

Figure 14

Lexis Diagram
Ranch Hand Flyers

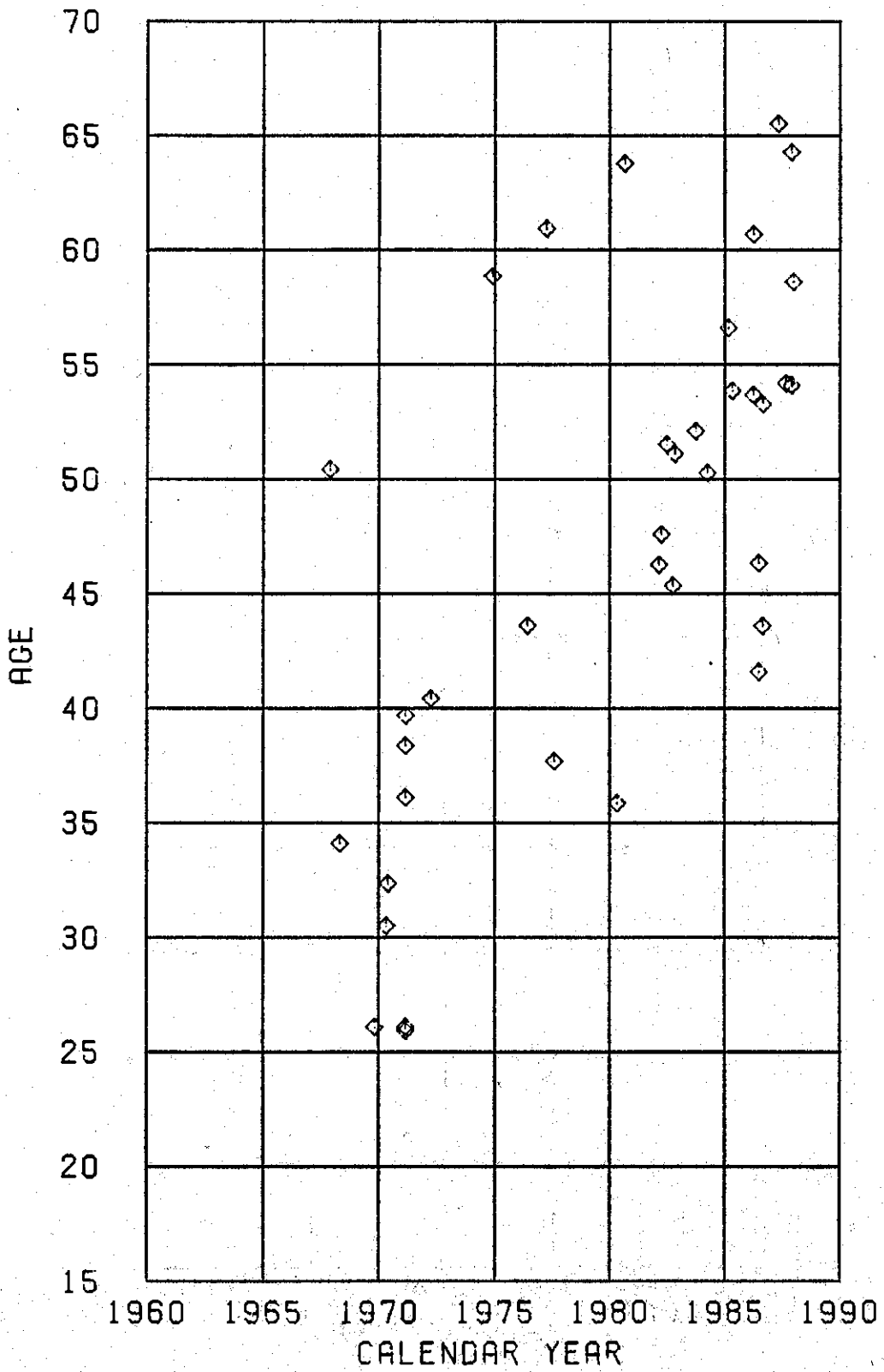
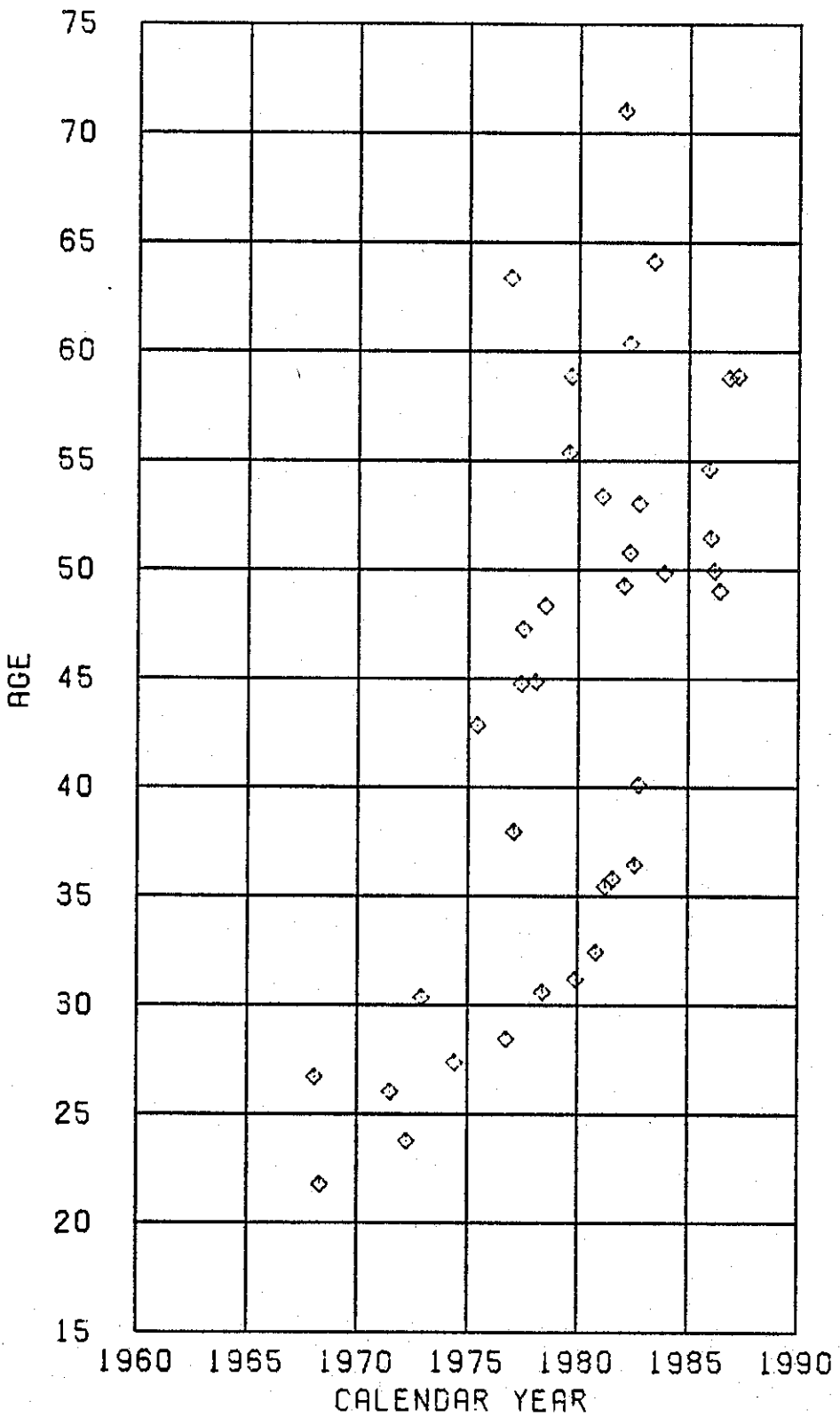


