis).

Conditioned on good or excellent health in 1982, the Model 2 longitudinal analysis detected a significant positive association between initial dioxin and the percentage of Ranch Hands with a fair or poor self-perception of health in 1992 (Table 9-12(b): Adj. RR=1.38,  $p=0.031$ ). Of the Ranch Hands with a good or excellent self-perception of health in 1982,

**Table 9-12.**  
**Longitudinal Analysis of Self-Perception of Health**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>Percent Fair or Poor/(n) Examination</b>			
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
<i>All</i>	<i>Ranch Hand</i>	18.2 (899)	8.3 (877)	6.0 (868)	10.6 (899)
	<i>Comparison</i>	14.8 (1,061)	6.6 (1,038)	6.0 (1,034)	7.8 (1,061)
Officer	Ranch Hand	10.6 (339)	4.2 (334)	4.2 (333)	6.5 (339)
	Comparison	10.2 (403)	4.8 (395)	2.8 (390)	5.7 (403)
Enlisted Flyer	Ranch Hand	20.9 (158)	6.4 (156)	5.9 (153)	13.3 (158)
	Comparison	18.9 (175)	8.1 (172)	6.3 (174)	9.1 (175)
Enlisted Groundcrew	Ranch Hand	23.6 (402)	12.7 (387)	7.6 (382)	12.9 (402)
	Comparison	17.2 (483)	7.4 (471)	8.5 (470)	9.1 (483)

<b>Occupational Category</b>	<b>Group</b>	<b>Excellent or Good in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value<sup>a</sup></b>
		<b>n in 1992</b>	<b>Percent Fair or Poor in 1992</b>		
<i>All</i>	<i>Ranch Hand</i>	735	5.6	1.22 (0.78,1.90)	0.385
	<i>Comparison</i>	904	4.7		
Officer	Ranch Hand	303	2.3	0.59 (0.23,1.48)	0.261
	Comparison	362	3.9		
Enlisted Flyer	Ranch Hand	125	9.6	1.59 (0.64,3.92)	0.317
	Comparison	142	6.3		
Enlisted Groundcrew	Ranch Hand	307	7.2	1.60 (0.85,3.04)	0.146
	Comparison	400	4.8		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1992 results; results adjusted for age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had an excellent or good self-perception of health in 1982 (see Chapter 7, Statistical Methods).

**Table 9-12. (Continued)  
Longitudinal Analysis of Self-Perception of Health**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>				
<b>Initial Dioxin</b>	<b>Percent Fair or Poor/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Low	16.3 (166)	8.6 (163)	4.9 (165)	10.2 (166)
Medium	24.4 (168)	11.7 (162)	8.5 (164)	13.7 (168)
High	19.1 (168)	13.9 (166)	8.0 (162)	13.7 (168)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Excellent or Good in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1992</b>	<b>Percent Fair or Poor in 1992</b>		
Low	139	4.3	1.38 (1.03,1.85)	0.031
Medium	127	9.5		
High	136	8.1		

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

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

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had an excellent or good self-perception of health in 1982 (see Chapter 7, Statistical Methods).

**Table 9-12. (Continued)**  
**Longitudinal Analysis of Self-Perception of Health**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>				
<b>Dioxin Category</b>	<b>Percent Fair or Poor/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Comparison	14.2 (915)	6.2 (904)	5.9 (904)	7.3 (915)
Background RH	16.1 (342)	3.8 (339)	3.9 (336)	7.0 (342)
Low RH	18.9 (249)	9.1 (243)	6.5 (247)	10.4 (249)
High RH	21.0 (253)	13.7 (248)	7.8 (244)	14.6 (253)
Low plus High RH	19.9 (502)	11.4 (491)	7.1 (491)	12.6 (502)

<b>Dioxin Category</b>	<b>Excellent or Good in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value<sup>b</sup></b>
	<b>n in 1992</b>	<b>Percent Fair or Poor in 1992</b>		
Comparison	785	4.6		
Background RH	287	3.1	0.73 (0.34,1.55)	0.409
Low RH	202	5.0	0.97 (0.47,2.01)	0.940
High RH	200	9.5	2.24 (1.23,4.09)	0.008
Low plus High RH	402	7.2	1.54 (0.92,2.57)	0.101

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had an excellent or good self-perception of health in 1982 (see Chapter 7, Statistical Methods).

the percentages of Ranch Hands who reported their health as fair or poor in 1992 were 4.3, 9.5, and 8.1 for the low, medium, and high categories of initial dioxin respectively.

For the Model 3 longitudinal analysis, there was a highly significant difference between Ranch Hands in the high dioxin category and Comparisons for participants who perceived their health as fair or poor in 1992 (Table 9-12(c): Adj. RR=2.24,  $p=0.008$ ). Of the participants who reported good or excellent health in the 1982 examination, 9.5 percent of the high Ranch Hands and 4.6 percent of the Comparisons reported a fair or poor perception of health in 1992. For background, low, and low plus high Ranch Hands, the percentages were 3.1, 5.0, and 7.2 respectively. However, none of these categories was significantly different from the Comparison category ( $p>0.10$  for each contrast).

### ***Physical Examination Variables***

#### **Appearance of Illness of Distress**

Longitudinal analyses for the physician's evaluation as to whether the participant appeared ill or distressed at the physical examination were conducted. These analyses were performed for participants who did not appear ill or distressed at the 1982 examination. Table 9-13 displays the results of these analyses.

For the Model 1 longitudinal analysis, no significant overall group effect existed for participants who appeared ill or distressed at the 1992 examination (Table 9-13(a):  $p=0.468$ ). This nonsignificant result remained after longitudinal analyses were performed within each of the three levels of occupation ( $p>0.22$  for each stratum). The percentage of Ranch Hands with an unhealthy appearance in 1992 was not significantly associated with initial dioxin in the Model 2 longitudinal analysis (Table 9-13(b):  $p=0.789$ ). For the participants who appeared healthy at the 1982 physical examination, the Model 3 longitudinal analyses did not detect a significant difference in the 1992 percentages of participants who appeared ill or distressed between the Comparison and Ranch Hand categories of dioxin (Table 9-13(c):  $p>0.57$  for each contrast).

#### **Relative Age Appearance**

Longitudinal analyses investigating associations between either group or dioxin and participants who appeared older than their age were performed. Only those participants who appeared as old as or younger than their stated age in 1982 were included in this analysis. The results of the longitudinal analyses of relative age appearance are shown in Table 9-14.

No significant difference in relative age appearance in 1992 between Ranch Hands and Comparisons was detected in either the overall or stratified Model 1 longitudinal analyses (Table 9-14(a):  $p>0.23$ ). The percentage of participants with an abnormal relative age appearance in 1992 was significantly associated with initial dioxin in the Model 2 longitudinal analysis (Table 9-14(b): Adj. RR=1.33,  $p=0.050$ ). Of those participants with a normal relative age appearance in 1982, the percentages of Ranch Hands who appeared older than their age at the 1992 examination were 4.8, 6.6, and 7.4 for the low, medium, and high categories of initial dioxin. In the Model 3 longitudinal analysis, for participants

**Table 9-13.**  
**Longitudinal Analysis of Appearance of Illness or Distress**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>Percent Yes/(n) Examination</b>			
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
<i>All</i>	<i>Ranch Hand</i>	0.2 (899)	0.2 (875)	0.4 (868)	2.5 (899)
	<i>Comparison</i>	0.1 (1,059)	0.4 (1,036)	0.4 (1,032)	1.9 (1,059)
Officer	Ranch Hand	0.3 (340)	0.3 (335)	0.3 (334)	2.7 (340)
	Comparison	0.0 (402)	0.0 (394)	0.3 (390)	1.5 (402)
Enlisted Flyer	Ranch Hand	0.0 (159)	0.6 (157)	0.0 (154)	3.1 (159)
	Comparison	0.0 (173)	1.2 (170)	0.6 (172)	1.2 (173)
Enlisted Groundcrew	Ranch Hand	0.3 (400)	0.0 (383)	0.5 (380)	2.0 (400)
	Comparison	0.2 (484)	0.4 (472)	0.4 (470)	2.5 (484)

