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PROJECT RANCH HAND II

AN EPIDEMIOLOGIC INVESTIGATION OF HEALTH EFFECTS IN AIR FORCE PERSONNEL FOLLOWING EXPOSURE TO HERBICIDES

MORTALITY UPDATE - 1984

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Project Ranch Hand II Mortality Update - 1984

EXECUTIVE SUMMARY

BACKGROUND

The purpose of the Ranch Hand II Study is to determine whether those individuals involved in the aerial spraying of herbicides in Vietnam during the Ranch Hand operation have experienced any adverse health effects as a result of their participation in that program. The study evaluates both mortality (death) and morbidity (disease) in these individuals over a 20-year period of time after the studies were initiated.

The baseline mortality study was released in June 1983 and the baseline morbidity study in February 1984. Neither study demonstrated health effects which could be conclusively attributed to herbicide or dioxin exposure. The reader is referred to reports of the studies for further details (1, 12).

METHOD

The present study report describes the second mortality analyses. Deaths in the 1256 Ranch Hand and 6171 comparison subjects were determined, using the data sources of the Air Force, Veterans Administration, Social Security Administration, Internal Revenue Service, and personal contacts. As of 31 December 1983, 54 Ranch Handers and 265 comparison subjects had died. Death certificates were obtained on all subjects. Autopsies were conducted on 157 of the individuals who had died. Results have been obtained for 104 of these autopsies to confirm the death certificate findings. Autopsy reports for the 53 others have been requested, but have not yet been obtained.

Extensive statistical analyses were accomplished, as detailed in the report, to compare the death experience in the Ranch Hand population with the comparison group. In addition, death experience in these groups was compared to the 1978 U.S. White Male Mortality experience, the 1978 Department of Defense Nondisability Retired Life Table, the mortality experience of the West Point Class of 1956, the USAF active duty personnel, and the active U.S. Civil Service population.

RESULTS

As was the case in the first mortality report, the current mortality analyses did not reveal any statistically significant differences in mortality between the exposed and comparison groups. The percentages dead in each major category are summarized below.

	Percent Deaths	
	Ranch Hand	Comparison
Rank		
Officers	3.2	4.0
Enlisted	4.9	4.5
Occupation		
Flying	3.6	4.7
Ground	5.1	3.9

Note: None of the above differences between the Ranch Hand and Comparison groups are statistically significant.

	Ranch Hand	Comparison
Total Overall	4.3	4.3

As was reported in the baseline mortality study, the Ranch Hand officers had a nonstatistically significant though slightly lower death rate than their comparisons, Ranch Hand flyers had a nonstatistically significant though slightly lower death rate than comparisons, and Ranch Hand ground personnel had a slightly higher but nonstatistically significant death rate than the comparisons.

The herbicide/dioxin exposure index described in the morbidity report was applied to the data, and no relationship between exposure and mortality experience was identified.

As was also noted in the baseline mortality study, analyses consistently demonstrated significantly better aurvival in the Ranch Hand officers than Ranch Hand enlisted members, as was the case with comparison officers and comparison enlisted personnel. Cause-specific analyses did not demonstrate any increased Ranch Hand mortality for accidents, suicide, homicide, malignancy or circulatory system disease. No unusual patterns of malignancy were observed in either the Ranch Hand or comparison groups, a finding which would be expected from the small number of deaths to date.

When compared to the 1978 U.S. White male population, the Ranch Hand officers, comparison officers, and comparison enlisted are living significantly longer than expected. Although Ranch Hand enlisted are also living longer, the difference is not significant. A similar pattern was seen in analyses using the DOD retired population. All groups had a mortality experience similar to the civil service population. As would be expected from the fact that individuals in the active duty population who develop severe chronic disease are medically retired, all groups in this study had an increased mortality when compared to the Air Force population currently on active duty. Both Ranch Hand and comparison officers had mortality similar to the West Point group.

CONCLUSION AND RECOMMENDATION

Continued mortality surveillance is recommended, since the study groups are still relatively young and healthy. While sufficient time may have elapsed for some clinically significant conditions to occur, additional time is necessary for other conditions, which may possibly be attributable to herbicide exposure, to develop. At this time, however, there is no evidence of increased mortality as a result of herbicide exposure in those individuals who accomplished the Ranch Hand spray operations in Vietnam.

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Project Ranch Hand II Mortality Update - 1984

1. Introduction

This report updates the findings of the baseline mortality report (1) released on June 30, 1983. The reader is referred to the baseline report for information regarding the study design, statistical procedures, the mortality determination process and previous findings. Nine newly identified Ranch Handers have been added to the data file since the baseline report. One of these, a non-Black Enlisted ground crew member, died in 1981 of circulatory disease. Summary counts of the population at risk and the number of deaths in each of the three groups are shown in Table 1. The analyses in this report are based on this data and the data in Table 4. Table 2 contains the counts of new deaths in the population since the last report. Table 3 in this report corresponds to Table 3 in the baseline report and contains summary counts and death rates by job, race and group. These counts reflect cumulative mortality as of 31 December 1983 (certified as of 8 June 1984).

Table 1

Summary Counts of Death by Rank and Occupation

	Ranch Hand			Comparison		
Rank	At Risk	Dead	Rate (%)	At Risk	Dead	Rate (%)
Officers	466	15	0.032 (3.2)	2278	91	0.040 (4.0)
Enlisted	790	39	0.049 (4.9)	3893	174	0.045 (4.5)
Occupation						
Flying	646	23	0.036 (3.6)	3163	149	0.047 (4.7)
Ground	610	31	0.051 (5.1)	3008	116	0.039 (3.9)
Total	1256	54	0.043 (4.3)	6171	265	0.043 (4.3)

Table 2

Deaths During 1983 by Rank and Occupation

	Ranch Hand		Comparison	
Rank	At Risk	1983 Deaths	At Risk	1983 Deaths
Officer*	451	0	2190	3
Enlisted*	754	3	3731	12
Occupation				
Flying*	624	1	3023	9
Ground*	581	2	2898	6

*At risk count does not include the newly identified Ranch Hander who died prior to 1983.

Table 3

Occupational and Race Specific Mortality

Race	Occupation	Ranch Hand At Risk	Ranch Hand Dead	Ranch Hand Rate	Comparisons At Risk	Comparisons Dead	Comparisons Rate
Non-Black	Officer-Pilot	350	12	0.034	1740	74	0.043
	Officer-Nav	82	2	0.024	390	14	0.036
	Officer-Other	25	1	0.040	123	3	0.024
	Enlisted-Flt Eng	191	7	0.037	935	51	0.055
	Enlisted-Other	532	28	0.053	2628	101	0.038
Black	Officer-Pilot	6	0	0.000	13	0	0.000
	Officer-Nav	2	0	0.000	10	0	0.000
	Officer-Other	1	0	0.000	2	0	0.000
	Enlisted-Flt Eng	15	2	0.133	75	10	0.133
	Enlisted-Other	52	2	0.038	255	12	0.047
Total		1256	54	0.043	6171	265	0.043

2. Ranch Hand Versus Comparison Group Analyses.

Survival contrasts were made using linear rank procedures, survival curves, relative risk estimation and standardized mortality ratios. Survival curves were estimated via the product-limit estimate of Kaplan and Meier (2). Linear rank testing was carried out using the logrank test and Prentice's censored data extension of the Wilcoxon test (3). All linear rank tests were carried out with matched sets merged when Ranch Handers differed by less than one year relative to date of birth. Within each stratum of job and race, these merged matched sets were used as separate strata for testing purposes. The matched data relative risk procedure, due to Ejigou and McHugh (4) is applied only to the 1241 Ranch Handers with matched comparisons and the stratified relative risk or SMR estimate is applied to all 1256 Ranch Handers.

Group contrasts were made on officers, enlisted personnel, flying personnel, ground personnel and the total group. Summary counts are shown in Table 4.

Table 4

Summary Counts by Rank, Occupation and Group

Flying Personnel

Groups	Officer			Enlisted			Total		
	At Risk	Dead	Rate	At Risk	Dead	Rate	At Risk	Dead	Rate
Ranch Hand	440	14	0.032	206	9	0.044	646	23	0.036
Comparisons	2153	88	0.041	1010	61	0.060	3163	149	0.047

Ground Personnel

Groups	Officer			Enlisted			Total		
	At Risk	Dead	Rate	At Risk	Dead	Rate	At Risk	Dead	Rate
Ranch Hand	26	1	0.038	584	30	0.051	610	31	0.051
Comparisons	125	3	0.024	2883	113	0.039	3008	116	0.039

Survival curves were estimated only for officers, enlisted, flying, ground personnel and all personnel in Ranch Hand and the comparison groups. There is a substantial degree of overlap between these subgroups, with 96% of both the Ranch Hand and comparison ground personnel being enlisted. The enlisted category includes both ground support and flying enlisted personnel. Survival curves for the overall Ranch Hand and comparison groups are shown in Figure 1. The curves for officers, enlisted personnel, flyers and ground personnel are shown in Figures 2 through 5.