Figure 15

Lexis Diagram
Ranch Hand Nonflyers



A statistically significant group (Ranch Hand, C1-C5 Comparison) by survival (dead, alive) by date of birth (<1935, >1935) by rank (officer, enlisted) interaction was described in the 1984 update. This interaction was not detected in any of the adjusted two-sample procedures applied to either Ranch Hand versus C1-C5 Comparison contrasts or to Ranch Hand versus all Comparison contrasts in this report. Current data relevant to the group by survival by date of birth by rank association for Ranch Hands and C1-C5 Comparisons is shown in Table 30.

TABLE 30

Survival by Group, Date of Birth and Rank for
Ranch Hands and C1-C5 Comparisons

Rank	Birth	Group	Number Dead	Number Alive	Total	Rate (%)	Relative Risk
Enlisted	<1935	Ranch Hand	28	196	224	12.5	0.99
		Comparison	141	974	1115	12.6	
		Total	169	1170	1339		
	>1935	Ranch Hand	20	550	570	3.5	0.92
		Comparison	108	2727	2835	3.8	
		Total	128	3277	3405		
Officer	<1935	Ranch Hand	16	219	235	6.8	0.86
		Comparison	90	1048	1138	7.9	
		Total	106	1267	1373		
	>1935	Ranch Hand	10	222	232	4.3	1.35
		Comparison	37	1125	1162	3.2	
		Total	47	1347	1394		

The group by survival by date of birth by rank association is not significant in these data with ($P=0.30$) or without ($P=0.34$) adjustment for occupation and tour start date.

The corresponding data for the Ranch Hand versus all Comparison contrast is shown in Table 31.

TABLE 31

Survival by Group, Date of Birth and Rank for
Ranch Hands and All Comparisons

Rank	Birth	Group	Number Dead	Number Alive	Total	Rate (%)	Relative Risk
Enlisted	<1935	Ranch Hand	25	165	190	13.1	1.02
		Comparison	327	2210	2537	12.8	
		Total	352	2375	2727		
	>1935	Ranch Hand	23	581	604	3.8	1.11
		Comparison	378	10655	11033	3.4	
		Total	401	11236	11637		
Officer	<1935	Ranch Hand	15	196	211	7.1	0.70
		Comparison	223	1973	2196	10.1	
		Total	238	2169	2407		
	>1935	Ranch Hand	11	245	256	4.3	1.29
		Comparison	111	3224	3335	3.3	
		Total	122	3469	3591		

The group by survival by date of birth by rank association is not statistically significant in these data with ($P=0.34$) or without ($P=0.28$) adjustment for occupation and tour start date.