<b>Occupational Category</b>	<b>Group</b>	<b>No in 1982</b>			
		<b>n in 1992</b>	<b>Percent Yes in 1992</b>	<b>Adj. Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value<sup>a</sup></b>
<i>All</i>	<i>Ranch Hand</i>	897	2.3	1.26 (0.68,2.34)	0.468
	<i>Comparison</i>	1,058	1.9		
Officer	Ranch Hand	339	2.4	1.61 (0.55,4.70)	0.381
	Comparison	402	1.5		
Enlisted Flyer	Ranch Hand	159	3.1	2.81 (0.53,14.87)	0.223
	Comparison	173	1.2		
Enlisted Groundcrew	Ranch Hand	399	2.0	0.83 (0.33,2.05)	0.681
	Comparison	483	2.5		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1992 results; results adjusted for age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who did not appear ill or distressed in 1982 (see Chapter 7, Statistical Methods).

**Table 9-13. (Continued)**  
**Longitudinal Analysis of Appearance of Illness or Distress**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>				
<b>Initial Dioxin</b>	<b>Percent Yes/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Low	0.0 (167)	0.0 (164)	0.0 (166)	1.8 (167)
Medium	0.0 (168)	0.6 (161)	0.0 (164)	2.4 (168)
High	0.6 (167)	0.0 (164)	0.6 (161)	1.8 (167)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>e</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>No in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1992</b>	<b>Percent Yes in 1992</b>		
Low	167	1.8	0.94 (0.57,1.53)	0.789
Medium	168	2.4		
High	166	1.8		

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

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

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who did not appear ill or distressed in 1982 (see Chapter 7, Statistical Methods).

**Table 9-13. (Continued)**  
**Longitudinal Analysis of Appearance of Illness or Distress**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>				
<b>Dioxin Category</b>	<b>Percent Yes/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Comparison	0.0 (915)	0.3 (904)	0.3 (904)	1.8 (915)
Background RH	0.0 (342)	0.3 (339)	0.3 (336)	2.3 (342)
Low RH	0.0 (249)	0.4 (243)	0.0 (247)	2.4 (249)
High RH	0.4 (253)	0.0 (246)	0.4 (244)	1.6 (253)
Low plus High RH	0.2 (502)	0.2 (489)	0.2 (491)	2.0 (502)

<b>Dioxin Category</b>	<b>No in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value<sup>b</sup></b>
	<b>n in 1992</b>	<b>Percent Yes in 1992</b>		
Comparison	915	1.8		
Background RH	342	2.3	1.29 (0.54,3.07)	0.571
Low RH	249	2.4	1.17 (0.45,3.08)	0.743
High RH	252	1.6	0.97 (0.31,3.01)	0.957
Low plus High RH	501	2.0	1.08 (0.48,2.46)	0.845

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who did not appear ill or distressed in 1982 (see Chapter 7, Statistical Methods).

**Table 9-14.**  
**Longitudinal Analysis of Relative Age Appearance**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>Percent Older/(n) Examination</b>			
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
<i>All</i>	<i>Ranch Hand</i>	1.7 (901)	3.5 (878)	5.1 (870)	5.8 (901)
	<i>Comparison</i>	2.2 (1,061)	4.1 (1,038)	4.6 (1,035)	6.1 (1,061)
Officer	Ranch Hand	0.9 (340)	1.5 (335)	3.6 (334)	3.2 (340)
	Comparison	1.5 (402)	0.3 (394)	2.6 (390)	3.7 (402)
Enlisted Flyer	Ranch Hand	0.0 (159)	3.2 (157)	7.1 (154)	9.4 (159)
	Comparison	3.4 (175)	8.7 (172)	8.1 (174)	7.4 (175)
Enlisted Groundcrew	Ranch Hand	3.0 (402)	5.4 (386)	5.5 (382)	6.5 (402)
	Comparison	2.3 (484)	5.5 (472)	5.1 (471)	7.6 (484)

<b>Occupational Category</b>	<b>Group</b>	<b>Same or Younger in 1982</b>			
		<b>n in 1992</b>	<b>Percent Older in 1992</b>	<b>Adj. Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value<sup>a</sup></b>
<i>All</i>	<i>Ranch Hand</i>	886	5.8	1.05 (0.71,1.55)	0.808
	<i>Comparison</i>	1,038	5.5		
Officer	Ranch Hand	337	3.3	0.99 (0.44,2.25)	0.988
	Comparison	396	3.3		
Enlisted Flyer	Ranch Hand	159	9.4	1.66 (0.72,3.80)	0.234
	Comparison	169	5.9		
Enlisted Groundcrew	Ranch Hand	390	6.4	0.89 (0.52,1.51)	0.659
	Comparison	473	7.2		

<sup>a</sup> Relative risk, confidence interval, and p-value are in reference to a contrast of 1982 and 1992 results; results adjusted for age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who appeared as old as or younger than their age in 1982 (see Chapter 7, Statistical Methods).

**Table 9-14. (Continued)  
Longitudinal Analysis of Relative Age Appearance**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>				
<b>Initial Dioxin</b>	<b>Percent Older/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Low	0.6 (167)	3.1 (164)	4.2 (166)	4.8 (167)
Medium	1.8 (169)	3.7 (163)	4.2 (165)	6.5 (169)
High	3.0 (168)	6.7 (165)	4.3 (162)	7.1 (168)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Same or Younger in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1992</b>	<b>Percent Older in 1992</b>		
Low	166	4.8	1.33 (1.01,1.75)	0.050
Medium	166	6.6		
High	163	7.4		

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

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

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who appeared as old as or younger than their age in 1982 (see Chapter 7, Statistical Methods).

**Table 9-14. (Continued)**  
**Longitudinal Analysis of Relative Age Appearance**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>				
<b>Dioxin Category</b>	<b>Percent Older/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Comparison	2.3 (916)	3.9 (905)	4.6 (906)	6.1 (916)
Background RH	1.2 (342)	2.4 (339)	5.7 (336)	4.7 (342)
Low RH	0.4 (250)	3.3 (244)	3.2 (248)	4.4 (250)
High RH	3.2 (254)	5.7 (248)	5.3 (245)	7.9 (254)
Low plus High RH	1.8 (504)	4.5 (492)	4.3 (493)	6.2 (504)

<b>Dioxin Category</b>	<b>Same or Younger in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value<sup>b</sup></b>
	<b>n in 1992</b>	<b>Percent Older in 1992</b>		
Comparison	895	5.5		
Background RH	338	4.4	0.83 (0.46,1.52)	0.553
Low RH	249	4.4	0.78 (0.40,1.52)	0.458
High RH	246	8.1	1.44 (0.83,2.51)	0.191
Low plus High RH	495	6.3	1.10 (0.69,1.76)	0.689

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

<sup>b</sup> Adjusted for percent fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who appeared as old as or younger than their age in 1982 (see Chapter 7, Statistical Methods).

who appeared as old as or younger than their age in 1982, no statistically significant associations were seen between the percentage of Comparisons who appeared older than their age in 1992 versus background, low, and high Ranch Hands who appeared older (Table 9-14(c):  $p > 0.19$ ).

### **Body Fat (Continuous)**

Longitudinal analyses that examined the mean difference in body fat between 1982 and 1992 were performed to explore associations with group and dioxin. The results of the longitudinal analysis are seen in Table 9-15.