Figure 1

Survival Curve Estimates for All Ranch Handers and All Comparisons

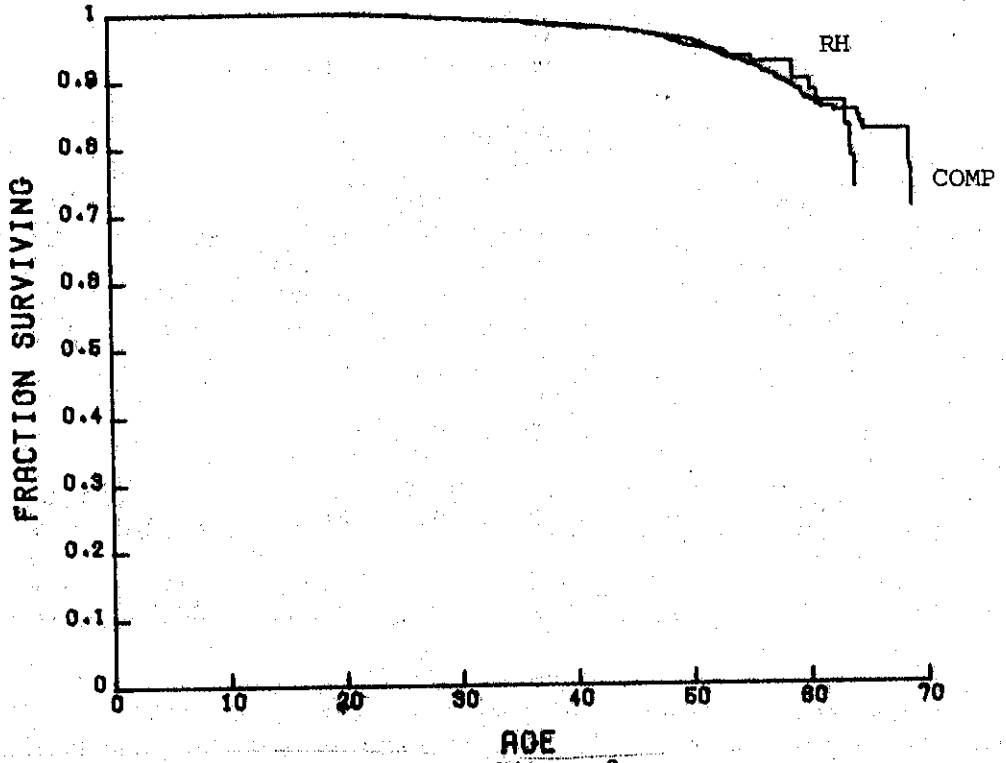


Figure 2

Survival Curve Estimates for Ranch Hand and Comparison Officers

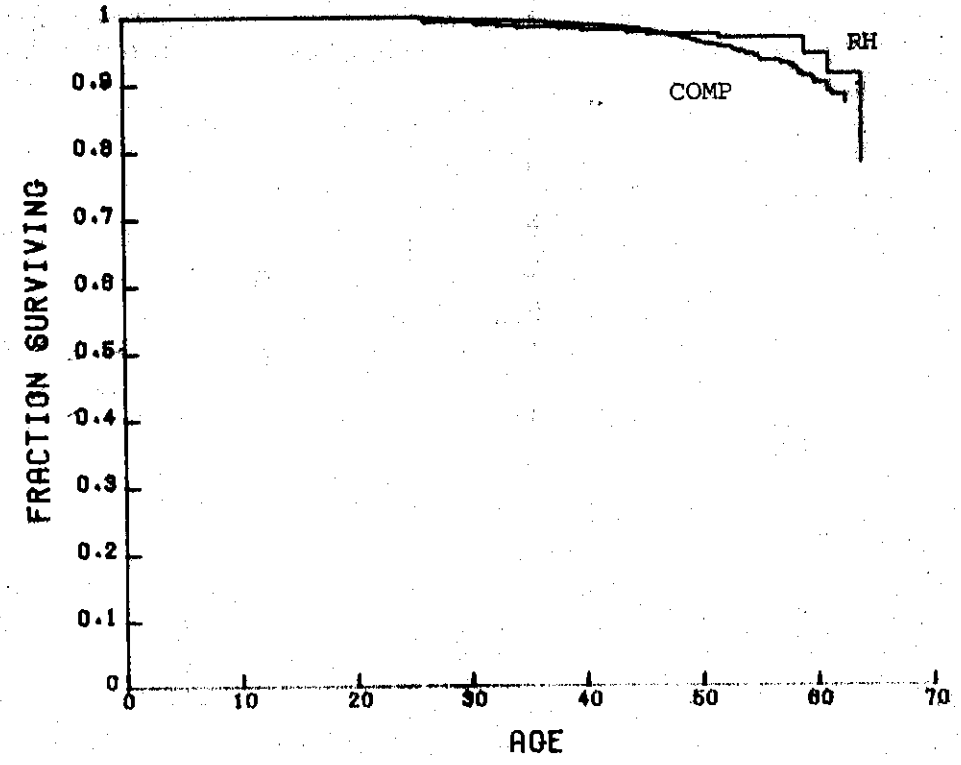


Figure 3

Survival Curve Estimates for Enlisted Ranch Handers and Comparisons

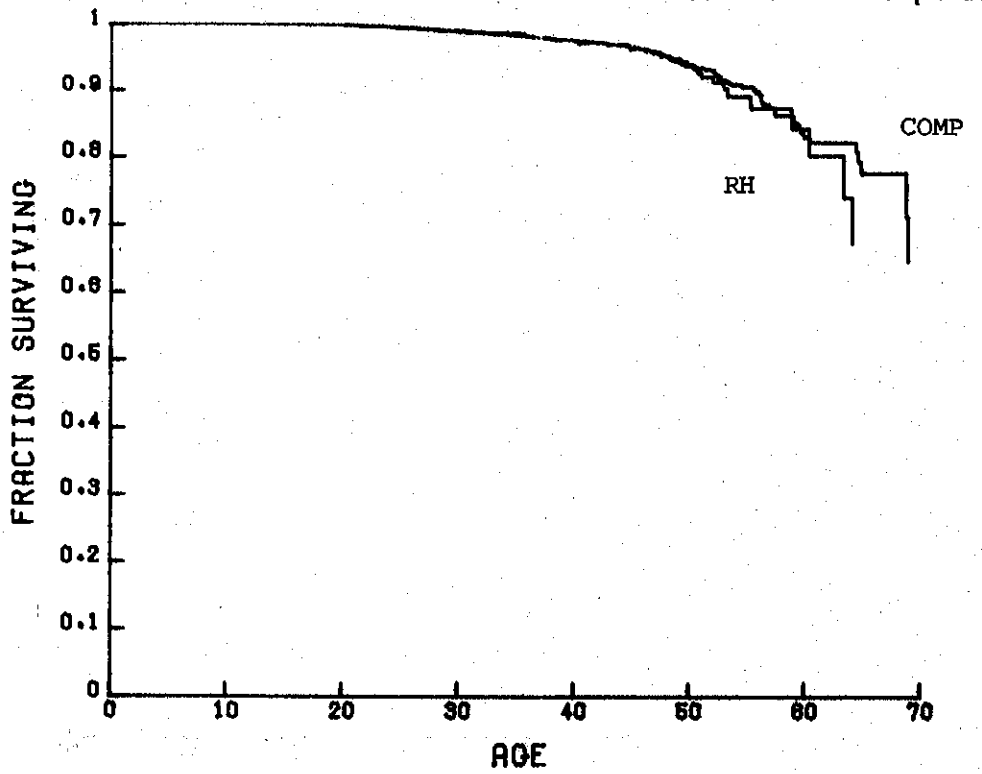


Figure 4

Survival Curve Estimates for Ranch Hand and Comparison Flyers

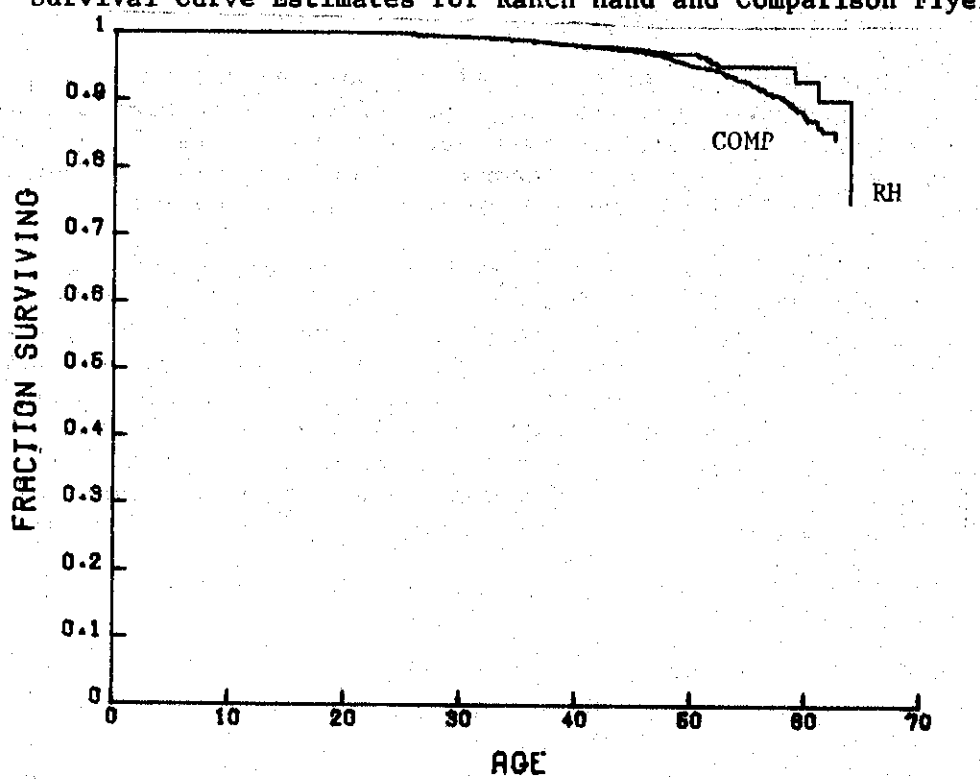
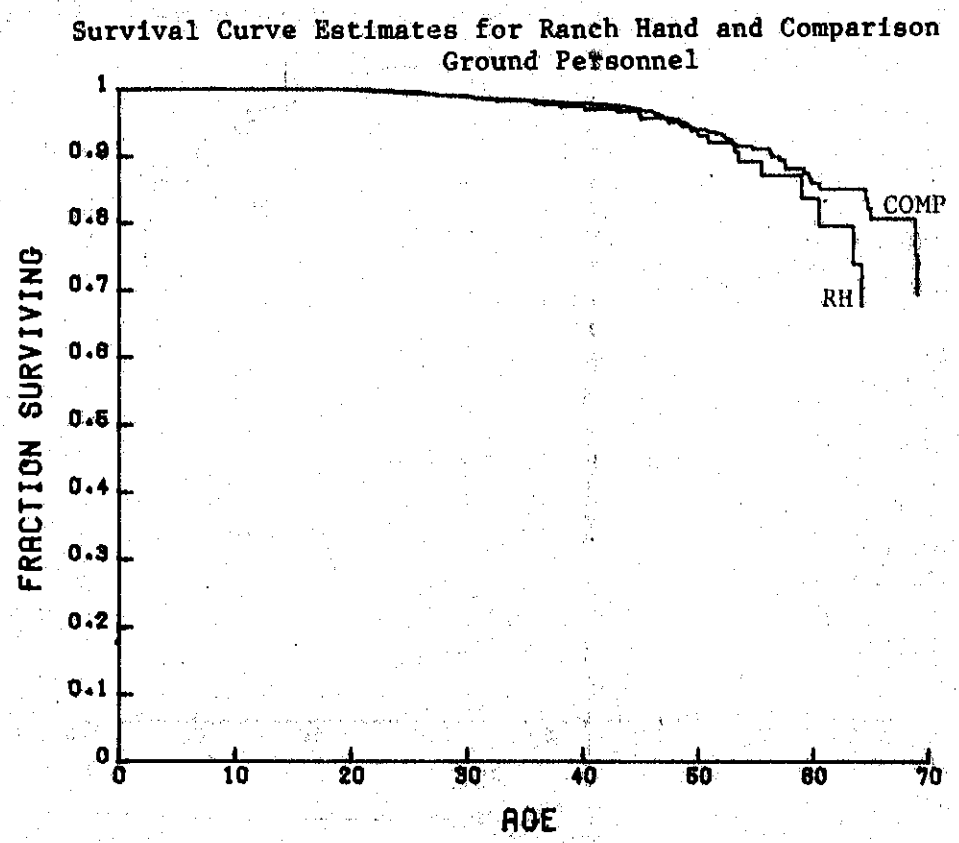


Figure 5



The patterns qualitatively evident in these graphs are seen quantitatively in subsequent statistical analyses.