A statistically significant group by survival-to-age-35 by rank association in Ranch Hand and C1-C5 Comparison data was also described in the 1984 update. The same association was investigated with current data in both Ranch Hand versus C1-C5 Comparisons and Ranch Hand versus all Comparisons. The same group by survival-to-age-35 by rank interaction is borderline significant in current data on Ranch Hand versus C1-C5 mortality ($P=0.05$). The data relevant to the Ranch Hand versus C1-C5 contrast on survival to age 35 is shown in Table 32.

TABLE 32

Ranch Hand versus C1-C5 Comparisons
Group, Survival to Age 35, Rank

Survival to Age 35

Rank	Group	Number Dead	Number Alive	Total	Rate (%)	Relative Risk
Officer	Ranch Hand Comparison	7	460	467	1.5	2.30
		15	2285	2300	0.6	
	Total	22	2745	2767		
Enlisted	Ranch Hand Comparison	9	785	794	1.1	0.72
		62	3888	3950	1.6	
	Total	71	4673	4744		

This interaction appears to be due to an excess of Ranch Hand officer deaths before the age of 35. The observed number of Ranch Hand officer deaths before the age of 35 is 7 and the expected number is 3. These small numbers limit the meaning of these findings. Six of the seven Ranch Hand officer deaths before age 35 were due to accidents and one was a suicide. Of the 15 C1-C5 Comparison officer deaths before age 35, 13 were due to accidents, one was due to disease and one was a suicide. Of the 9 Ranch Hand enlisted deaths before the age of 35, 7 were due to accidents, one was a suicide and one was a homicide. Of the 62 C1-C5 Comparison enlisted deaths before the age of 35, 39 were due to accidents, 14 were disease related, 1 was a homicide and 8 were suicides. When these analyses were restricted to accidental deaths before the age of 35, the group by survival by rank association is not statistically significant ($P=0.13$). The same interaction is not statistically significant when suicide before the age of 35 is considered ($P=0.31$). Taken together, these results suggest that the observed interaction is spurious rather than attributable to herbicide exposure. The same analysis revealed no significant group by survival-to-age-35 by rank association when all Comparisons are analyzed ($P=0.27$). The relevant data is shown in Table 33.

TABLE 33

Ranch Hand versus All Comparisons
Group, Survival to Age 35, Rank

Survival to Age 35

Rank	Group	Number Dead	Number Alive	Total	Rate (%)	Relative Risk
Officer	Ranch Hand	7	460	467	2.0	1.54
	Comparison	54	5477	5531	1.0	
	Total	61	5937	5998		
Enlisted	Ranch Hand	9	785	794	1.0	0.86
	Comparison	178	13392	13570	1.0	
	Total	187	14177	14364		

When survival to age 35 is replaced by accidental death before the age of 35, the group by survival by rank association is not statistically significant ($P=0.48$). These results lend further weight to the conclusion that the group by survival to age 35 by rank association seen in Ranch Hand versus C1-C5 data was indeed spurious.

4. CAUSE-SPECIFIC ANALYSES

Table 34 shows death counts and death rates (deaths per 1000 person-years) referenced to the start of the qualifying tour by cause and subgroup. The death rate units are deaths per 1,000 person-years.

TABLE 34
Deaths and Death Rates by Cause and Group
Flying Officers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	9	1.03	38	0.87	93	0.84
Suicide	0	0.00	7	0.16	15	0.14
Homicide	0	0.00	0	0.00	3	0.03
Infections, Parasitic	0	0.00	2	0.05	2	0.02
Neoplasm, Malignant	5	0.57	23	0.52	79	0.72
Neoplasms, Uncertain	0	0.00	1	0.02	2	0.02
Endocrine	0	0.00	1	0.02	1	0.01
Blood, Blood Forming	0	0.00	0	0.00	1	0.01
Mental Disorders	0	0.00	0	0.00	2	0.02
Nervous System	0	0.00	1	0.02	4	0.04
Circulatory System	8	0.92	36	0.82	97	0.88
Respiratory System	0	0.00	3	0.07	5	0.05
Digestive	2	0.23	7	0.16	11	0.10
Genitourinary System	0	0.00	1	0.02	1	0.01
Congenital Anomalies	0	0.00	0	0.00	1	0.01
Ill-Defined	0	0.00	1	0.02	2	0.02
Unknown	1	0.11	0	0.00	0	0.00
Total	25		121		319	

TABLE 34 (Cont'd)