The Model 1 longitudinal analysis of body fat did not detect a significant overall difference in the average change in body fat from 1982 to 1992 between Ranch Hands and Comparisons (Table 9-15(a):  $p = 0.325$ ). However, when stratified across the levels of occupation, the category of enlisted groundcrew revealed a marginally significant difference in body fat between the two groups over time (difference =  $-0.35$ ,  $p = 0.053$ ). A marginally significant negative association between initial dioxin and the change in body fat between 1982 and 1992 was evident in the Model 2 longitudinal analysis (Table 9-15(b): Slope =  $-0.0075$ ,  $p = 0.075$ ). The Model 3 longitudinal analysis of the mean change in body fat between 1982 and 1992 revealed a significant negative association with categorized dioxin for high Ranch Hands versus Comparisons (Table 9-15(c): difference =  $-0.23$ ,  $p = 0.025$ ). The remaining three contrasts between Ranch Hands and Comparisons did not reveal significant associations between body fat and categorized dioxin.

### **Body Fat (Discrete)**

For the longitudinal analyses, the percentages of participants with elevated (i.e.,  $> 25\%$ ) body fat at the 1992 examination were examined for associations with group and dioxin. Only those participants with less than 25 percent body fat at the 1982 Baseline examination were included in these analyses. Table 9-16 presents the results of the longitudinal analyses for body fat.

Neither the overall nor stratified Model 1 longitudinal analyses detected a significant difference in the percentages of abnormal body fat in 1992 between Ranch Hands and Comparisons (Table 9-16(a):  $p > 0.70$ ). Of the participants with a 1982 body fat measurement less than 25 percent, the relationship between initial dioxin and Ranch Hands with an abnormal body fat measurement in 1992 was nonsignificant for the Model 2 longitudinal analysis (Table 9-16(b):  $p = 0.696$ ). For the Model 3 longitudinal analysis there were no significant differences in the percentages among the participants with abnormal body fat measurements in 1992 for the four current dioxin categories (Table 9-16(c):  $p \geq 0.51$  for all contrasts).

**Table 9-15.**  
**Longitudinal Analysis of Body Fat (Percent)**  
**(Continuous)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>								
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n)</b>				<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>			
<i>All</i>	<i>Ranch Hand</i>	<i>19.92</i> <i>(901)</i>	<i>20.73</i> <i>(879)</i>	<i>21.08</i> <i>(870)</i>	<i>21.82</i> <i>(901)</i>	<i>1.91</i>	<i>-0.12</i>	<i>0.325</i>
	<i>Comparison</i>	<i>19.99</i> <i>(1,063)</i>	<i>20.99</i> <i>(1,040)</i>	<i>21.23</i> <i>(1,037)</i>	<i>22.01</i> <i>(1,063)</i>	<i>2.02</i>		
Officer	Ranch Hand	20.07 (340)	20.86 (335)	21.15 (334)	21.85 (340)	1.78	0.03	0.827
	Comparison	19.90 (403)	20.87 (395)	21.00 (391)	21.65 (403)	1.74		
Enlisted Flyer	Ranch Hand	19.66 (159)	20.56 (157)	20.83 (154)	21.48 (159)	1.82	0.17	0.623
	Comparison	19.86 (175)	20.43 (172)	20.76 (174)	21.51 (175)	1.65		
Enlisted Groundcrew	Ranch Hand	19.89 (402)	20.68 (387)	21.11 (382)	21.94 (402)	2.05	-0.35	0.053
	Comparison	20.11 (485)	21.30 (473)	21.59 (472)	22.51 (485)	2.40		

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

<sup>b</sup> Difference between 1992 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of body fat; results adjusted for natural logarithm of body fat in 1982 and age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-15. (Continued)**  
**Longitudinal Analysis of Body Fat (Percent)**  
**(Continuous)**

<b>b) MODEL 2: RANCH HANDS -- INITIAL DIOXIN</b>						
<b>Initial Dioxin Category Summary Statistics</b>					<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>	
<b>Initial Dioxin</b>	<b>Mean<sup>a</sup>/(n) Examination</b>				<b>Adj. Slope (Std. Error)</b>	<b>p-Value</b>
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>		
Low	20.55 (167)	21.48 (164)	21.67 (166)	22.67 (167)	-0.0075 (0.0042)	0.075
Medium	20.74 (169)	21.68 (163)	21.86 (165)	22.50 (169)		
High	21.82 (168)	22.84 (166)	23.11 (162)	23.64 (168)		

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

<sup>b</sup> Results based on difference between natural logarithm of 1992 body fat and natural logarithm of 1982 body fat versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, natural logarithm of 1982 body fat, and age in 1992.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-15. (Continued)**  
**Longitudinal Analysis of Body Fat (Percent)**  
**(Continuous)**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>							
<b>Dioxin Category</b>	<b>Mean<sup>a</sup>/(n)</b>				<b>Exam.</b>	<b>Difference of</b>	<b>p-Value<sup>c</sup></b>
	<b>Examination</b>						
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>		<b>Mean Change</b>	
Comparison	20.10 (917)	21.08 (906)	21.37 (907)	22.16 (917)	2.06		
Background RH	18.42 (342)	19.14 (339)	19.60 (336)	20.35 (342)	1.93	-0.13	0.432
Low RH	20.67 (250)	21.57 (244)	21.83 (248)	22.64 (250)	1.97	-0.09	0.654
High RH	21.39 (254)	22.41 (249)	22.57 (245)	23.22 (254)	1.83	-0.23	0.025
Low plus High RH	21.03 (504)	21.99 (493)	22.20 (493)	22.93 (504)	1.90	-0.16	0.251

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

<sup>b</sup> Difference between 1992 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of body fat; results adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, natural logarithm of body fat in 1982, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): Current Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): Current Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  143 ppt.

High (Ranch Hand): Current Dioxin  $>$  10 ppt, Initial Dioxin  $>$  143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-16.**  
**Longitudinal Analysis of Body Fat**  
**(Discrete)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>Percent Obese/(n) Examination</b>			
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
<i>All</i>	<i>Ranch Hand</i>	14.4 (901)	18.8 (879)	20.0 (870)	25.6 (901)
	<i>Comparison</i>	14.6 (1,063)	20.2 (1,040)	22.6 (1,037)	26.6 (1,063)
Officer	Ranch Hand	12.7 (340)	17.6 (335)	18.0 (334)	23.5 (340)
	Comparison	10.4 (403)	14.9 (395)	17.7 (391)	23.6 (403)
Enlisted Flyer	Ranch Hand	12.0 (159)	16.6 (157)	18.8 (154)	23.3 (159)
	Comparison	14.9 (175)	20.4 (172)	20.7 (174)	21.7 (175)
Enlisted Groundcrew	Ranch Hand	16.9 (402)	20.7 (387)	22.3 (382)	28.4 (402)
	Comparison	17.9 (485)	24.5 (473)	27.3 (472)	30.9 (485)

<b>Occupational Category</b>	<b>Group</b>	<b>Lean or Normal in 1982</b>			
		<b>n in 1992</b>	<b>Percent Obese in 1992</b>	<b>Adj. Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value<sup>a</sup></b>
<i>All</i>	<i>Ranch Hand</i>	771	15.7	0.99 (0.76,1.29)	0.966
	<i>Comparison</i>	908	15.8		
Officer	Ranch Hand	297	15.8	1.00 (0.66,1.53)	0.989
	Comparison	361	15.8		
Enlisted Flyer	Ranch Hand	140	14.3	1.14 (0.58,2.24)	0.702
	Comparison	149	12.8		
Enlisted Groundcrew	Ranch Hand	334	16.2	0.95 (0.64,1.40)	0.788
	Comparison	398	16.8		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1992 results; results adjusted for age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who were lean or had normal body fat in 1982 (see Chapter 7, Statistical Methods).