Linear rank procedures were carried out on the same four subgroups and on all personnel to assess death patterns by time. These procedures are designed so that the statistic will be positive when Ranch Handers are dying before comparison subjects and negative when comparisons are dying prior to Ranch Handers. The results are shown in Table 5 (Table 6 in the baseline report).

The rank statistic used is a fair measure of group difference only when this difference occurs consistently within each tested stratum. Since the strata in these analyses were formed by date of birth, occupation and race, the rank statistic is fair only when the group difference in death times does not change with date of birth, race and occupation. As will be shown later, there is an indication that there is an effect of date of birth on relative risks in the officer subgroup. Thus, rank statistics on officers must be interpreted carefully. Further, since there is an indication that mortality contrasts change with rank and occupation, the overall logrank value and p-value, shown in Table 5 are not valid summary statistics.

Table 5

Test Results and P-values for Noncause-Specific Survival

	Logrank		Wilcoxon	
Group	(value)	P-value	(value)	P-value
Officer	(-0.682)	0.495	(-0.771)	0.441
Enlisted	(0.640)	0.522	(0.575)	0.565
Flying	(-1.144)	0.253	(-1.228)	0.220
Ground	(1.303)	0.192	(1.235)	0.217
Total	(0.076)	0.939	(0.009)	0.993

Table 5 suggests that ground personnel in the Ranch Hand group are dying sooner than their matched comparisons (logrank = 1.303), but the difference is not statistically significant (p=0.192). The negative values of the logrank and Wilcoxon statistics for officers (logrank = -0.682) and flying personnel (logrank = -1.144) suggest that Ranch Handers in this group may be living longer than their matched comparisons.

Similar analyses on the same subgroups (officer, enlisted, flying, ground and total) were carried out on data from non-Black subjects only. The results are shown in Table 6.

Table 6

Test Results and P-values for Noncause-Specific Survival
Non-Black Ranch Handers and Non-Black Comparisons

	Logrank		Wilcoxon	
Group	(value)	P-value	(value)	P-value
Officer	(-0.668)	0.504	(-0.755)	0.450
Enlisted	(0.686)	0.492	(0.626)	0.531
Flying	(-1.229)	0.219	(-1.305)	0.192
Ground	(1.436)	0.151	(1.360)	0.174
Total	(0.101)	0.919	(0.037)	0.970

The findings in Table 6 clearly parallel those of Table 5, as would be expected from the small size of the Black cohort in this study.

Relative risk estimates, the associated 95% confidence intervals, two-sided p-values for testing the null hypothesis of relative risk equal to unity, and power for detecting a relative risk of 2 in these data are shown in Table 7. These estimates are based on a matched data algorithm and summarize the relative prevalence of death in the Ranch Hand and comparison groups. As with the rank tests, the estimated relative risks are unbiased only when the relative risks can be assumed to be constant across date of birth strata. There is indication that this assumption is not met in the officer cohort so that their estimated relative risks must be viewed with caution. On the other hand, the assumption appears to be well met in the flying, ground and enlisted subgroups so that these relative risk estimates appear to be reliable. Since there is an indication that relative risk changes with rank and occupation, the overall relative risk, 0.965, is not a valid summary statistic.

Table 7

Relative Risks, 95% Confidence Intervals, P-Values and Power for Noncause-Specific Deaths to Date (1241 Ranch Handers Versus 6171 Matched Comparisons)

Group	Rel Risk	Conf Int	P-value	Power
Officer	0.715	(0.295, 1.134)	0.275	0.886
Enlisted	1.077	(0.679, 1.475)	0.692	0.980
Flying	0.718	(0.385, 1.052)	0.174	0.968
Ground	1.259	(0.724, 1.793)	0.274	0.928
Total	0.965	(0.666, 1.264)	0.823	0.998

Table 7 shows that Ranch Hand flyers are experiencing fewer deaths than their matched comparisons (relative risk = 0.718), but this group difference is not statistically significant (p=0.174). The Ranch Hand ground personnel have experienced more deaths (relative risk = 1.259) than their matched ground comparisons, but, again, this excess is also not statistically significant (p=0.274).

Year-of-birth specific mortality rates are given in Tables 8 through 12, with the corresponding standardized mortality ratios (SMR) and associated p-values (5). In each analysis, the comparison group is the internal standard. The SMR will accurately estimate the relative risks within each stratum in these analyses if the year-of-birth specific relative risks are equal. A likelihood ratio test for the hypothesis of equal year-of-birth specific relative risks was carried out for each analysis, and its p-value is denoted by P1. In addition, the hypothesis that the relative risk is unity, given that relative risk is constant across strata, was tested; its p-value is denoted by P2. The SMR and both p-values are given for each contrast. Additional post hoc analyses are presented at the end of this section to show that the hypothesis of equal year-of-birth specific relative risks may not be met in the officer and flying cohorts.

Table 8

Year-Of-Birth Specific Mortality Rates (1256 Ranch Handers Versus 6171 Comparisons) (SMR = 1.008, P1 = 0.258, P2 = 0.983)

Birth Year	Ranch Hand			Comparison		
	At Risk	Dead	Rate	At Risk	Dead	Rate
1905-1914	5	2	0.400	14	3	0.214
1915-1919	17	5	0.294	96	12	0.125
1920-1924	48	3	0.063	241	24	0.100
1925-1929	84	2	0.024	501	44	0.088
1930-1934	305	17	0.056	1389	73	0.053
1935-1939	210	7	0.033	1020	36	0.035
1940-1944	210	5	0.024	1096	23	0.021
1945-1954	377	13	0.034	1814	50	0.028
Total	1256	54		6171	265	

Table 9

Officer-Specific Mortality Rates by Year-Of-Birth
(SMR =0.797, P1 = 0.236, P2 = 0.404)

Birth Year	Ranch Hand			Comparison		
	At Risk	Dead	Rate	At Risk	Dead	Rate
1910-1924	41	3	0.073	205	17	0.083
1925-1934	194	4	0.021	930	51	0.055
1935-1939	95	4	0.042	458	12	0.026
1940-1944	91	2	0.022	495	6	0.012
1945-1949	45	2	0.044	190	5	0.026
Total	466	15		2278	91	

Table 10

Enlisted-Specific Mortality Rates by Year-Of-Birth
(SMR = 1.105, P1 = 0.663. P2 = 0.590)

Birth Year	Ranch Hand			Comparison		
	At Risk	Dead	Rate	At Risk	Dead	Rate
1905-1914	4	2	0.500	12	3	0.250
1915-1919	9	2	0.222	54	8	0.148
1920-1924	16	3	0.188	80	11	0.138
1925-1929	41	2	0.049	211	24	0.114
1930-1934	154	13	0.084	749	42	0.056
1935-1939	115	3	0.026	562	24	0.043
1940-1944	119	3	0.025	601	17	0.028
1945-1954	332	11	0.033	1624	45	0.028
Total	790	39		3893	174	

Table 11

Flying-Specific Mortality Rates by Year-Of-Birth
(SMR =0.751, P1 = 0.765. P2 = 0.186)

Birth Year	Ranch Hand			Comparison		
	At Risk	Dead	Rate	At Risk	Dead	Rate
1910-1924	44	4	0.091	220	23	0.105
1925-1934	272	9	0.033	1316	78	0.059
1935-1939	145	6	0.041	698	24	0.034
1940-1944	121	2	0.017	653	14	0.021
1945-1949	64	2	0.031	276	10	0.036
Total	646	23		3163	149	

Table 12

Ground Specific Mortality Rates by Year-of-Birth
(SMR = 1.306, P1 = 0.604, P2 = 0.203)

Birth Year	Ranch Hand			Comparison		
	At Risk	Dead	Rate	At Risk	Dead	Rate
1905-1914	5	2	0.400	14	3	0.214
1915-1919	8	1	0.125	51	6	0.118
1920-1924	13	3	0.231	66	7	0.106
1925-1929	31	2	0.065	151	19	0.126
1930-1934	86	8	0.093	423	20	0.047
1935-1939	65	1	0.015	322	12	0.037
1940-1944	89	3	0.034	443	9	0.020
1945-1954	313	11	0.035	1538	40	0.026
Total	610	31		3008	116	

When year-of-birth is dichotomized (1905-1934, 1935-1954) and survival status (alive, dead) is analyzed by group (Ranch Hand, comparison) and rank (officer, enlisted), a significant four-way interaction is evident (p=0.024). That is, the survival status by birth year by group relationship changes with rank. The officer and enlisted relative risks are 0.50 and 1.23 in the 1905-1934 year-of-birth stratum and 1.72 and 0.97 in the 1935-1954 birth-year stratum. There were no three-way interactions in this analysis. When rank is replaced by flying status (flying, ground) in this four factor analysis, no four-way interaction is seen (p=0.250), and no significant group by flying status by birth-year interaction (p=0.790) is observed.

Further, when the officer, enlisted, flying and ground subgroups are analyzed separately on survival status, group and birth year, there is no three-way interaction for enlisted (p=0.480), flying (p=0.265) or ground personnel (p=0.634) but there is a significant three-way interaction for the officers (p=0.027). That is, the survival status by group relationship changes with year of birth in the officer cohort.