Deaths and Death Rates by Cause and Group

Enlisted Flyers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	4	0.97	27	1.30	67	1.11
Suicide	1	0.24	5	0.24	17	0.28
Homicide	0	0.00	2	0.10	3	0.05
Infections, Parasitic	0	0.00	0	0.00	1	0.02
Neoplasm, Malignant	1	0.24	17	0.82	39	0.65
Endocrine	0	0.00	1	0.05	1	0.02
Nervous System	0	0.00	0	0.00	1	0.02
Circulatory System	2	0.49	22	1.06	54	0.90
Respiratory System	0	0.00	3	0.14	3	0.05
Digestive	2	0.49	4	0.19	11	0.18
Congenital Anomalies	0	0.00	1	0.05	1	0.02
Ill-Defined	2	0.49	1	0.05	3	0.05
Unknown	0	0.00	0	0.00	1	0.02
Total	12		83		202	

All Flyers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	13	1.01	65	1.01	160	0.94
Suicide	1	0.08	12	0.19	32	0.19
Homicide	0	0.00	2	0.03	6	0.04
Infections, Parasitic	0	0.00	2	0.03	3	0.02
Neoplasm, Malignant	6	0.47	40	0.62	118	0.69
Neoplasms, Uncertain	0	0.00	1	0.02	2	0.01
Endocrine	0	0.00	2	0.03	2	0.01
Blood, Blood Forming	0	0.00	0	0.00	1	0.01
Mental Disorders	0	0.00	0	0.00	2	0.01
Nervous System	0	0.00	1	0.02	5	0.03
Circulatory System	10	0.78	58	0.90	151	0.89
Respiratory System	0	0.00	6	0.09	8	0.05
Digestive	4	0.31	11	0.17	22	0.13
Genitourinary System	0	0.00	1	0.02	1	0.01
Congenital Anomalies	0	0.00	1	0.02	2	0.01
Ill-Defined	2	0.16	2	0.03	5	0.03
Unknown	1	0.08	0	0.00	1	0.01
Total	37		204		521	

TABLE 34 (Cont'd)

Deaths and Death Rates by Cause and Group

Nonflying Officers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	0	0.00	1	0.39	1	0.16
Suicide	1	1.95	0	0.00	1	0.16
Neoplasm, Malignant	0	0.00	3	1.17	5	0.81
Circulatory System	0	0.00	1	0.39	7	1.13
Digestive	0	0.00	1	0.39	1	0.16
Total	1		6		15	

Nonflying Enlisted

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	9	0.78	38	0.64	129	0.54
Suicide	1	0.09	13	0.22	41	0.17
Homicide	2	0.17	3	0.05	14	0.06
Infections, Parasitic	0	0.00	3	0.05	6	0.03
Neoplasm, Malignant	6	0.52	38	0.64	103	0.43
Neoplasms, Uncertain	0	0.00	1	0.02	1	0.00
Endocrine	1	0.09	0	0.00	1	0.00
Blood, Blood Forming	0	0.00	0	0.00	1	0.00
Mental Disorders	0	0.00	1	0.02	7	0.03
Nervous System	0	0.00	1	0.02	7	0.03
Circulatory System	15	1.29	56	0.95	151	0.64
Respiratory System	0	0.00	4	0.07	14	0.06
Digestive	2	0.17	6	0.10	14	0.06
Genitourinary System	0	0.00	2	0.03	8	0.03
Ill-Defined	0	0.00	0	0.00	5	0.02
Unknown	0	0.00	0	0.00	1	0.00
Total	36		166		503	

TABLE 34 (Cont'd)

Deaths and Death Rates by Cause and Group

	All Nonflying				All	
	Ranch Hand No. Rate		C1-C5 No. Rate		Comparison No. Rate	
Accidental	9 0.74		39 0.63		130 0.53	
Suicide	2 0.17		13 0.21		42 0.17	
Homicide	2 0.17		3 0.05		14 0.06	
Infections, Parasitic	0 0.00		3 0.05		6 0.02	
Neoplasm, Malignant	6 0.50		41 0.66		108 0.44	
Neoplasms, Uncertain	0 0.00		1 0.02		1 0.00	
Endocrine	1 0.08		0 0.00		1 0.00	
Blood, Blood Forming	0 0.00		0 0.00		1 0.01	
Mental Disorders	0 0.00		1 0.02		7 0.03	
Nervous System	0 0.00		1 0.02		7 0.03	
Circulatory System	15 1.24		56 0.91		158 0.65	
Respiratory System	0 0.00		4 0.06		14 0.06	
Digestive	2 0.17		7 0.11		15 0.06	
Genitourinary System	0 0.00		2 0.03		8 0.03	
Ill-Defined	0 0.00		0 0.00		5 0.02	
Unknown	0 0.00		0 0.00		1 0.00	
Total	37		172		518	