**Table 9-16. (Continued)  
Longitudinal Analysis of Body Fat  
(Discrete)**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>				
<b>Initial Dioxin</b>	<b>Percent Obese/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Low	16.2 (167)	20.1 (164)	20.5 (166)	27.0 (167)
Medium	17.2 (169)	24.5 (163)	25.5 (165)	33.1 (169)
High	23.2 (168)	30.7 (166)	30.3 (162)	37.5 (168)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Lean or Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1992</b>	<b>Percent Obese in 1992</b>		
Low	140	16.4	0.95 (0.71,1.25)	0.696
Medium	140	22.9		
High	129	21.7		

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

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

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who were lean or had normal body fat in 1982 (see Chapter 7, Statistical Methods).

**Table 9-16. (Continued)  
Longitudinal Analysis of Body Fat  
(Discrete)**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>				
<b>Dioxin Category</b>	<b>Percent Obese/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Comparison	14.5 (917)	20.0 (906)	22.6 (907)	27.4 (917)
Background RH	8.2 (342)	10.6 (339)	12.2 (336)	15.2 (342)
Low RH	17.6 (250)	22.1 (244)	23.0 (248)	29.2 (250)
High RH	20.1 (254)	28.1 (249)	27.8 (245)	35.8 (254)
Low plus High RH	18.9 (504)	25.2 (493)	25.4 (493)	32.5 (504)

<b>Dioxin Category</b>	<b>Lean or Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>ab</sup></b>	<b>p-Value<sup>b</sup></b>
	<b>n in 1992</b>	<b>Percent Obese in 1992</b>		
Comparison	784	16.6		
Background RH	314	8.9	0.88 (0.49,1.58)	0.675
Low RH	206	17.0	1.03 (0.60,1.79)	0.905
High RH	203	23.7	1.19 (0.71,2.02)	0.510
Low plus High RH	409	20.3	1.11 (0.73,1.69)	0.611

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin  $\leq$  10 ppt.

Background (Ranch Hand): Current Dioxin  $\leq$  10 ppt.

Low (Ranch Hand): Current Dioxin  $>$  10 ppt, 10 ppt  $<$  Initial Dioxin  $\leq$  143 ppt.

High (Ranch Hand): Current Dioxin  $>$  10 ppt, Initial Dioxin  $>$  143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who were lean or had normal body fat in 1982 (see Chapter 7, Statistical Methods).

## ***Laboratory Variable***

### **Sedimentation Rate (Continuous)**

The change in sedimentation rate between 1982 and 1992 was examined for an association with group and dioxin. Table 9-17 presents the results of the analysis.

The overall and stratified Model 1 longitudinal analyses of the mean difference in sedimentation rate between 1982 and 1992 did not uncover a significant group effect for Ranch Hands versus Comparisons (Table 9-17(a):  $p > 0.13$ ). The association between initial dioxin and change in sedimentation rate from 1982 to 1992 was nonsignificant in the Model 2 longitudinal analyses (Table 9-17(b):  $p = 0.334$ ). The Model 3 longitudinal analysis detected a marginally significant association between categorized dioxin and the mean difference in sedimentation rate between the Baseline and the 1992 followup examinations for Ranch Hands in the high dioxin category (Table 9-17(c): difference = 0.75,  $p = 0.060$ ) and low plus high dioxin category (difference = 0.77,  $p = 0.066$ ) versus Comparisons. The contrasts involving background and low Ranch Hands versus Comparisons were nonsignificant ( $p > 0.25$ ).

### **Sedimentation Rate (Discrete)**

Longitudinal analyses were conducted to investigate associations between abnormal sedimentation rates at the 1992 examination and dioxin or group. The longitudinal study was conditioned on participants with normal sedimentation rates at the 1982 Baseline examination. The results of the analysis for sedimentation rate are shown in Table 9-18.

For participants with normal sedimentation rates in 1982, Model 1 analyses investigating the overall and stratified differences between Ranch Hands and Comparisons with abnormal sedimentation rates in 1992 were not significant (Table 9-18(a):  $p > 0.64$ ). The Model 2 longitudinal analysis of Ranch Hands with normal sedimentation rates in 1982 did not reveal a significant association between initial dioxin and the percentage of Ranch Hands in 1992 with abnormal sedimentation rates (Table 9-18(b):  $p = 0.272$ ). There were no significant differences in patterns of sedimentation rate changes over time for participants in the four current dioxin categories in the Model 3 longitudinal analysis (Table 9-18(c):  $p \geq 0.12$ ).

## **DISCUSSION**

In ambulatory medicine, the assessment of an individual's general state of health is based on subjective and objective indices including the individual's history, physical examination, and laboratory testing. The variables analyzed in this chapter are frequently employed by clinicians in outpatient practice and were selected to be sensitive to the overall state of health rather than specific to any organ system.

As in the 1982 and 1985 examinations (though not in 1987), Ranch Hand participants perceive themselves to be less healthy than Comparisons, particularly those who as a group were known to have had the highest level of dioxin exposure, the enlisted groundcrew. In the unadjusted analysis, 10.4 percent of Ranch Hands viewed their health as fair or poor

**Table 9-17.**  
**Longitudinal Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>								
<b>Occupational Category</b>	<b>Group</b>	<b>Mean<sup>a</sup>/(n)</b>				<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>			
<i>All</i>	<i>Ranch Hand</i>	1.82 (901)	4.94 (879)	5.22 (869)	8.35 (901)	6.53	0.25	0.570
	<i>Comparison</i>	1.63 (1,063)	4.83 (1,040)	5.05 (1,035)	7.91 (1,063)	6.28		
Officer	Ranch Hand	1.85 (340)	4.94 (335)	5.06 (333)	7.75 (340)	5.90	-0.32	0.198
	Comparison	1.48 (403)	4.79 (395)	4.88 (391)	7.70 (403)	6.22		
Enlisted Flyer	Ranch Hand	1.97 (159)	5.18 (157)	5.93 (154)	9.26 (159)	7.29	0.52	0.348
	Comparison	2.29 (175)	5.34 (172)	5.39 (174)	9.06 (175)	6.77		
Enlisted Groundcrew	Ranch Hand	1.74 (402)	4.84 (387)	5.09 (382)	8.53 (402)	6.79	0.64	0.132
	Comparison	1.57 (485)	4.69 (473)	5.08 (470)	7.71 (485)	6.14		

<sup>a</sup> Transformed from natural logarithm of sedimentation rate + 0.1 scale.

<sup>b</sup> Difference between 1992 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of sedimentation rate + 0.1; results adjusted for natural logarithm of sedimentation rate + 0.1 in 1982 and age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-17. (Continued)**  
**Longitudinal Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>						
<b>Initial Dioxin Category Summary Statistics</b>					<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>b</sup></b>	
<b>Initial Dioxin</b>	<b>Mean<sup>a</sup>/(n) Examination</b>				<b>Adj. Slope (Std. Error)</b>	<b>p-Value</b>
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>		
Low	1.76 (167)	5.12 (164)	5.37 (166)	8.52 (167)	0.0247 (0.0256)	0.334
Medium	2.20 (169)	5.64 (163)	5.94 (165)	9.76 (169)		
High	1.70 (168)	4.93 (166)	5.58 (162)	8.74 (168)		

<sup>a</sup> Transformed from natural logarithm of sedimentation rate + 0.1 scale.