Taken together, these log-linear analyses indicate that date of birth is affecting the relative risk estimate (and thus the SMR and rank tests) in the officer category. Specifically, the overall death experience of the Ranch Hand officers appears to compare favorably with the comparisons. However, these diminished death rates appear to be found in the Ranch Hand officers born before 1935, while Ranch Hand officers with later birth dates evidence a rate equal to or exceeding that of the comparisons (as seen in Table 14).

A summary of logrank, relative risk and SMR results obtained is shown in Table 13.

Table 13

Noncause-Specific Statistical Summary

	Age at Death	
	Logrank	
Group	Value	P-value
Officer	-0.682	0.495
Enlisted	0.640	0.522
Flying	-1.144	0.253
Ground	1.303	0.192
Total	0.076	0.939

	Deaths to Date			
	Relative Risk		SMR	
Group	RR	P-value	SMR	P-value
Officer	0.715	0.275	0.797	0.404
Enlisted	1.077	0.692	1.105	0.590
Flying	0.718	0.174	0.751	0.186
Ground	1.259	0.274	1.306	0.203
Total	0.965	0.823	1.008	0.983

The data in Table 13 show reasonable consistency. The ground cohort displays excess death in the Ranch Hand group in contrast to the comparison group, but this group difference is not statistically significant. The officer cohort evidences less death in the Ranch Hand group in contrast to the comparison group, but, again, this group difference is not statistically significant. However, as discussed above and shown in Table 14, this favorable mortality experience occurs in those individuals born before 1935, while Ranch Hand officers born after 1935 have experienced the same or greater death rate than their comparisons.

Table 14

Death Rates by Group, Rank, Occupation and Year-Of-Birth

Rank	Year of Birth	Ranch Hand Death Rate	Comparison Death Rate	Relative Risk
Officer	Before 1935	0.030	0.060	0.50
	After 1935	0.034	0.020	1.72
Enlisted	Before 1935	0.100	0.080	1.23
	After 1935	0.030	0.031	0.97
Occupation				
Flying	Before 1935	0.041	0.066	0.62
	After 1935	0.030	0.030	1.00
Ground	Before 1935	0.112	0.078	1.44
	After 1935	0.032	0.026	1.23

The favorable, though not statistically significant, survival experience of Ranch Hand flying personnel, relative to the matched comparison flyers is shown in Figure 4, where the survival curves for Ranch Hand and comparison flyers are drawn on the same scale and coordinate system. In contrast, the relatively poorer, but not statistically significant, survival experience of the Ranch Hand ground personnel is illustrated in Figure 5, wherein the Ranch Hand and comparison ground personnel survival curves are drawn on the same coordinate system.

3. Within Group Analyses of Mortality

Within group year-of-birth adjusted contrasts by occupation and rank via SMR's are summarized in Table 15. The corresponding SMR analyses are shown in the Appendix.

Table 15

Summary of Within Group SMR Analyses

Subgroups	SMR	P1	P2
Officers versus Enlisted			
Ranch Hand	0.483	0.204	0.031
Comparison	0.663	0.811	0.003
Flying versus Ground			
Ranch Hand	0.548	0.376	0.052
Comparison	0.926	0.607	0.782

Table 15 shows that Ranch Hand officers are having significantly fewer deaths (SMR=0.483, p=0.031) than Ranch Hand enlisted personnel, after adjustment for year-of-birth. This officer versus enlisted differential is also significant and in the same direction in the comparison group (SMR=0.663, p=0.003). The table demonstrates the favorable mortality experience of Ranch Hand flyers and adverse mortality of the Ranch Hand ground personnel in that Ranch Hand flyers are experiencing significantly fewer deaths than Ranch Hand ground personnel (SMR=0.548, p=0.052). This flyer versus ground differential is not apparent in the comparison group (SMR=0.926, p=0.782). As discussed before and as displayed in Table 14, the favorable Ranch Hand officer and flyer mortality experience is confined to the group born before 1935.

4. Cause-Specific Analyses

Table 16 shows death counts by cause and subgroup (flying officer, ground officer, flying enlisted and ground enlisted). Counts are shown for all 1256 Ranch Handers and the 6171 comparisons. The distribution of new deaths in the Ranch Hand and comparison groups are presented in Table 17 and age adjusted relative risks for these data are shown in Table 18. Relative risks are calculated using a matched data algorithm, hence, only the 1241 Ranch Handers having matched comparisons are used. Of the 15 unmatched Ranch Handers, two have died; a flying officer died of an accident and a ground airman died of circulatory system disease. Since these data are sparse, relative risks are only calculated on officer, enlisted, flying and ground subgroups, as well as on all personnel combined. Three cells in Table 18 contain two p-values for the significance of the relative risk estimate. The first is calculated using a null variance of the estimated relative risk and the second, within parentheses, is calculated using the group non-null variance estimate. A null variance is defined as a variance that requires knowledge of the true value of the estimated parameter, and that value is set equal to the value specified in the null hypothesis. The question of which variance estimate to use, and hence, which p-value to report is a point of research in theoretical statistics. We have chosen to use the null variance when computing p-values because of analogies with other testing situations and because our power studies have shown the resulting test to be more powerful than the test using the general non-null estimate. Unfortunately, the non-null variance must be used in computing 95% confidence intervals for the relative risk, making the p-value and confidence interval sometimes incompatible. Whenever this kind of disparity occurs, both p-values are given.

Table 16

Deaths by Cause and Subgroup

	Flying		Ground		Flying		Ground		Total	
Cause	RH	C	RH	C	RH	C	RH	C	RH	C
Accident	8	32	0	1	4	26	7	35	19	94
Suicide	0	4	1	0	1	3	1	9	3	16
Homicide	0	0	0	0	0	1	2	3	2	4
Parasitic infection	0	2	0	0	0	0	0	2	0	4
Malignant neoplasm	0	13	0	1	1	11	5	18	6	43
Uncertain neoplasm	0	1	0	0	0	0	0	1	0	2
Endocrine	0	1	0	0	0	0	1	0	1	1
Mental disorder	0	0	0	0	0	0	0	1	0	1
Nervous System	0	1	0	0	0	0	0	1	0	2
Circulatory System	4	27	0	0	1	14	12	34	17	75
Respiratory System	0	1	0	0	0	2	0	2	0	5
Digestive System	2	4	0	1	1	3	2	5	5	13
Genitourinary System	0	1	0	0	0	0	0	2	0	3
Congenital anomalies	0	0	0	0	0	0	0	0	0	0
Ill defined	0	1	0	0	1	1	0	0	1	2
Total	14	88	1	3	9	61	30	113	54	265

Table 17

New Deaths by Cause

	Ranch Hand		Comparison
	1	Lung Cancer	4 Circulatory
	1	Stomach Cancer	2 Digestive
	1	Undetermined*	4 Cancer
	1	Circulatory	1 Homicide
			1 Parasitic Infection
			1 Respiratory
			2 Suicides
Total	4		15

*The newly identified deceased Ranch Hander.

Table 18

Cause-Specific Age Adjusted Relative Risks by Group
(1241 Ranch Hanaers versus 6171 Comparisons)

Group	Statistic	Cause: Accident	Suicide	Homicide	Malignancy	Circulatory	Digestive
Officer	Rel Risk	0.994				0.400	
	Conf Int	(0.161, 1.827)				(0.000, 0.972)	
	P-Value	0.989				0.221 (0.412)	
	Power	0.601				0.526	
Enlisted	Rel Risk	0.844	0.833	2.500	0.998	1.258	1.875
	Conf Int	(0.279, 1.410)	(0.000, 2.081)	(0.000,6.743)	(0.108,1.889)	(0.445,2.072)	(0.000,4.363)
	P-Value	0.624	0.814	0.221	0.997	0.474	0.312
	Power	0.780	0.374	0.262	0.565	0.701	0.320
Flying	Rel Risk	0.935	0.714		0.208	0.385	2.143
	Conf Int	(0.324,1.546)	(0.000,2.211)		(0.000,0.625)	(0.000,0.836)	(0.000,5.041)
	P-Value	0.841	0.758		0.113(0.000)	0.117(0.008)	0.217
	Power	0.767	0.306		0.515	0.652	0.306
Ground	Rel Risk	0.803	1.111	3.333	1.235	1.633	1.667
	Conf Int	(0.090, 1.516)	(0.000, 2.814)	(0.000, 9.297)	(0.000, 2.486)	(0.480, 2.786)	(0.000, 4.334)
	P-Value	0.633	0.892	0.099	0.675	0.144	0.505
	Power	0.621	0.334	0.246	0.461	0.592	0.291
Total	Rel Risk	0.937	0.937	2.500	0.684	1.043	1.923
	Conf Int	(0.456, 1.418)	(0.000, 2.094)	(0.000, 6.743)	(0.095, 1.272)	(0.459, 1.627)	(0.000, 3.907)
	P-Value	0.804	0.919	0.221	0.397	0.883	0.174
	Power	0.899	0.425	0.262	0.681	0.832	0.387

Tables 16 and 18 must be interpreted with care since the data are very sparse in some categories. The Ejigou-McHugh relative risk estimate uses a variance weighting scheme of relative risks. The variance expression used is correct only for large aggregates of such matched sets. Since matched sets with large numbers of comparison deaths are rare, but tend to occur in the older subject cohorts, it must be anticipated that relative risks from the older cohorts may not be properly weighted in the relative risks shown here. Most disease information resides in the categories of malignant neoplasm and circulatory system deaths.

Digestive system mortality by ICD code is shown in Table 19, site-specific malignant neoplasm mortality is shown in Table 20 and the morphology of neoplasms is shown in Table 21. There was one case of soft tissue sarcoma in a comparison individual, but none in the Ranch Hand group.

Table 19

Digestive System Mortality

ICD Code	Deaths	
	Ranch Hand	Comparison
Pancreatitis (5770)	1	2
Alcoholic cirrhosis (5712)	0	4
Nonalcoholic cirrhosis (5715)	3	3
Nonalcoholic fatty liver (5718)	0	1
Chronic liver disease (5728)	0	2
Alcoholic liver disease (5711)	1	0
Duodenal ulcer (5325)	0	1
Peptic ulcer (5334)	0	0
Hepatocellular disease (573a)	0	0
Total	5	13

These codes were based on death certificate data; more detailed etiologic information has been requested but not yet received for the nonalcoholic cirrhosis and fatty liver deaths.