	All Personnel				All	
	Ranch Hand No. Rate		C1-C5 No. Rate		Comparison No. Rate	
Accidental	22 0.88		104 0.82		290 0.70	
Suicide	3 0.12		25 0.20		74 0.18	
Homicide	2 0.08		5 0.04		20 0.05	
Infections, Parasitic	0 0.00		5 0.04		9 0.02	
Neoplasm, Malignant	12 0.48		81 0.64		226 0.55	
Neoplasms, Uncertain	0 0.00		2 0.02		3 0.01	
Endocrine	1 0.04		2 0.02		3 0.01	
Blood, Blood Forming	0 0.00		0 0.00		2 0.00	
Mental Disorders	0 0.00		1 0.01		9 0.02	
Nervous System	0 0.00		2 0.02		12 0.03	
Circulatory System	25 1.00		115 0.91		309 0.75	
Respiratory System	0 0.00		10 0.08		22 0.05	
Digestive	6 0.24		18 0.14		37 0.09	
Genitourinary System	0 0.00		3 0.02		9 0.02	
Congenital Anomalies	0 0.00		1 0.01		2 0.00	
Ill-Defined	2 0.08		2 0.02		10 0.02	
Unknown	1 0.04		0 0.00		2 0.00	
Total	74		376		1039	

Deaths occurring during the calendar years 1986 and 1987 are cross-tabulated in Tables 35 and 36. The corresponding tabulations for the calendar years 1983, 1984 and 1985 are shown in the Appendix. The death rate units are deaths per 1000 person-years.

TABLE 35

Deaths and Death Rates by Cause and Group for 1986

Flying Officers					
	Ranch Hand		C1-C5		All Comparison
	No.	Rate	No.	Rate	No. Rate
Accidental	0	0.00	1	0.48	2 0.40
Suicide	0	0.00	0	0.00	1 0.20
Neoplasm, Malignant	3	7.11	1	0.48	9 1.81
Blood, Blood Forming	0	0.00	0	0.00	1 0.20
Nervous System	0	0.00	0	0.00	1 0.20
Circulatory System	1	2.37	2	0.97	7 1.41
Unknown	1	2.37	0	0.00	0 0.00
Total	5		4		21

Enlisted Flyers					
	Ranch Hand		C1-C5		All Comparison
	No.	Rate	No.	Rate	No. Rate
Accidental	0	0.00	1	1.04	3 1.13
Suicide	0	0.00	0	0.00	1 0.38
Infections, Parasitic	0	0.00	0	0.00	1 0.38
Neoplasm, Malignant	0	0.00	3	3.13	6 2.26
Circulatory System	1	5.08	4	4.17	7 2.64
Total	1		8		18

All Flyers					
	Ranch Hand		C1-C5		All Comparison
	No.	Rate	No.	Rate	No. Rate
Accidental	0	0.00	2	0.66	5 0.66
Suicide	0	0.00	0	0.00	2 0.26
Infections, Parasitic	0	0.00	0	0.00	1 0.13
Neoplasm, Malignant	3	4.85	4	1.32	15 1.97
Blood, Blood Forming	0	0.00	0	0.00	1 0.13
Nervous System	0	0.00	0	0.00	1 0.13
Circulatory System	2	3.23	6	1.98	14 1.84
Unknown	1	1.62	0	0.00	0 0.00
Total	6		12		39

TABLE 35 (Cont'd)

Deaths and Death Rates by Cause and Group for 1986

Nonflying Officers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Circulatory System	0	0.00	0	0.00	2	7.24
Total	0		0		2	

Nonflying Enlisted

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	1	1.81	0	0.00	4	0.39
Suicide	0	0.00	1	0.36	4	0.39
Neoplasm, Malignant	0	0.00	7	2.53	15	1.46
Circulatory System	2	3.61	4	1.44	10	0.97
Respiratory System	0	0.00	0	0.00	1	0.10
Digestive	0	0.00	1	0.36	1	0.10
Total	3		13		35	

All Nonflying

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	1	1.73	0	0.00	4	0.38
Suicide	0	0.00	1	0.35	4	0.38
Neoplasm, Malignant	0	0.00	7	2.42	15	1.42
Circulatory System	2	3.46	4	1.38	12	1.14
Respiratory System	0	0.00	0	0.00	1	0.09
Digestive	0	0.00	1	0.35	1	0.09
Total	3		13		37	

TABLE 35 (Cont'd)

Deaths and Death Rates by Cause and Group for 1986

	All Personnel				All	
	Ranch Hand No. / Rate		C1-C5 No. Rate		Comparison No. Rate	
Accidental	1 0.84		2 0.34		9 0.50	
Suicide	0 0.00		1 0.17		6 0.33	
Infections, Parasitic	0 0.00		0 0.00		1 0.06	
Neoplasm, Malignant	3 2.51		11 1.86		30 1.65	
Blood, Blood Forming	0 0.00		0 0.00		1 0.06	
Nervous System	0 0.00		0 0.00		1 0.06	
Circulatory System	4 3.34		10 1.69		26 1.43	
Respiratory System	0 0.00		0 0.00		1 0.06	
Digestive	0 0.00		1 0.17		1 0.06	
Unknown	1 0.84		0 0.00		0 0.00	
Total	9		25		76	

TABLE 36

Deaths and Death Rates by Cause and Group for 1987

Flying Officers

					All	
	Ranch Hand No. Rate		C1-C5 No. Rate		Comparison No. Rate	
Accidental	1 2.39		1 0.49		2 0.40	
Suicide	0 0.00		0 0.00		1 0.20	
Neoplasm, Malignant	1 2.39		4 1.94		12 2.43	
Circulatory System	2 4.77		2 0.97		9 1.82	
Respiratory System	0 0.00		1 0.49		1 0.20	
Digestive	0 0.00		2 0.97		2 0.40	
Total	4		10		27	