<sup>b</sup> Results based on difference between natural logarithm of 1992 sedimentation rate + 0.1 and natural logarithm of 1982 sedimentation rate + 0.1 versus log<sub>2</sub> (initial dioxin); results adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, natural logarithm of 1982 sedimentation rate + 0.1, and age in 1992.

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-17. (Continued)**  
**Longitudinal Analysis of Sedimentation Rate (mm/hr)**  
**(Continuous)**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>							
<b>Dioxin Category</b>	<b>Mean<sup>a</sup>/(n) Examination</b>				<b>Exam. Mean Change<sup>b</sup></b>	<b>Difference of Exam. Mean Change</b>	<b>p-Value<sup>c</sup></b>
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>			
Comparison	1.65 (917)	4.84 (906)	5.10 (906)	8.00 (917)	6.35		
Background RH	1.79 (342)	4.71 (339)	4.81 (335)	7.72 (342)	5.93	-0.41	0.250
Low RH	1.92 (250)	5.37 (244)	5.60 (248)	9.06 (250)	7.13	0.78	0.327
High RH	1.83 (254)	5.08 (249)	5.65 (245)	8.93 (254)	7.10	0.75	0.060
Low plus High RH	1.88 (504)	5.22 (493)	5.62 (493)	8.99 (504)	7.12	0.77	0.066

<sup>a</sup> Transformed from natural logarithm of sedimentation rate + 0.1 scale.

<sup>b</sup> Difference between 1992 and 1982 examination means after transformation to original scale.

<sup>c</sup> P-value is based on analysis of natural logarithm of sedimentation rate + 0.1; results adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, natural logarithm of sedimentation rate + 0.1 in 1982, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations.

**Table 9-18.**  
**Longitudinal Analysis of Sedimentation Rate**  
**(Discrete)**

<b>a) MODEL 1: RANCH HANDS VS. COMPARISONS</b>					
<b>Occupational Category</b>	<b>Group</b>	<b>Percent Abnormal/(n) Examination</b>			
		<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
<i>All</i>	<i>Ranch Hand</i>	2.9 (901)	6.5 (879)	7.5 (869)	17.9 (901)
	<i>Comparison</i>	4.5 (1,063)	5.3 (1,040)	5.4 (1,035)	17.6 (1,063)
Officer	Ranch Hand	3.2 (340)	4.8 (335)	5.4 (333)	14.7 (340)
	Comparison	4.0 (403)	4.3 (395)	4.1 (391)	14.4 (403)
Enlisted Flyer	Ranch Hand	2.5 (159)	8.3 (157)	9.7 (154)	22.0 (159)
	Comparison	8.0 (175)	7.6 (172)	5.8 (174)	21.7 (175)
Enlisted Groundcrew	Ranch Hand	2.7 (402)	7.2 (387)	8.4 (382)	18.9 (402)
	Comparison	3.7 (485)	5.3 (473)	6.4 (470)	18.8 (485)

<b>Occupational Category</b>	<b>Group</b>	<b>Normal in 1982</b>			
		<b>n in 1992</b>	<b>Percent Abnormal in 1992</b>	<b>Adj. Relative Risk (95% C.I.)<sup>a</sup></b>	<b>p-Value<sup>a</sup></b>
<i>All</i>	<i>Ranch Hand</i>	872	16.0	1.04 (0.81,1.33)	0.767
	<i>Comparison</i>	1,015	15.6		
Officer	Ranch Hand	329	12.5	0.96 (0.62,1.50)	0.863
	Comparison	387	12.9		
Enlisted Flyer	Ranch Hand	155	20.7	1.14 (0.65,1.99)	0.647
	Comparison	161	18.6		
Enlisted Groundcrew	Ranch Hand	391	17.1	1.05 (0.73,1.51)	0.779
	Comparison	467	16.7		

<sup>a</sup> Relative risk, confidence interval, and p-values are in reference to a contrast of 1982 and 1992 results; results adjusted for age in 1992.

Note: Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had a normal sedimentation rate ( $\leq 12$  mm/hr) in 1982 (see Chapter 7, Statistical Methods).

**Table 9-18. (Continued)  
Longitudinal Analysis of Sedimentation Rate  
(Discrete)**

<b>b) MODEL 2: RANCH HANDS — INITIAL DIOXIN</b>				
<b>Initial Dioxin</b>	<b>Percent Abnormal/(n) Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Low	6.0 (167)	9.2 (164)	7.2 (166)	19.2 (167)
Medium	1.8 (169)	8.6 (163)	10.9 (165)	23.1 (169)
High	2.4 (168)	8.4 (166)	9.3 (162)	20.2 (168)

<b>Initial Dioxin Category Summary Statistics</b>			<b>Analysis Results for Log<sub>2</sub> (Initial Dioxin)<sup>a</sup></b>	
<b>Initial Dioxin</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk (95% C.I.)<sup>b</sup></b>	<b>p-Value</b>
	<b>n in 1992</b>	<b>Percent Abnormal in 1992</b>		
Low	157	15.9	1.11 (0.92,1.33)	0.272
Medium	166	21.7		
High	164	18.9		

<sup>a</sup> Adjusted for percent body fat at the time of duty in SEA, change in percent body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

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

Note: Low = 39-98 ppt; Medium = >98-232 ppt; High = >232 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had a normal sedimentation rate ( $\leq 12$  mm/hr) in 1982 (see Chapter 7, Statistical Methods).

**Table 9-18. (Continued)**  
**Longitudinal Analysis of Sedimentation Rate**  
**(Discrete)**

<b>c) MODEL 3: RANCH HANDS AND COMPARISONS BY DIOXIN CATEGORY</b>				
<b>Dioxin Category</b>	<b>Percent Abnormal/(n)</b>			
	<b>Examination</b>			
	<b>1982</b>	<b>1985</b>	<b>1987</b>	<b>1992</b>
Comparison	4.3 (917)	5.4 (906)	5.1 (906)	17.7 (917)
Background RH	2.3 (342)	3.8 (339)	4.8 (335)	13.7 (342)
Low RH	4.8 (250)	9.4 (244)	8.1 (248)	21.2 (250)
High RH	2.0 (254)	8.0 (249)	10.2 (245)	20.5 (254)
Low plus High RH	3.4 (504)	8.7 (493)	9.1 (493)	20.8 (504)

<b>Dioxin Category</b>	<b>Normal in 1982</b>		<b>Adj. Relative Risk</b> <b>(95% C.I.)<sup>ab</sup></b>	<b>p-Value<sup>b</sup></b>
	<b>n in 1992</b>	<b>Percent Abnormal</b> <b>in 1992</b>		
Comparison	878	15.7		
Background RH	334	12.0	0.74 (0.51,1.09)	0.126
Low RH	238	18.5	1.18 (0.80,1.72)	0.403
High RH	249	19.3	1.34 (0.93,1.95)	0.120
Low plus High RH	487	18.9	1.26 (0.94,1.69)	0.128

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

<sup>b</sup> Adjusted for percent body fat at the time of duty in SEA, change in body fat from the time of duty in SEA to the date of the blood draw for dioxin, and age in 1992.

Note: RH = Ranch Hand.

Comparison: Current Dioxin ≤ 10 ppt.

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

Low (Ranch Hand): Current Dioxin > 10 ppt, 10 ppt < Initial Dioxin ≤ 143 ppt.

High (Ranch Hand): Current Dioxin > 10 ppt, Initial Dioxin > 143 ppt.

Summary statistics for 1985 are provided for reference purposes for participants who attended the Baseline, 1985, and 1992 examinations. Summary statistics for 1987 are provided for reference purposes for participants who attended the Baseline, 1987, and 1992 examinations. Statistical analyses are based only on participants who had a normal sedimentation rate (≤ 12 mm/hr) in 1982 (see Chapter 7, Statistical Methods).

versus 7.4 percent of Comparisons, percentages very similar to the 1985 examination (9.1% vs. 7.3%) and reflecting a symmetrical decline from the Baseline examination (20.0% vs. 14.2%).