Table 20

Site-Specific Malignant Neoplasm Mortality

Site ICD Code	Ranch Hand	Comparison
Lip, oral cavity, pharynx (140-149)	0	4
Digestive organs, peritoneum (150-159)	1	9
Respiratory, intrathoracic (160-165)	3	17
Bone, connective tissue, skin, breast (170-175)	0	1
Genitourinary organs (179-189)	1	3
Brain (191-192)	0	3
Lymphatic and hematopoietic tissue (200-208)	0	5
No site specification (199)	1	1
Total	6	43

Table 21

Morphology of Neoplasms

ICD Code 9th Ed.	Nomenclature	Deaths Ranch Hand	Deaths Comp
M800	Neoplasms not otherwise specified (NOS)		
	Brain	0	1
	Bronchus and Lung	1	5
	Colon	0	1
	Esophagus	0	0
	Pancreas	0	1
	Intestinal Tract	0	1
	Unspecified site	0	0
M801-804	Epithelial neoplasms (NOS)		
	Bronchus and Lung	1	8
	Esophagus	0	1
	Kidney	1	1
	Nasopharynx	0	1
	Pancreas	0	2
	Stomach	1	0
	Prostate	0	0
	Unspecified site	1	1
	Colon	0	0
M805-808	Papillary and Squamous Cell		
	Nasal Sinus	0	1
	Lip	0	1
	Tongue	0	1
	Lung	0	0
	Tonsil	0	1
M814-838	Adenomas and Adenocarcinomas		
	Appendix	0	1
	Bronchus and Lung	0	2
	Colon	0	1
	Kidney	0	2
	Stomach	0	1
	Pancreas	0	0
M872-879	Nevi and Melanomas		
	Skin (NOS)	0	1
	Mediastinal	1	0
	Trunk	0	0
M905	Mesothelioma		
	Bronchus and Lung	0	1
M938-948	Gliomas		
	Frontal Lobe	0	1
	Brain (NOS)	0	1
M959-963	Lymphomas NOS and Diffuse		
	Lymphomas (NOS)	0	1
M964	Reticulosarcoma		
	Malignant lymphoma histiocytic, (NOS)	0	1
M965-966	Hodgkin's disease		
	Hodgkin's (NOS)	0	2
M986	Myeloid Leukemias		
	Acute Myelocytic Leukemia	0	1
	Total	6	43

5. Noncause-Specific Comparisons with External Populations

It is important to know not only how Ranch Handers and their matched comparisons relate to each other, but also how their mortality rates compare with other military and civilian populations in the United States. These contrasts are used in an attempt to place the study groups in perspective with the overall mortality experience of known populations. Given the selection factors involved for entry to and retention in the military service, it is anticipated that the study groups would exhibit lower mortality than the U.S. White male population but poorer mortality than the active duty Air Force population. Similarly, they might be expected to be more equivalent to the DOD retired personnel or occupational cohorts such as the U.S. civil service. In this report, the mortality experience of Ranch Handers and their matched comparisons is compared with the expected death rates with reference to the 1978 U.S. White Male Life Table (6), the 1978 Department of Defense period life tables for nondisability retired military officer and enlisted personnel (7), 1979 active duty Air Force officer and enlisted personnel life tables (8) and a 1974 U.S. active male civil service life table (9) and the West Point class of 1956 (10).

5.1 Comparisons with 1978 DOD Life Tables

In Tables 22 and 23, Ranch Hand officers and comparison group officers are contrasted to a 1978 DOD nondisability retired officer life table and in Tables 24 and 25, Ranch Hand and comparison group enlisted personnel are compared with a 1978 DOD nondisability retired enlisted life table. In each table, the column labeled "At Risk" lists the number of subjects entering each five-year age interval, the column labeled "Deaths" tabulates the number of deaths in the age intervals and the column labeled "Expected Deaths" gives the expected number of deaths in the age intervals of the study subjects if they had experienced the same death rates as those specified by the DOD table. The value of the test statistic for testing the null hypothesis of equality of the study and referenced life table is denoted by T; its two-sided p-value is denoted by P. While each table summarizes the findings with five-year age intervals for ease of presentation, one-year age intervals were used for the actual computation of the statistic T. A negative value of T means that the study cohort has lived longer than expected relative to the reference population. All contrasts are unadjusted for race since the DOD tables are not race-specific. All analyses are conditioned on survival to age 35, since the DOD tables do not begin until that age. The totals in Tables 22 through 25 do not, therefore, agree with Table 1.

Table 22

Ranch Hand Officer Versus DOD Nondisability Retired Officer Life Table
(T=-4.494, P<0.001)

Age	At Risk	Deaths	Expected Deaths
36-39	459	2	3.568
40-44	386	1	4.469
45-49	309	1	5.021
50-54	209	1	3.847
55-59	71	1	2.320
60-64	36	2	1.212
65-69	5	0	0.141
Total		8	20.578

Table 23

Comparison Officers Versus DOD Nondisability Retired Officer Life Table
(T=-3.288, P<0.001)

Age	At Risk	Deaths	Expected Deaths
35-39	2264	12	21.630
40-44	1924	13	21.892
45-49	1448	24	23.808
50-54	988	14	19.291
55-59	367	10	11.860
60-64	170	4	6.144
65-69	33	0	1.158
Total		77	105.783

Table 24

Ranch Hand Enlisted Personnel Versus DOD Nondisability
Retired Enlisted Life Table
(T=-0.220, P=0.826)

Age	At Risk	Deaths	Expected Deaths
35-39	735	7	7.562
40-44	432	5	5.999
45-49	311	6	7.163
50-54	182	6	5.228
55-59	54	2	2.553
60-64	23	3	1.774
65-69	9	0	0.779
70-71	2	1	0.118
Total		30	31.176

Table 25

Comparison Enlisted Personnel Versus DOD Nondisability Retired Enlisted Life Table
(T=-3.731, P<0.001)

Age	At Risk	Deaths	Expected Deaths
35-39	3611	21	37.166
40-44	2117	20	29.397
45-49	1534	36	35.350
50-54	907	17	25.533
55-59	258	14	12.545
60-64	116	4	9.005
65-69	46	2	3.638
70-74	7	0	0.908
75-76	2	0	0.065
Total		114	153.607

Tables 22 and 23 show highly favorable mortality experiences for Ranch Hand and comparison officers. Conditioned on survival to age 35, they are living significantly longer than expected using the DOD death rates ($p<0.001$ and $p<0.001$, respectively). Tables 24 and 25 show that Ranch Hand enlisted personnel are experiencing mortality patterns similar to the DOD retired enlisted population ($p=0.826$), and comparison enlisted are living significantly longer ($p< 0.001$) than the DOD nondisability retired enlisted population (conditioned on survival to age 35). This, together with the nonsignificant logrank value for Ranch Hand versus comparison enlisted personnel shown in Table 5 ($p=0.522$), suggests that the Ranch Hand versus comparison officer and enlisted contrasts change with age at death. A view of this is seen in Table 26, which shows linear rank test results, comparing Ranch Handers and comparisons conditioned on survival to age 35 (analogous to Table 5).

Table 26

Test Results and P-values for Noncause-Specific Survival
Conditioned on Survival to Age 35

	Logrank		Wilcoxon	
Group	(value)	P-value	(value)	P-value
Officer	(-1.741)	0.082	(-1.879)	0.060
Enlisted	(1.379)	0.168	(1.345)	0.179
Flying	(-1.331)	0.183	(-1.440)	0.150
Ground	(1.535)	0.125	(1.491)	0.136
Total	(-0.033)	0.974	(-0.110)	0.913

Categorical analyses reveal the interaction suggested by the Ranch Hand versus U.S. White male contrasts. These are shown in Tables 27 and 28 where survival status (alive, dead) is analyzed as a function of group (Ranch Hand, comparison) and rank (officer, enlisted) on deaths under 35 years of age and separately, on deaths over 35 years of age.

Table 27

Death Before 35, Ranch Hand Versus Comparisons
(Group By Rank By Status Interaction: P=0.043)

		Status			
Rank	Group	Alive	Dead	Total	Relative Risk
Officer	Ranch Hand	459	7	466	2.44
	Comparison	2264	14	2278	
Enlisted	Ranch Hand	781	9	790	0.74
	Comparison	3833	60	3893	

Table 28

Death After 35, Ranch Hand Versus Comparisons
(Group By Rank By Status Interaction: P=0.019)

		Status			
Rank	Group	Alive	Dead	Total	Relative Risk
Officer	Ranch Hand	451	8	459	0.51
	Comparison	2187	77	2264	
Enlisted	Ranch Hand	705	30	735	1.29
	Comparison	3497	114	3611	

In Table 28, the Ranch Hand versus comparison contrast in the officer category is significantly different from the corresponding contrast in the enlisted category. This suggests that, among those surviving to age 35, Ranch Hand officers are experiencing fewer deaths (relative risk = 0.51) than their matched comparisons while the Ranch Hand enlisted are experiencing more deaths than their matched comparisons (relative risk = 1.29). Death rates are shown in Table 29. The rate that is most apparently different is the low Ranch Hand officer death rate for those officers who survived to age 35. This low rate may parallel the favorable mortality experienced by those Ranch Hand officers born before 1935. Further analyses will attempt to clarify these patterns, with specific attention to cause of death.

Table 29

Death Rates as a Function of Age at Death

Death Rates	Ranch Hand		Comparison	
	Officers	Enlisted	Officers	Enlisted
Before Age 35	0.015 (N=466)	0.014 (N=790)	0.006 (N=2278)	0.016 (N=3893)
After Age 35	0.017 (N=459)	0.041 (N=735)	0.035 (N=2264)	0.033 (N=3611)

5.2 Comparison with Active Duty Air Force Life Tables

The mortality experience of the Ranch Handers and their matched comparisons is contrasted with the total active duty 1979 Air Force life table, unadjusted for race, in Tables 30-35. Officers and enlisted personnel in the Ranch Hand and comparison cohorts are contrasted with active duty officer and enlisted Air Force life tables in Tables 32-35. Since the active duty Air Force life tables were accurate to only three significant figures, the expected deaths shown in Tables 30-35 are computed to three significant figures. In the active duty Air Force, individuals found to have major health deficits are quickly removed from the population by medical discharge or disability retirement. Hence, this external population is biased toward excellent health and favorable mortality. These contrasts are conditioned on survival to age 20 and death up to age 50. The totals in Tables 30 through 35 do not, therefore, agree with Table 1.