Enlisted Flyers

					All	
	Ranch Hand No. Rate		C1-C5 No. Rate		Comparison No. Rate	
Suicide	0 0.00		0 0.00		1 0.38	
Neoplasm, Malignant	0 0.00		0 0.00		5 1.90	
Circulatory System	0 0.00		3 3.15		4 1.52	
Ill-Defined	1 5.11		0 0.00		0 0.00	
Total	1		3		10	

TABLE 36 (Cont'd)

Deaths and Death Rates by Cause and Group for 1987

All Flyers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	1	1.63	1	0.33	2	0.26
Suicide	0	0.00	0	0.00	2	0.26
Neoplasm, Malignant	1	1.63	4	1.33	17	2.24
Circulatory System	2	3.25	5	1.66	13	1.72
Respiratory System	0	0.00	1	0.33	1	0.13
Digestive	0	0.00	2	0.66	2	0.26
Ill-Defined	1	1.63	0	0.00	0	0.00
Total	5		13		37	

Nonflying Officers

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Neoplasm, Malignant	0	0.00	2	16.68	3	10.99
Circulatory System	0	0.00	1	8.34	1	3.66
Total	0		3		4	

Nonflying Enlisted

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	0	0.00	1	0.36	2	0.20
Suicide	0	0.00	1	0.36	2	0.20
Infections, Parasitic	0	0.00	1	0.36	1	0.10
Neoplasm, Malignant	1	1.81	5	1.81	13	1.27
Blood, Blood Forming	0	0.00	0	0.00	1	0.10
Circulatory System	0	0.00	4	1.45	10	0.98
Respiratory System	0	0.00	2	0.73	5	0.49
Genitourinary System	0	0.00	0	0.00	1	0.10
Ill-Defined	0	0.00	0	0.00	2	0.20
Total	1		14		37	

TABLE 36 (Cont'd)

Deaths and Death Rates by Cause and Group for 1987

All Nonflying

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	0	0.00	1	0.35	2	0.19
Suicide	0	0.00	1	0.35	2	0.19
Infections, Parasitic	0	0.00	1	0.35	1	0.09
Neoplasm, Malignant	1	1.74	7	2.43	16	1.52
Blood, Blood Forming	0	0.00	0	0.00	1	0.09
Circulatory System	0	0.00	5	1.74	11	1.04
Respiratory System	0	0.00	2	0.70	5	0.47
Genitourinary System	0	0.00	0	0.00	1	0.09
Ill-Defined	0	0.00	0	0.00	2	0.19
Total	1		17		41	

All Personnel

	Ranch Hand		C1-C5		All Comparison	
	No.	Rate	No.	Rate	No.	Rate
Accidental	1	0.84	2	0.34	4	0.22
Suicide	0	0.00	1	0.17	4	0.22
Infections, Parasitic	0	0.00	1	0.17	1	0.06
Neoplasm, Malignant	2	1.68	11	1.87	33	1.82
Blood, Blood Forming	0	0.00	0	0.00	1	0.06
Circulatory System	2	1.68	10	1.70	24	1.33
Respiratory System	0	0.00	3	0.51	6	0.33
Digestive	0	0.00	2	0.34	2	0.11
Genitourinary System	0	0.00	0	0.00	1	0.06
Ill-Defined	1	0.84	0	0.00	2	0.11
Total	6		30		78	

Unadjusted group contrasts on each cause of death are shown in Tables 37 and 38. Ranch Hand versus C1-C5 Comparison contrasts were accomplished via Wald tests on the logarithm of the odds ratio. The odds ratio estimate and associated confidence interval are also shown. Ranch Hand versus all Comparison contrasts were based on Wald tests on the logarithm of the odds ratio and score tests on the one-sample SMR. Associated confidence intervals for the SMR are also presented.

TABLE 37
Unadjusted Group Contrasts by Cause of Death
Ranch Hands versus C1-C5 Comparisons

	Two-sample				
	Ranch Hand Dead	Comp C1-C5 Dead	Odds Ratio	95% Conf. Interval	P-value
Accidental	22	104	1.05	(0.66, 1.67)	0.84
Suicide	3	25	0.59	(0.18, 1.97)	0.39
Homicide	2	5	1.98	(0.38, 10.2)	0.41
Infections, Parasitic	0	5			
Neoplasm, Malignant	12	81	0.73	(0.40, 1.35)	0.32
Neoplasms, Uncertain	0	2			
Endocrine	1	2	2.48	(0.22, 27.4)	0.32
Blood, Blood Forming	0	0			
Mental Disorders	0	1			
Nervous System	0	2			
Circulatory System	25	115	1.08	(0.70, 1.67)	0.73
Respiratory System	0	10			
Digestive	6	18	1.66	(0.66, 4.18)	0.29
Genitourinary System	0	3			
Congenital Anomalies	0	1			
Ill-Defined	2	2	4.96	(0.70, 35.3)	0.11
Unknown	1	0			

In the second panel of Table 38, the confidence interval for the SMR in the one-sample analysis of digestive deaths is based on a Poisson approximation. The other confidence intervals in the second panel of Table 38 are based on the asymptotic normality of the SMR.