Dependent variable-covariate analyses confirmed several associations that have been documented in previous examination cycles. As a group, officers continue to appear healthier than enlisted personnel by several indices including subjective perception of health, appearance of illness or distress, relative age appearance, and percent body fat. In covariate analyses of sedimentation rate, older participants had more abnormally elevated results than younger participants. With occupation as a covariate, enlisted participants appeared to be at detriment relative to officers, but the pattern did not suggest a dose response effect by either continuous or discrete analysis.

The highly significant ( $p < 0.001$ ) association in Ranch Hands of the current level of serum dioxin with a negative self-perception of health deserves comment. Subsequent to the 1987 examinations, when no group differences with respect to this variable were defined, serum dioxin data were incorporated in the analyses and individual serum level results were provided to the participants. As noted in Chapter 12, Psychological Assessment, numerous reports have documented the negative psychological and subjective consequences associated with the perception of dioxin exposure. Given that the degree of prior exposure is now established rather than perceived, it is not surprising to find an elevated prevalence of negative self-perceptions of health in those Ranch Hands with the highest levels of serum dioxin. In contrast, as recorded by examining physicians, no group differences were noted in the appearance of illness or distress or relative age appearance.

The percent body fat is easily derived as an objective index related to general health and, to the extent that it can reflect significant weight gain or loss, can serve as a valuable clinical clue to the presence of occult disease. In the current study, the prevalence of obesity was similar in the Ranch Hands and Comparison cohorts. In Ranch Hands, a consistent and highly significant positive association was found in all occupational categories between percent body fat and the current serum dioxin whether calculated on a whole-weight or lipid-adjusted basis. Although a mobile equilibrium exists between serum dioxin and adipose tissue, the current results point strongly to a difference in dioxin pharmacokinetics in obese versus lean individuals. Clinically, it would be difficult to explain the finding of higher levels of dioxin in relatively obese participants on the basis of any health detriment. It is not clear whether a causal relationship exists between dioxin exposure and increased body fat.

In the analyses relating current caloric intake to obesity, 27.1 percent of the participants who reported consuming less than 2,000 calories/day were obese, while only 23.3 percent of the participants who consumed more than 2,000 calories/day were obese. This apparent inconsistency is most likely reflective of the recognized tendency for overweight individuals to underestimate their caloric intake on self-reporting nutrition inventory questionnaires.

The sedimentation rate can be a sensitive, although nonspecific, index of general health. Pertinent to the longitudinal design of the current study is the effect of age—a rate as high as 40 millimeters per hour is considered within the range of normal at age 65. Extreme elevations in the sedimentation rate are consistently associated with serious underlying

disease, usually malignancy. In prior examinations, Ranch Hands were found to have a significantly higher prevalence of elevated sedimentation rates than Comparisons in a pattern consistent with a dose-response effect. In the current study, no significant differences between Ranch Hands and Comparisons (Model 1) were defined by either discrete or continuous analyses. In the occupation at highest risk, the enlisted groundcrew, Ranch Hands had a slightly higher mean sedimentation rate than Comparisons, but the difference (9.27 mm/hr vs. 8.43 mm/hr) is not clinically significant. In the models employing current serum dioxin, several of the analyses yielded results that were consistent with a subtle dose-response effect, but the differences were slight and the biologic significance is uncertain.

The longitudinal analyses yielded some results that were at variance with previous examinations. Between 1982 and 1987, despite advancing age, a greater than 50-percent reduction occurred in the percentage of Ranch Hands and Comparisons reporting ill health and the initial difference between the cohorts had narrowed to nil. The 1992 examinations revealed reversals in these trends most prominently in those Ranch Hands in the medium and high categories of current and calculated initial levels of serum dioxin. In contrast, in neither the appearance of illness or distress nor relative age appearance were there any significant associations with the current body burden of dioxin. Again the potentially negative subjective effect of established prior exposure is raised.

In the 1985 and 1987 examinations, Ranch Hands were noted to have a significantly higher percentage of abnormal sedimentation rates than Comparisons raising the possibility of a subtle inflammatory effect related to dioxin exposure. In the current study, no significant group differences were defined and the differences in the means across dioxin categories were not biologically significant.

In summary, the general health of the Ranch Hand and Comparison cohorts appears comparable by all objective indices, although significant and increasing group differences in the self-perception of health were evident in the 1992 data.

## **SUMMARY**

Five dependent variables were analyzed in the General Health Assessment, including self-perception of health, appearance of illness or distress, relative age appearance, percent body fat, and sedimentation rate. These five health endpoints were analyzed for associations with group (Model 1), initial dioxin (Model 2), categorized dioxin (Model 3), current lipid-adjusted dioxin (Model 4), and current whole-weight dioxin (Models 5 and 6). Each of the five variables were analyzed in discrete form; additionally, percent body fat and sedimentation rate were analyzed on a continuous scale. All variables were examined longitudinally. The results of the group, initial dioxin, categorized dioxin, and current dioxin analyses are summarized in Tables 9-19 through 9-22. A summary of group-by-covariate and dioxin-by-covariate interactions is found in Table 9-23.

**Table 9-19.**  
**Summary of Group Analyses (Model 1) for General Health Variables**  
**(Ranch Hands vs. Comparisons)**

Variable	UNADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
<b>Questionnaire</b>				
Self-Perception of Health (D)	+0.017	NS	NS	+0.031
<b>Physical Examination</b>				
Appearance of Illness or Distress (D)	NS	NS	NS	ns
Relative Age Appearance (D)	ns	ns	NS	ns
Body Fat (C)	ns	NS	ns	ns
Body Fat (D)	ns	ns	NS	NS
<b>Laboratory</b>				
Sedimentation Rate (C)	NS	ns	NS	NS
Sedimentation Rate (D)	NS	NS	NS	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$ .

NS or ns: Not significant ( $p > 0.10$ ).

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or differences of means nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00 for discrete analyses or difference of means negative for continuous analyses.

**Table 9-19. (Continued)**  
**Summary of Group Analyses (Model 1) for General Health Variables**  
**(Ranch Hands vs. Comparisons)**

Variable	ADJUSTED			
	All	Officer	Enlisted Flyer	Enlisted Groundcrew
<b>Questionnaire</b>				
Self-Perception of Health (D)	+0.016	NS	NS	+0.023
<b>Physical Examination</b>				
Appearance of Illness of Distress (D)	NS*	NS	NS	ns
Relative Age Appearance (D)	ns	ns	NS	ns
Body Fat (C)	ns	NS	ns	ns
Body Fat with Adjustment for Caloric Intake (C)	ns	NS	ns	ns
Body Fat (D)	ns	NS	NS	NS
Body Fat with Adjustment for Caloric Intake (D)	ns	ns	NS	NS
<b>Laboratory</b>				
Sedimentation Rate (C)	NS	NS	ns	NS*
Sedimentation Rate (D)	NS	NS	ns	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$ .

NS or ns: Not significant ( $p > 0.10$ ).

NS\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or differences of means nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00 for discrete analyses or difference of means negative for continuous analyses.

**Table 9-20.**  
**Summary of Initial Dioxin Analyses (Model 2) for General Health Variables**  
**(Ranch Hands Only)**

Variable	Unadjusted	Adjusted
<b>Questionnaire</b>		
Self-Perception of Health (D)	+0.049	NS
<b>Physical Examination</b>		
Appearance of Illness or Distress (D)	ns	ns
Relative Age Appearance (D)	NS*	NS
Body Fat (C)	ns	ns
Body Fat with Adjustment for Caloric Intake (C)	--	ns
Body Fat (D)	ns	ns
Body Fat with Adjustment for Caloric Intake (D)	--	ns
<b>Laboratory</b>		
Sedimentation Rate (C)	NS	NS*
Sedimentation Rate (D)	NS	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$ .