Table 30

Ranch Handers Versus 1979 Active Duty Air Force Life Table
(T=3.99, P 0.001)

Age	At Risk	Deaths	Expected Deaths
20-24	1256	2	5.04
25-29	1254	7	5.06
30-34	1247	7	3.72
35-39	1194	9	5.12
40-44	818	6	4.41
45-49	620	7	4.17
Total		38	27.52

Table 31

Comparison Versus 1979 Active Duty Air Force
(T=7.41, P<0.001)

Age	At Risk	Deaths	Deaths Expected
17-19	6171	2	18.5
20-24	6169	18	24.7
25-29	6151	29	24.8
30-34	6122	25	18.2
35-39	5875	33	25.2
40-44	4041	33	21.6
45-49	2982	60	20.2
Total		200	153.20

Table 32

Ranch Hand Officers Versus 1979 Active Duty
Air Force Officer Life Table
(T=4.43, P<0.001)

Age	At Risk	Deaths	Expected Deaths
25-29	466	3	2.34
30-34	463	4	1.40
35-39	459	2	0.859
40-44	386	1	1.06
45-49	309	1	1.32
Total		11	6.979

Table 33

Comparison Officers Versus 1979 Active Duty Air Force
Officer Life Table
(T=8.37, P<0.001)

Age	At Risk	Deaths	Deaths Expected
25-29	2278	9	11.4
30-34	2269	5	6.86
35-39	2264	12	4.26
40-44	1924	13	5.15
45-49	1448	24	6.25
Total		63	33.92

Table 34

Ranch Hand Enlisted Versus the 1979
Active Duty Air Force Enlisted Life Table
(T=3.30, P<0.001)

Age	At Risk	Deaths	Expected Deaths
20-24	790	2	3.17
25-29	788	4	3.18
30-34	784	3	2.31
35-39	735	7	3.57
40-44	432	5	2.67
45-49	311	6	3.59
Total		27	18.49

Table 35

Comparison Enlisted Personnel Versus the 1979 Active Duty Air Force
Enlisted Life Table
(T=6.42, P<0.001)

Age	At Risk	Deaths	Expected Deaths
17-19	3893	2	11.7
20-24	3891	18	15.6
25-29	3873	20	15.6
30-34	3853	20	11.4
35-39	3611	21	17.5
40-44	2117	20	13.1
45-49	1534	36	17.8
Total		137	102.70

As expected, the central death rates for the active duty Air Force population are lower than those for the DOD nondisability retired population. In addition, it is expected that the Ranch Handers and their comparisons should lie somewhere between these two reference populations, for reasons such as the healthy worker effect and the medical retirement of unfit individuals from the active force. This is, in fact, the case for Ranch Hand officers, comparison officers and comparison enlisted personnel. All three of these groups are living significantly longer than expected from the DOD life table, but are dying significantly sooner than expected relative to the active duty Air Force life tables. The exception to this pattern is seen in the Ranch Hand enlisted personnel who are experiencing mortality only equivalent to the DOD enlisted life table (p=0.826). They, like the other groups, are also having a significantly worse than expected mortality experience relative to the active duty Air Force enlisted life table (p<0.001).

5.3 Comparisons with the U.S. Active Male Civil Service Life Table

To further place the Ranch Handers and their matched comparisons in perspective, Ranch Handers, comparisons, and officer and enlisted personnel are contrasted with the 1974 male active U.S. civil service life table (9). These contrasts are shown in Tables 36 through 41. There is no adjustment for civil service grade in these analyses. Therefore, socioeconomic factors may not be fully equivalent, especially in the analyses of the officer and enlisted subgroups. In future mortality updates, attempts will be made to account for the grade structure of the civil service population.

Table 36

All Ranch Handers Versus U.S. Male Civil Service
(T=0.140, P=0.889)

Age	At Risk	Deaths	Expected Deaths
21-24	1256	2	6.773
25-29	1254	7	5.998
30-34	1247	7	5.679
35-39	1194	9	6.495
40-44	818	6	7.830
45-49	620	7	8.853
50-54	391	7	5.907
55-59	125	3	3.176
60-64	59	5	1.758
65-69	14	0	0.463
70-71	2	1	0.054
Total		54	52.997

Table 37

Comparison Versus U.S. Male Civil Service
(T=-0.957, P=0.339)

Age	At Risk	Deaths	Expected Deaths
19-19	6169	2	10.523
20-24	6167	18	43.093
25-29	6149	29	29.444
30-34	6120	25	27.912
35-39	5873	33	31.995
40-44	4039	33	38.333
45-49	2980	60	42.793
50-54	1893	31	29.220
55-59	623	24	15.906
60-64	284	8	8.797
65-69	77	2	2.355
70-73	5	0	0.168
Total		265	280.549

Table 38

Ranch Hand Officers Versus U.S. Male Civil Service
(T=-1.728, P=0.084)

Age	At Risk	Deaths	Expected Deaths
25-29	466	3	2.226
30-34	463	4	2.118
35-39	459	2	2.885
40-44	386	1	3.821
45-49	309	1	4.461
50-54	209	1	3.239
55-59	71	1	1.886
60-64	36	2	0.917
65-69	5	0	0.099
Total		15	21.652

Table 39

Comparison Officers Versus U.S. Male Civil Service
(Comparisons: T=-1.658, P=0.097)

Age	At Risk	Deaths	Expected Deaths
25-29	2278	9	10.910
30-34	2269	5	10.418
35-39	2264	12	14.261
40-44	1924	13	18.710
45-49	1448	24	21.152
50-54	988	14	16.237
55-59	367	10	9.648
60-64	170	4	4.635
65-69	33	0	0.817
Total		91	106.788

Table 40

Ranch Hand Enlisted Personnel Versus U.S. Male Civil Service
(T=1.661, P=0.097)

Age	At Risk	Deaths	Expected Deaths
21-24	790	2	4.258
25-29	788	4	3.772
30-34	784	3	3.561
35-39	735	7	3.610
40-44	432	5	4.009
45-49	311	6	4.392
50-54	182	6	2.668
55-59	54	2	1.289
60-64	23	3	0.841
65-69	9	0	0.364
70-71	2	1	0.054
Total		39	28.828

Table 41

Comparison Enlisted Personnel Versus U.S. Male Civil Service
(T=1.528, P=0.127)

Age	At Risk	Deaths	Expected Deaths
19-19	3891	2	6.637
20-24	3889	18	27.158
25-29	3871	20	18.535
30-34	3871	20	17.494
35-39	3609	21	17.733
40-44	2115	20	19.623
45-49	1532	36	21.641
50-54	905	17	12.983
55-59	256	14	6.258
60-64	114	4	4.162
65-69	44	2	1.538
70-73	5	0	0.168
Total		174	153.930

The Ranch Handers and their matched comparisons are statistically quite close to the male civil service population. In these contrasts, the healthy worker effect is roughly equivalent although there is no adjustment for socioeconomic status. The contrasts of officers and enlisted personnel in the Ranch Hand and comparison cohorts with the male civil service reveal that the Ranch Hand and comparison

officers are experiencing a slightly, but not significantly better mortality than the civil service, with the Ranch Hand officers faring somewhat better than the comparison officers. Ranch Hand and comparison enlisted personnel are experiencing more mortality than the civil service with the Ranch Hand enlisted personnel faring slightly worse than the matched comparison personnel, but none of these observations are statistically significant. All of these findings are consistent with the linear rank testing shown in Table 5, the relative risks in Table 6 and the SMR's in Tables 8, 9, and 10.

5.4 Comparisons With the U.S. 1978 White Male Life Table

Finally, the mortality experience of the non-Black Ranch Handers and their matched comparisons is contrasted with the 1978 U.S. White Male Life Table.

Table 42

Non-Black Ranch Handers Versus the 1978 U.S. White Male Life Table
(T=-4.828, P<0.001)

Age	At Risk	Deaths	Expected Deaths
21-24	1180	2	9.073
25-29	1178	6	9.858
30-34	1172	7	9.596
35-39	1121	8	10.022
40-44	779	5	11.028
45-49	592	7	13.424
50-54	379	6	10.093
55-59	124	3	5.763
60-64	59	5	3.699
65-69	14	0	0.959
70-71	2	1	0.110
Total		50	83.635

Table 43

Non-Black Comparisons Versus the 1978 U.S. White Male Life Table
(T=-12.286, P<0.001)

Age	At Risk	Deaths	Expected Deaths
19-19	5816	1	10.325
20-24	5815	16	55.444
25-29	5799	27	48.592
30-34	5772	23	47.336
35-39	5537	31	49.594
40-44	3857	29	54.105
45-49	2846	53	64.837
50-54	1831	31	49.932
55-59	618	22	28.956
60-64	286	8	18.756
65-69	79	2	5.228
70-74	7	0	0.845
75-76	2	0	0.063
Total		243	430.324

Table 44

Non-Black Ranch Hand Officers Versus the 1978 U.S. White Male Life Table
(T=-5.438, P<0.001)

Age	At Risk	Dead	Expected Deaths
25-29	457	3	3.819
30-34	454	4	3.735
35-39	450	2	4.620
40-44	381	1	5.585
45-49	306	1	6.981
50-54	208	1	5.633
55-59	71	1	3.429
60-64	36	2	1.919
65-69	5	0	0.205
Total		15	35.926

Table 45

Non-Black Comparison Officers Versus the 1978 U.S. White Male Life Table
(T=-9.141, P<0.001)

Age	At Risk	Dead	Expected Deaths
25-29	2253	9	18.880
30-34	2244	5	18.530
35-39	2239	12	22.997
40-44	1899	13	27.325
45-49	1433	24	33.096
50-54	980	14	28.249
55-59	367	10	17.513
60-64	170	4	9.725
65-69	33	0	1.699
Total		91	150.689

Table 46

Non-Black Ranch Hand Enlisted Personnel Versus the 1978 U.S. White Male Life Table
(T=-1.585, P=0.113)

Age	At Risk	Dead	Expected Deaths
21-24	723	2	5.556
25-29	721	3	6.039
30-34	718	3	5.861
35-39	671	6	5.402
40-44	398	4	5.443
45-49	286	6	6.443
50-54	171	5	4.460
55-59	53	2	2.334
60-64	23	3	1.779
65-69	9	0	0.754
70-71	2	1	0.110
Total		35	44.181

Table 47

Non-Black Comparison Enlisted Personnel Versus the 1978 U.S. White Male Life Table (T=-6.393, P 0.001)

Age	At Risk	Dead	Expected Deaths
18-19	3563	1	6.325
20-24	3562	16	33.938
25-29	3546	18	29.713
30-34	3528	18	28.806
35-39	3298	19	26.597
40-44	1958	16	26.780
45-49	1413	29	31.741
50-54	851	17	21.683
55-59	251	12	11.443
60-64	116	4	9.031
65-69	46	2	3.529
70-74	7	0	0.845
75-75	2	0	0.063
Total		152	230.494

The healthy worker effect is an expected phenomenon in these data since Air Force veterans have been selected for active duty on the basis of health and technical ability. This effect is clearly evident in the overall contrasts shown in Tables 42. Both Ranch Handers and comparisons are seen to be living far longer than expected relative to the general U.S. White male population. The same effect is seen in both Ranch Hand and comparison officers (Table 44) and in comparison enlisted personnel in Table 47. The Ranch Hand enlisted personnel, however, are seen to be similar to the U.S. White male population (T=-1.585, p=0.113); they are living longer than expected but not significantly so, in contrast to the other groups. The healthy worker effect is less evident in the Ranch Hand enlisted group, and this suggests that they are faring less well against the U.S. White male population than their matched comparisons.