TABLE 38

Unadjusted Group Contrasts by Cause of Death
Ranch Hands versus All Comparisons

Two-sample

	Ranch Hand Dead	All Comp Dead	Odds Ratio	95% Conf. Interval	P-value
Accidental	22	290	1.15	(0.74, 1.78)	0.53
Suicide	3	74	0.61	(0.19, 1.95)	0.41
Homicide	2	20	1.58	(0.35, 6.49)	0.58
Infections, Parasitic	0	6			
Neoplasm, Malignant	12	226	0.80	(0.45, 1.44)	0.46
Neoplasms, Uncertain	0	3			
Endocrine	1	3	5.05	(0.53, 48.6)	0.16
Blood, Blood Forming	0	2			
Mental Disorders	0	9			
Nervous System	0	12			
Circulatory System	25	309	1.23	(0.82, 1.86)	0.32
Respiratory System	0	22			
Digestive	6	37	2.46	(1.04, 5.85)	0.04
Genitourinary System	0	9			
Congenital Anomalies	0	2			
Ill-Defined	2	10	3.03	(0.60, 13.9)	0.15
Unknown	1	2	7.58	(0.69, 83.6)	0.10

One-sample

	Dead	Expected	SMR	95% Conf. Interval	P-value
Accidental	22	17.50	1.26	(0.73, 1.78)	0.28
Suicide	3				
Homicide	2				
Infections, Parasitic	0				
Neoplasm, Malignant	12	13.64	0.88	(0.38, 1.38)	0.66
Neoplasms, Uncertain	0				
Endocrine	1				
Blood, Blood Forming	0				
Mental Disorders	0				
Nervous System	0				
Circulatory System	25	18.64	1.34	(0.82, 1.87)	0.14
Respiratory System	0				
Digestive	6	2.23	2.69	(1.00, 5.85)	0.01
Genitourinary System	0				
Congenital Anomalies	0				
Ill-Defined	2				
Unknown	1				

The unadjusted two-sample contrast of all Ranch Hands with all Comparisons on digestive deaths was statistically significant (odds ratio = 2.5, $P=0.04$) and is of concern. The unadjusted one-sample analysis also indicates a significant elevation (SMR = 2.7, $P=0.01$). Of these two analyses, the one-sample analysis is

considered superior since it takes survival time into account, through the person-year determination, whereas the two-sample method depends only on the occurrence of death and not time to death. Both analyses are deficient, however, in that they are not adjusted for date of birth, rank or occupation. Adjusted analyses were not carried out since the number of Ranch Hand digestive system deaths (6) is too few for meaningful adjustment. Regarding rank and occupation, Table 34 shows that the 6 Ranch Hand digestive system deaths are approximately uniformly distributed across the four combinations of rank and occupation. These distributions tend to contradict a herbicide effect, since unpublished dioxin assay results on living Ranch Hands suggest that Ranch Hand officers were relatively unexposed to dioxin with the heaviest exposure occurred in nonflying enlisted personnel. A distribution of these 6 deaths by site (Table 44) reveals wide variation and is not suggestive of a herbicide effect.

TABLE 39

Cause-Specific Adjusted Analyses
Ranch Hand versus C1-C5 Comparisons

Discrete Covariates

Cause	Adjusted Odds Ratio	95% C I	P-value	Covariates and Interactions (P-value)
Accidents	1.02	(0.81, 1.29)	0.84	Occupation (0.02)
Malignant Neoplasm	0.85	(0.63, 1.16)	0.31	Rank (0.02) DOB (P<0.01)
Circulatory	1.07	(0.86, 1.34)	0.54	Occupation (0.30) Tour (0.01) DOB (P<0.01) Occ*DOB (P<0.01)

Continuous Covariates

Cause	Adjusted Odds Ratio	95% C I	P-value	Covariates and Interactions (P-value)
Accidents	1.02	(0.81, 1.29)	0.84	Occupation (0.02)
Malignant Neoplasm	0.85	(0.63, 1.16)	0.31	Rank (0.01) Occupation (0.07) Tour (0.49) DOB (P<0.01) Rank*tour (0.03) Occ*tour (0.03)
Circulatory	1.07	(0.86, 1.34)	0.55	Rank (P<0.01) Tour (0.29) DOB (0.28) Tour*DOB (0.04)

The same two-sample adjusted analyses of accidental, malignant neoplasm and circulatory deaths on Ranch Hands and all Comparisons are summarized in Table 40.