NS or ns: Not significant ( $p > 0.10$ ).

NS\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

--: Not applicable for unadjusted analysis.

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or slope nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00 for discrete analyses or slope negative for continuous analyses.

**Table 9-21.**  
**Summary of Categorized Dioxin Analyses (Model 3) for General Health Variables**  
**(Ranch Hands vs. Comparisons)**

Variable	UNADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
<b>Questionnaire</b>				
Self-Perception of Health (D)	NS	NS	+ <0.001	+0.001
<b>Physical Examination</b>				
Appearance of Illness or Distress (D)	NS	NS	ns	NS
Relative Age Appearance (D)	ns	ns	NS	ns
Body Fat (C)	ns*	NS	ns	ns
Body Fat (D)	ns	NS	NS	NS
<b>Laboratory</b>				
Sedimentation Rate (C)	ns	NS*	NS	NS*
Sedimentation Rate (D)	ns	NS	NS	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$ .

NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or differences of means nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00 for discrete analyses or difference of means negative for continuous analyses.

**Table 9-21. (Continued)**  
**Summary of Categorized Dioxin Analyses (Model 3) for General Health Variables**  
**(Ranch Hands vs. Comparisons)**

Variable	ADJUSTED			
	Background Ranch Hands vs. Comparisons	Low Ranch Hands vs. Comparisons	High Ranch Hands vs. Comparisons	Low plus High Ranch Hands vs. Comparisons
<b>Questionnaire</b>				
Self-Perception of Health (D)	NS	NS	+0.005	+0.006
<b>Physical Examination</b>				
Appearance of Illness of Distress (D)	NS	NS	NS	NS
Relative Age Appearance (D)	ns	ns	ns	ns
Body Fat (C)	ns	NS	ns*	ns
Body Fat with Adjustment for Caloric Intake (C)	** <i>(ns)</i>	** <i>(NS)</i>	** <i>(ns*)</i>	** <i>(ns)</i>
Body Fat (D)	ns	NS	NS	NS
Body Fat with Adjustment for Caloric Intake (D)	ns	NS	NS	NS
<b>Laboratory</b>				
Sedimentation Rate (C)	ns	NS	NS	NS*
Sedimentation Rate (D)	ns	NS	NS	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$ .

NS or ns: Not significant ( $p > 0.10$ ).

NS\* or ns\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

\*\**(NS)* or \*\**(ns)*: Categorized dioxin-by-covariate interaction ( $p \leq 0.05$ ); not significant when interaction is deleted; refer to Appendix E-2 for further analysis of this interaction.

\*\**(ns\*)*: Categorized dioxin-by-covariate interaction ( $p \leq 0.05$ ); marginally significant when interaction is deleted; refer to Appendix E-2 for further analysis of this interaction.

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or differences of means for nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00 for discrete and analyses or difference of means negative for continuous analyses.

**Table 9-22.**  
**Summary of Current Dioxin Analyses (Models 4, 5, and 6) for General Health Variables**  
**(Ranch Hands Only)**

Variable	UNADJUSTED		
	Model 4: Lipid-Adjusted Current Dioxin	Model 5: Whole-Weight Current Dioxin	Model 6: Whole-Weight Current Dioxin Adjusted for Total Lipids
<b>Questionnaire</b>			
Self-Perception of Health (D)	+0.002	+ <0.001	+0.018
<b>Physical Examination</b>			
Appearance of Illness or Distress (D)	ns	ns	ns
Relative Age Appearance (D)	NS	NS	NS
Percent Body Fat (C)	+ <0.001	+ <0.001	+ <0.001
Percent Body Fat (D)	+ <0.001	+ <0.001	+ <0.001
<b>Laboratory</b>			
Sedimentation Rate (C)	+0.014	+0.001	NS*
Sedimentation Rate (D)	+0.019	+0.009	NS*

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analyses; slope nonnegative for continuous analyses.

NS or ns: Not significant.

NS\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or slope nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00.

**Table 9-22. (Continued)**  
**Summary of Current Dioxin Analyses (Models 4, 5, and 6) for General Health Variables**  
**(Ranch Hands Only)**

Variable	ADJUSTED		
	Model 4: Lipid-Adjusted Current Dioxin	Model 5: Whole-Weight Current Dioxin	Model 6: Whole-Weight Current Dioxin Adjusted for Total Lipids
<b>Questionnaire</b>			
Self-Perception of Health (D)	** (NS*)	** (+0.024)	** (NS)
<b>Physical Examination</b>			
Appearance of Illness of Distress (D)	** (ns)	** (ns)	** (ns)
Relative Age Appearance (D)	** (ns)	ns	ns
Body Fat (C)	** (+0.001)	+ <0.001	+ <0.001
Body Fat with Adjustment for Caloric Intake (C)	** (+0.001)	+ <0.001	+ <0.001
Body Fat (D)	** (+ <0.001)	+ <0.001	+ <0.001
Body Fat with Adjustment for Caloric Intake (D)	** (+ <0.001)	+ <0.001	+ <0.001
<b>Laboratory</b>			
Sedimentation Rate (C)	+0.045	+0.006	NS
Sedimentation Rate (D)	NS*	+0.001	NS

C: Continuous analysis.

D: Discrete analysis.

+: Relative risk  $\geq 1.00$  for discrete analysis; slope nonnegative for continuous analysis.

NS or ns: Not significant.

NS\*: Marginally significant ( $0.05 < p \leq 0.10$ ).

\*\* (NS) or \*\* (ns):  $\text{Log}_2$  (current dioxin + 1)-by-covariate interaction ( $p \leq 0.05$ ); not significant when interaction is deleted; refer to Appendix Table E-2 for further analysis of this interaction.

\*\* (NS\*):  $\text{Log}_2$  (current dioxin + 1)-by-covariate interaction ( $p \leq 0.05$ ); marginally significant when interaction is deleted; refer to Appendix E-2 for further analysis of this interaction.

\*\* (...):  $\text{Log}_2$  (current dioxin + 1)-by-covariate interaction ( $p \leq 0.05$ ); significant when interaction is deleted and p-value is given in parentheses; refer to Appendix E-2 for further analysis of this interaction.

Note: P-value given if  $p \leq 0.05$ .

A capital "NS" denotes a relative risk 1.00 or greater for discrete analyses or slope nonnegative for continuous analyses. A lower case "ns" denotes relative risk less than 1.00.

**Table 9-23.**  
**Summary of Dioxin-by-Covariate Interactions**  
**from Analyses of General Health Variables**

Model	Variable	Covariate
3 <sup>a</sup>	Body Fat with Adjustment for Caloric Intake (C)	Caloric Intake
4 <sup>b</sup>	Self-Perception of Health (D)	Age
	Appearance of Illness or Distress (D)	Age
	Relative Age Appearance (D)	Occupation
	Body Fat (C)	Occupation
	Body Fat with Adjustment for Caloric Intake (C)	Occupation
	Body Fat (D)	Occupation
	Body Fat with Adjustment for Caloric Intake (D)	Occupation
5 <sup>c</sup>	Self-Perception of Health (D)	Age
	Appearance of Illness or Distress (D)	Age
6 <sup>d</sup>	Self-Perception of Health (D)	Age
	Appearance of Illness or Distress (D)	Age

C: Continuous analysis.

D: Discrete analysis.

<sup>a</sup> Categorized Dioxin.

<sup>b</sup> Ranch Hands—Log<sub>2</sub> (Current Lipid-Adjusted Dioxin).