It is also important to note, in view of the poorer aurvival experience of Ranch Hand ground personnel, shown in Tables 5 and 6, that this group is closer to the U.S. White male population than the enlisted (T=-0.729, p=0.466) with an observed to expected death ratio of 0.883, based on 557 non-Black Ranch Hand enlisted personnel. Further, the corresponding finding for Ranch Hand enlisted ground personnel, T=-0.559, p=0.576, with an observed to expected ratio of 0.909 (based on 584 Ranch Hand enlisted ground personnel) suggests that the enlisted ground personnel may be experiencing adverse mortality that, while not significant relative to their matched comparisons, deserves close attention in future updates.

6. Comparisons with the West Point Study Group

The mortality experience of Ranch Hand and comparison officers is also contrasted with the West Point Study Group. Although the West Point group is too small for all but very crude statistical comparisons, it does provide a useful benchmark for general mortality contrasts.

The West Point Study Group consists of 474 members of the West Point Class of 1956. These men have been followed since that time for morbidity and mortality. All members of that class were, or still are, officers in the U.S. Armed Forces. The purpose of the West Point Study is to investigate the relationship between blood lipid levels and cardiovascular disease. Each study subject is physically examined biennially and blood samples are obtained for lipid and lipoprotein analyses at the USAF School of Aerospace Medicine (11).

6.1 Noncause-Specific Comparisons of Ranch Hand and Comparison Subgroups with the West Point Study Group

No new deaths have occurred in the West Point (10) group since the baseline report and prior to 31 December 1983. The number of West Point deaths, therefore, remains at 36. For the purpose of these mortality comparisons, 15 of the 36 known West Point deaths occurring on or before 31 December 1983 were deleted; 9 of the 15 were killed in action, 1 was killed in 1959 in the line of duty and 5 were killed in automobile crashes prior to 1962. The rationale for these deletions is identical to that used for deaths of personnel killed in action from the Ranch Hand and comparison groups. Noncombat or accidental deaths prior to 1962 were deleted because death prior to 1962 would have precluded membership in the Ranch Hand or comparison group. In addition, one West Pointer is also a Ranch Hander and was removed from the West Point data base. That individual was alive on 31 December 1983.

A summary of the remaining 21 deaths among the 458 West Point subjects used in these analyses is given in Table 48 and by age in Table 49. Table 49 lists the number of West Pointers at risk in each age group, the number alive on 31 December 1983, and the number dead.

Table 48

West Point Deaths by Year-Of-Birth

Year of Birth	At Risk	Dead
1930	20	0
1931	59	2
1932	90	6
1933	136	8
1934	141	4
1935	12	1
Total	458	21

Table 49

West Point Deaths by Age

Age	At Risk	Alive	Dead
25-29	458	0	2
30-34	456	0	5
35-39	451	0	3
40-44	448	0	2
45-49	446	148	8
50-52	290	289	1
Total		437	21

In this analysis, non-Black Ranch Hand and comparison officers are compared, without regard to cause of death, with the West Point Study group (all of the West Point subjects are non-Black). Non-Black Ranch Hand officers were matched, one-to-one, by year-of-birth, to West Point subjects. Due to the relatively small number of Ranch Hand officers and the limited year-of-birth range imposed by the age of the class of 1956, only 297 of the 458 West Point subjects received a matched Ranch Hander. Matched sets with West Pointers having the same year-of-birth were then merged to create six matched sets, corresponding to the six years-of-birth, 1930 through 1935. To compare West Pointers with comparison officers, 1368 non-Black comparison officers were matched to the 458 West Point officers, and these were then merged to six single-year-of-birth strata.

Logrank tests were carried out on these matched data sets and the results are summarized in Table 50. In these analyses, survival time is age at death. SMR analyses, with the West Pointers being the standard, are shown in Table 51.

Table 50

Non-Black Study Group Versus West Point Group
Logrank P-values

Contrasts	P-value
Ranch Hand officers versus West Point	0.273
Comparison officers versus West Point	0.944

Table 51

SMR Comparison of Non-Black Ranch Hand and Comparison Officers With West Point

	(SMR=0.490) Ranch Hand			(SMR=0.790) Comparison			(SMR=1.00) West Point		
Birth Year	At Risk	Dead	Rate	At Risk	Dead	Rate	At Risk	Dead	Rate
1925-31	98	2	0.020	500	38	0.076	79	2	0.025
1932	35	1	0.029	164	7	0.043	90	6	0.067
1933-34	60	1	0.017	257	6	0.023	277	12	0.043
1935-40	107	4	0.037	555	13	0.023	12	1	0.083
Total	300	8		1476	64		458	21	

In Table 51, the test for constant relative risk across year-of-birth strata has a p-value of 0.134, and a likelihood ratio test suggests that these groups are not different (p=0.306). The analyses shown in Tables 50 and 51 indicate that there is no significant difference between non-Black Ranch Hand and comparison officers and the West Pointers.

6.2 Cause-Specific Comparisons

The cause-specific death counts for the West Point study group are given in Table 52.

Table 52

West Point Mortality by Cause

Cause	Deaths
Accidents	6
Infectious Diseases	1
Malignant Neoplasms	6
Circulatory	5
Digestive	1
Genitourinary	1
Ill-Defined Conditions	1
Total	21

Cause-specific comparisons are carried out for cancer (malignant neoplasms), other diseases, and nondiseases (accidents, suicides, homicides and ill-defined conditions), with an adjustment for year-of-birth by stratification on year-of-birth. Relative risks are calculated using the method of Mantel and Haenszel (11). The results, based on the counts in Tables 53 and 54, are shown in Table 55.

Table 53

Cause-Specific Comparisons
Non-Black Ranch Hand Officers Versus West Point

Cause	Birth Year	Ranch Hand		West Point	
		At Risk	Dead	At Risk	Dead
Nondisease	1925-1933	169	1	305	5
	1934-1940	131	4	153	1
Cancer	1925-1930	74	0	20	0
	1931	24	0	59	1
	1932	35	0	90	3
	1933	36	0	136	1
	1934	24	0	141	1
	1935-1940	107	0	12	0
Other diseases	1925-1934	193	2	446	8
	1935-1940	107	1	12	1

Table 54

Cause-Specific Comparisons
Non-Black Comparison Officers Versus West Point

Cause	Birth Year	Comparison		West Point	
		At Risk	Dead	At Risk	Dead
Nondisease	1925-1931	500	18	79	1
	1932	164	2	90	2
	1933	148	1	136	2
	1934-1940	664	6	153	1
Cancer	1925-1931	500	4	79	2
	1932	164	2	90	3
	1933	148	1	136	1
	1934-1940	664	3	153	1
Other diseases	1925-1932	664	19	169	1
	1933	148	1	136	5
	1934	109	1	141	2
	1935-1940	555	6	12	1

Table 55

Cause-Specific Relative Risks, P-values and
95% Confidence Intervals for Relative Risk

Cause	Comparison	Rel Risk	95% Conf Int	P-value
Nondisease	RH vs WP	1.250	(0.257, 6.072)	0.782
	Comp vs WP	1.192	(0.361, 3.939)	0.774
Cancer	RH vs WP			
	Comp vs WP	0.551	(0.156, 1.949)	0.355
Other diseases	RH vs WP	0.446	(0.027, 7.278)	0.571
	Comp vs WP	0.951	(0.131, 6.916)	0.961
All causes	RH vs WP	0.475	(0.198, 2.279)	0.352
	Comp vs WP	0.882	(0.189, 4.100)	0.872

The Ranch Hand versus West Point cancer comparison cannot be assessed using the Mantel-Haenszel procedure due to the lack of cancer deaths in the Ranch Hand officer group. The overall and cause specific equivalence of these study groups and the West Pointers suggest that these analyses do not contribute enough to this study to warrant yearly reporting.

7. Further Covariate Adjustments

Some of the contrasts shown in previous sections in this report are further analyzed here using information about the Vietnam experience for Ranch Handers and comparisons. These analyses are motivated by the need for clarification of previous contrasts and should be viewed as preliminary to more complete analyses which will be presented in future reports. The information used here consists of (1) tour length and (2) a measure of cumulative exposure to dioxin.

Tour length is defined as the cumulative time, in months, spent on assignment to Ranch Hand units by a Ranch Hander and to C-130 cargo units in SEA by a comparison. Cumulative exposure to dioxin, termed the "exposure index," is defined in the baseline morbidity report (12) and is proportional to the dioxin content of the herbicides being sprayed and inversely proportional to the number of persons sharing the workload with the subject to whom it is applied.

7.1 Ranch Hand and Comparison Contrasts On Tour Length

The effect of tour length on mortality will be investigated in detail in future reports. In this report, some descriptive statistics on tour length are presented, and tour length is used as a factor in some exposure analyses. Table 56 shows the 5, 50 and 95 percentiles of tour length in months for flying and ground personnel, and officers and enlisted personnel in Ranch Handers and the comparisons.