<sup>c</sup> Ranch Hands—Log<sub>2</sub> (Current Whole-Weight Dioxin).

<sup>d</sup> Ranch Hands—Log<sub>2</sub> (Current Whole-Weight Dioxin), Adjusted for Total Lipids.

### **Model 1: Group Analysis**

In the unadjusted analysis, the percentage of Ranch Hands that reported their self-perception of health as poor or fair was significantly greater than the percentage of Comparisons that reported their health as poor or fair. Stratification across the three occupational levels revealed a significant difference in self-perception of health between Ranch Hands and Comparisons for the enlisted groundcrew stratum only. The unadjusted analyses of the remaining four variables did not reveal significant group differences.

The adjusted analysis of self-perception of health displayed a significant positive difference between Ranch Hands and Comparisons both overall and for the enlisted groundcrew category. For appearance of illness or distress, a marginally significant group effect was revealed, but this difference was not evident when examined within each of the three occupations. In the continuous adjusted analysis of sedimentation rate, a marginally significant difference was found to exist between Ranch Hands and Comparisons in the enlisted groundcrew stratum with Ranch Hands having a higher mean sedimentation rate than Comparisons. The adjusted results for the remaining dependent variables were nonsignificant. Adjusting the percent body fat analyses for caloric intake did not change the significance of the results.

### **Model 2: Initial Dioxin Analysis**

For the unadjusted analysis of self-perception of health, there was a significant association with initial dioxin with an estimated relative risk of 1.21. In the unadjusted analysis of relative age appearance, a marginally significant increased relative risk of appearing older than one's stated age was found with an increase in initial dioxin. The remaining three dependent variables displayed nonsignificant associations with initial dioxin for the unadjusted analyses.

The adjusted analysis of self-perception of health revealed a nonsignificant relative risk; however, removal of occupation from the final model caused the initial dioxin effect to become significant.

A marginally significant positive relationship between initial dioxin and sedimentation rate in its continuous form was revealed in the adjusted analysis. These were the only relationships of significance in the adjusted analyses of the dependent general health variables. Adjustments for caloric intake in the analyses of percent body fat did not change the significance of the results.

### **Model 3: Categorized Dioxin Analysis**

In the unadjusted analysis of self-perception of health, highly significant differences were seen between the high Ranch Hand and Comparison dioxin categories and for the low plus high Ranch Hand versus Comparison dioxin categories. For both contrasts, the percentage of participants who perceived their health as poor or fair was greater in the Ranch Hand categories than in the Comparison category. For body fat measured in the continuous form, the unadjusted analysis revealed a negative association of marginal significance for

background Ranch Hands versus Comparisons. Marginally significant differences between low Ranch Hands and Comparisons and between low plus high Ranch Hands and Comparisons were revealed in the unadjusted analysis of sedimentation rate in its continuous form. For both of these contrasts, the Ranch Hands exceeded the Comparisons in mean sedimentation rate.

The adjusted analysis of self-perception of health yielded results very similar to the unadjusted analysis. The difference in categorized dioxin between high Ranch Hands and Comparisons was highly significant as was the difference between low plus high Ranch Hands and Comparisons. The relative risk exceeded 1.5 in each of these contrasts.

For the adjusted analysis of body fat expressed in continuous form, the difference between the dioxin categories of high Ranch Hands and Comparisons was marginally significant with mean body fat percentages of 21.70 and 22.01 respectively. No significant differences between the dioxin categories were revealed in the discrete body fat analysis.

For the continuous analysis of body fat with adjustment for caloric intake, there was a significant interaction between categorized dioxin and caloric intake. After removing the interaction from the final model, the difference between the dioxin categories of high Ranch Hands and Comparisons was marginally significant with Comparisons exceeding Ranch Hands. In the discrete analysis of body fat with adjustment for caloric intake, no significant difference between the dioxin categories was observed.

#### **Models 4, 5, and 6: Current Dioxin Analyses**

For self-perception of health, each of the Models 4 through 6 unadjusted analyses exhibited a significant positive relationship with current dioxin, where the percentage of abnormalities increased with each level of dioxin. In the Models 4 through 6 unadjusted analyses of body fat in either form, a strong positive association between current dioxin and body fat was displayed. Both the continuous and discrete unadjusted analyses of sedimentation rate revealed a positive significant dioxin effect for Models 4 and 5. The Model 6 unadjusted analyses of sedimentation rate led to marginally significant results.

The Models 4 through 6 adjusted analyses of self-perception of health found the interaction of current dioxin and age to be significant. Removal of the interaction from the final model led to marginally significant and significant positive associations between current dioxin and self-perception of health for Models 4 and 5 only. In addition, the removal of occupation, retained in each of the adjusted analyses, led to a significant current dioxin effect in all three models.

In the adjusted analyses of appearance of illness or distress for Models 4 through 6, a significant interaction between current dioxin and age was evident. After deleting the interaction from the final models, negative associations between current dioxin and appearance of illness or distress were detected, but these associations were nonsignificant.

The adjusted analyses of relative age appearance showed the current dioxin-by-occupation interaction to be significant for Model 4. A significant dioxin effect did not

remain after the interaction was deleted from the final model. The adjusted analyses of Models 5 and 6 led to nonsignificant results.

For both the discrete and continuous adjusted analyses of body fat, a current dioxin-by-occupation interaction was significant for Model 4. Once the interaction was removed from each of the final models, a highly significant positive relationship between current dioxin and body fat remained. Regardless of form, the Models 5 and 6 adjusted analyses displayed highly significant positive associations between current whole-weight dioxin and body fat. Adjusting the analyses of body fat for caloric intake did not change the significance of the results.

For both continuous and discrete analyses of sedimentation rate, positive associations with current dioxin were evident from the results of the adjusted analyses of Models 4 and 5. Both continuous and discrete adjusted analyses of Model 6 showed that the association between sedimentation rate and current dioxin, albeit positive, was nonsignificant. However, the deletion of occupation, retained in each of the adjusted analyses, yielded a significant current dioxin effect in Models 4, 5, and 6.

## CONCLUSION

In the assessment of general health, significant differences between Ranch Hands and Comparisons, the enlisted groundcrew in particular, were evident for self-perception of health. Significant associations between negative self-perception of health and initial and current levels of dioxin were also evident. Because participants were aware of their serum dioxin levels, the possibility of bias in these results should be considered. Participants who knew they possessed an elevated dioxin level or whose occupation implied a greater risk for exposure (i.e., enlisted groundcrew) may consciously or subconsciously have perceived their health to be poorer than did their Comparisons. These results are consistent with the 1985 and 1987 followup examinations. In contrast to self-perception of health, no significant results were found for the appearance of illness or distress and relative age appearance, which were objectively recorded by the examining physicians.

The analyses of percent body fat displayed a significant positive association with current dioxin, whether calculated on a whole-weight or lipid-adjusted basis. These results seem to imply a difference in the dioxin pharmacokinetics in obese versus lean participants but would be difficult to explain clinically. Also, it is not clear whether a causal relationship exists. Sedimentation rate also displayed a significant positive association with current dioxin levels.

In the longitudinal analysis, the increase in the percentage of Ranch Hands who perceived their health to be poor in 1992 from those that were normal in 1982 was significantly associated with initial dioxin levels. Relative age appearance also displayed a significant positive association with initial dioxin. The change in percent body fat from 1982 to 1992 was significantly associated with initial dioxin, and a significant difference between Ranch Hands and Comparisons also was found, especially in enlisted groundcrew.

In conclusion, self-perception of health displayed an association with herbicide exposure, but the results are subject to considerable bias. Percent body fat and sedimentation rate displayed significant associations with current serum dioxin levels.

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