Table 56

Tour Length Percentiles (In Months) for Ranch Handers and Comparisons

Group	Rank	Flying Status	Percentiles 5%	50%	95%	Sample Size
Ranch Hand	Officer	Flying	5	13	19	439
		Ground	5	13	16	26
	Enlisted	Flying	4	12	22	206
		Ground	5	13	19	582
Comparison	Officer	Flying	12	20	48	2939
		Ground	11	17	44	152
	Enlisted	Flying	10	20	52	1412
		Ground	10	19	48	3767

In general, the comparisons had longer tour lengths than Ranch Handers. This is the result of longer tours of duty at noncombat zone bases (comparisons) relative to combat area bases (Ranch Hand).

7.2 Ranch Hand Exposure Analyses

The effect of exposure on mortality was assessed on the 1230 Ranch Handers having exposure information in a log-linear analysis based on survival (dead, alive), rank (officer, enlisted), year-of-birth (1905-1934, 1935-1954) and exposure (light, medium, heavy). These data are shown in Table 57.

Table 57

Ranch Hand Mortality Adjusted for Year-Of-Birth, Rank and Exposure

Exposure	Rank	Birth Year	Survival Status Dead	Alive	Total	Death Rate
Light	Officer	1905-1934	2	62	64	0.031
		1935-1954	3	80	83	0.036
	Enlisted	1905-1934	8	62	70	0.114
		1935-1954	6	173	179	0.034
Medium	Officer	1905-1934	2	80	82	0.024
		1935-1954	2	66	68	0.029
	Enlisted	1905-1934	9	55	64	0.141
		1935-1954	5	274	279	0.018
Heavy	Officer	1905-1934	3	78	81	0.037
		1935-1954	2	60	62	0.032
	Enlisted	1905-1934	5	81	86	0.058
		1935-1954	6	106	112	0.054

There is no four-way interaction in these data (p=0.304), there is no three-way interaction involving survival and exposure and the two-way survival by exposure interaction is not significant (p=0.691). The survival by year-of-birth by rank interaction is marginally significant (p=0.0627) and the year-of-birth by rank by exposure interaction is very significant (p 0.001). Both of these observations are expected from previous analyses of these data. In summary, survival is not affected by exposure, with or without adjustment for rank and year-of-birth.

A restriction of the analysis to officers shows no relationship between survival, exposure and birth year (p=0.967) or between survival and exposure adjusted for birth year (p=0.907) or unadjusted for birth year (p=0.905). Finally, a restriction to deaths after 35 years of age in non-Black Ranch Handers yields no new findings.

A restriction of the analysis to enlisted personnel shows a significant survival by exposure by birth year interaction (p=0.044), indicating that the survival by exposure relationship within the 1905-1934 birth year cohort is significantly different from that of the 1935-1954 cohort. Classic dose-response patterns are not seen here so that a herbicide effect cannot be reliably inferred at this time.

8. Future Commitments

Future work will attempt to evaluate mortality patterns as a function of occupational subgroup in the ground cohort. This effort will require simulation studies and additional interviews to delineate differential exposure between occupational subgroups. Flight line duties and herbicide contact will be ascertained objectively along with additional medical risk factors, occupational exposures and socioeconomic factors. These analyses will be increasingly meaningful as the population ages and mortality rates permit use of more incisive statistical tools. Finally, joint morbidity-mortality analyses, adjusting for relevant covariates will be carried out.

Future research will be directed at the development of statistical procedures which take the repeated testing aspect of these updates into account. The feasibility of using comparison data from the entire 1:8 design will also be studied.

9. Summary and Conclusion

Evaluation of summary counts of death by rank and occupation did not reveal any statistically significant differences between the Ranch Hand and comparison groups. Other mortality analyses described in this report have revealed some differences in death experience between the herbicide/dioxin exposed group, their matched comparisons and other external comparison groups.

Overall mortality of the Ranch Hand group is nearly identical to that of the comparison group, being 4.3%. Ranch Hand officers born between 1905 and 1935 have experienced fewer deaths than comparison officers born during the same era. On the other hand, Ranch Hand officers born after 1935 have experienced more deaths than their comparisons. Although these differences within birth year strata are not statistically significant, this change in the group by survival status relationship with birth year is statistically significant (p=0.027). Additionally, Ranch Hand officers experienced fewer deaths after age 35 years than did comparison officers, while

Ranch Hand officers experienced more deaths before age 35 years than did comparisons. Further research will investigate whether there is any association between birth year and age of death and mortality patterns in these officer cohorts.

At this time, Ranch Hand ground and enlisted personnel have experienced more mortality than their comparisons, but these differences are not statistically significant. Preliminary analyses using exposure indices have indicated no association between herbicide exposure in either the officer, enlisted, flying or ground Ranch Hand subgroups.

Both Ranch Hand and comparison officers have experienced less mortality than Ranch Hand or comparison enlisted personnel. Ranch Hand flying personnel have experienced less mortality than Ranch Hand ground personnel, while comparison flying and ground personnel have experienced similar mortality patterns.

Examining causes of death, Ranch Hand officer and flying groups have experienced fewer deaths from cardiovascular disease and cancer than have the comparisons, hut this difference is not statistically significant. No apparent specific disease excesses were noted in the Ranch Hand ground or enlisted groups relative to their comparisons. All Ranch Hand cohorts are elevated in the category of digestive system deaths, but this difference is not statistically significant. There was a single case of soft tissue sarcoma in the comparison group and no cases occurred in the Ranch Handers.

The Ranch Hand and comparison groups have been contrasted with five comparison groups. Ranch Hand and comparison officers are experiencing significantly less mortality than U.S. White males and DOD retired officers. Comparison enlisted personnel are similarly experiencing significantly less mortality than U.S. White males and DOD retired enlisted. Ranch Hand enlisted personnel have experienced a mortality rate not statistically distinguishable from U.S. White males or DOD retired enlisted personnel.

The Ranch Hand and comparison groups taken together have experienced a mortality pattern not statistically different from civil service employees. However, all Ranch Hand and comparison groups are experiencing significantly more mortality than the active duty Air Force, as would be expected by active duty Air Force health qualification standards. Finally, no significant differences between Ranch Hand or comparison officer death rates and those of West Point officers from the class of 1956 were detected.

In conclusion, summary counts of death by rank and occupation did not reveal any statistically significant differences between the Ranch Hand and comparison groups. However, Ranch Hand officers born between 1905 and 1935 have experienced favorable mortality relative to their comparisons while the converse is true for officers born after 1935. Analogous patterns are seen in officers conditioned on age at death. Although Ranch Hand ground personnel have experienced unfavorable mortality relative to comparisons irrespective of date of birth or age at death, this difference is not statistically significant. Exposure index analyses indicate that these mortality rate differences cannot be attributed to herbicide exposure at this time. These analyses have identified several findings of interest, which will be further evaluated in future mortality updates.

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Appendix Table 1

Ranch Hand Officers Versus Ranch Hand Enlisted
Mortality by Year-Of-Birth
(SMR = 0.483, P1 = 0.204, P2 = 0.031)

Birth Year	Ranch Hand Officers At Risk	Dead	Rate	Ranch Hand Enlisted At Risk	Dead	Rate
1905-1924	41	3	0.073	29	7	0.241
1925-1934	194	4	0.021	195	15	0.077
1935-1939	95	4	0.042	115	3	0.026
1940-1944	91	2	0.022	119	3	0.025
1945-1954	45	2	0.044	332	11	0.033
Total	466	15		790	39	

Appendix Table 2

Comparison Officers Versus Comparison Enlisted Mortality by Year-Of-Birth
(SMR = 0.663, P1 = 0.811, P2 = 0.003)

Birth Year	Officers At Risk	Dead	Rate	Enlisted At Risk	Dead	Rate
1905-1919	44	4	0.091	66	11	0.167
1920-1924	161	13	0.081	80	11	0.138
1925-1929	290	20	0.069	211	24	0.114
1930-1934	640	31	0.048	749	42	0.056
1935-1939	458	12	0.026	562	24	0.043
1940-1944	495	6	0.012	601	17	0.028
1945-1954	190	5	0.026	1624	45	0.028
Total	2278	91		3893	174	

Appendix Table 3

Ranch Hand Flying Personnel Versus Ranch Hand Ground Personnel
Mortality by Year-Of-Birth
(SMR = 0.548, P1 = 0.376, P2 = 0.052)

Birth Year	Flyers At Risk	Dead	Rate	Ground At Risk	Dead	Rate
1905-1924	44	4	0.091	26	6	0.231
1925-1934	272	9	0.033	117	10	0.085
1935-1939	145	6	0.041	65	1	0.015
1940-1944	121	2	0.017	89	3	0.034
1945-1954	64	2	0.031	313	11	0.035
Total	646	23		610	31	

Appendix Table 4

Comparison Flying Versus Comparison Ground Personnel Mortality by Year-Of-Birth Within Comparison Group
(SMR = 0.926, P1 = 0.607, P2 = 0.782)

Birth Year	Flyers At Risk	Flyers Dead	Flyers Rate	Ground At Risk	Ground Dead	Ground Rate
1905-1919	45	6	0.133	65	9	0.138
1920-1924	175	17	0.097	66	7	0.106
1925-1929	350	25	0.071	151	19	0.126
1930-1934	966	53	0.055	423	20	0.047
1935-1939	698	24	0.034	322	12	0.037
1940-1944	653	14	0.021	443	9	0.020
1945-1954	276	10	0.036	1538	40	0.026
Total	3163	149		3008	116	

Appendix Table 5

Non-Black Ranch Hand Ground Personnel
Versus the 1978 U.S. White Male Life Table
(T = -0.728, P = 0.466)

Age	At Risk	Dead	Expected Deaths
21-24	557	2	4.277
25-29	555	3	4.647
30-34	552	4	4.481
35-39	504	4	3.742
40-44	255	3	3.433
45-49	179	4	4.152
50-54	117	3	3.236
55-59	45	2	2.052
60-64	22	3	1.789
65-69	10	0	0.902
70-71	2	1	0.110
Total		29	32.824

Appendix Table 6

Non-Black Ranch Hand Enlisted Ground Personnel
Versus the 1978 U.S. White Male Life Table
(T = -0.549, P = 0.583)

Age	At Risk	Dead	Expected Deaths
21-24	532	2	4.085
25-29	530	3	4.437
30-34	527	3	4.281
35-39	480	4	3.492
40-44	235	3	3.193
45-49	169	4	3.927
50-54	110	3	2.991
55-59	41	2	1.884
60-64	21	3	1.674
65-69	9	0	0.754
70-71	2	1	0.110
Total		28	30.828