TABLE 40

Cause-Specific Adjusted Analyses
Ranch Hands versus All Comparisons

Two-sample, Discrete Covariates

Cause	Adjusted Odds Ratio	95% C I	P-value	Covariates and Interactions (P-value)
Accidents	1.05	(0.85, 1.31)	0.64	Rank (0.04) Occupation (P<0.01)
Malignant Neoplasm	0.82	(0.62, 1.11)	0.20	Rank (0.26) DOB (P<0.01) Rank*DOB (P<0.01)
Circulatory	1.06	(0.86, 1.31)	0.58	Occupation (0.78) Rank (0.02) Tour (0.01) DOB (P<0.01) Occ*DOB (0.03)

Continuous Covariates

Cause	Adjusted Odds Ratio	95% C I	P-value	Covariates and Interactions (P-value)
Accidents	1.05	(0.85, 1.31)	0.64	Rank (0.04) Occupation (P<0.01)
Malignant Neoplasm	0.83	(0.62, 1.12)	0.23	Rank (0.01) DOB (P<0.01) Rank*DOB (0.02)
Circulatory	1.05	(0.85, 1.30)	0.65	Rank (P<0.01) DOB (P<0.01)

The Ranch Hands appear to be experiencing slightly more accidental deaths (odds ratio = 1.05), and deaths due to circulatory disease (odds ratio = 1.05) and fewer deaths due to malignant neoplasm (odds ratio = 0.83) than all Comparisons after adjustment for rank, occupation, date of birth and tour date. However, none of the adjusted cause-specific odds ratios in Tables 39 and 40 are statistically significant. These two-sample analyses did not take survival time into account.

Adjusted one-sample analyses contrasting Ranch Hands with all Comparisons on accidental, malignant neoplasm and circulatory deaths were carried out with person-years computed from tour start date. These analyses are adjusted for date of birth, survival time, calendar time, rank and occupation. The results are summarized in Tables 41, 42 and 43.

TABLE 41

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Accidental Deaths

Accidental Deaths Among Officers

SMR=1.23, 95% C I: (0.43, 2.03), P=0.54

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	1	22	0	0.00
1915-1919	8	130	0	0.08
1920-1924	32	651	0	0.47
1925-1929	43	867	1	0.67
1930-1934	151	3108	2	2.37
1935-1939	96	1969	3	1.35
1940-1944	91	1725	1	1.63
1945-1949	45	777	2	0.77
Total	467	9249	9	7.35

Accidental Deaths Among Enlisted Personnel

SMR=1.18, 95% C I: (0.54, 1.83), P=0.54

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	4	77	0	0.09
1915-1919	9	185	0	0.15
1920-1924	16	333	0	0.14
1925-1929	41	851	0	0.55
1930-1934	154	3030	4	2.15
1935-1939	117	2368	2	1.71
1940-1944	121	2486	1	1.72
1945-1949	321	6188	6	4.32
1950-1954	11	197	0	0.15
Total	794	15715	13	10.99

TABLE 41 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Accidental Deaths

Accidental Deaths Among Flying Personnel

SMR=1.09, 95% C I: (0.50, 1.69), P=0.75

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1915-1919	9	136	0	0.11
1920-1924	35	720	0	0.63
1925-1929	53	1079	1	0.99
1930-1934	219	4435	5	3.98
1935-1939	146	2954	4	2.49
1940-1944	122	2379	1	2.50
1945-1949	64	1144	2	1.19
Total	648	12847	13	11.89

Accidental Deaths Among Nonflying Personnel

SMR=1.29, 95% C I: (0.45, 2.13), P=0.44

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	5	99	0	0.11
1915-1919	8	179	0	0.10
1920-1924	13	264	0	0.04
1925-1929	31	639	0	0.25
1930-1934	86	1703	1	0.91
1935-1939	67	1383	1	0.74
1940-1944	90	1831	1	0.96
1945-1949	302	5822	6	3.70
1950-1954	11	197	0	0.16
Total	613	12117	9	6.98

TABLE 41 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Accidental Deaths

Accidental Deaths Among All Ranch Hands

SMR=1.16, 95% C I: (0.64, 2.36), P=0.54

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1905-1914	5	99	0	0.07
1915-1919	17	315	0	0.21
1920-1924	48	984	0	0.62
1925-1929	84	1718	1	1.24
1930-1934	305	6138	6	4.46
1935-1939	213	4337	5	3.04
1940-1944	212	4211	2	3.13
1945-1949	366	6966	8	5.09
1950-1954	11	197	0	0.15
Total	1261	24965	22	18.02

In the one-sample adjusted analysis of all Ranch Hand accidental deaths summarized in the last panel of Table 41, there was no survival by rank by occupation interaction ($P=0.94$). Additionally, the Ranch Hand versus all Comparison contrast on accidental deaths did not vary significantly with rank ($P=0.53$) or occupation ($P=0.48$).

TABLE 42

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons On Malignant Neoplasm Deaths

Malignant Neoplasm Deaths Among Officers

SMR=0.71, 95% C I: (0.09, 1.34), P=0.45

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	1	22	0	0.04
1915-1919	8	130	0	0.33
1920-1924	32	651	1	1.50
1925-1929	43	867	2	1.09
1930-1934	151	3108	1	2.47
1935-1939	96	1969	0	0.90
1940-1944	91	1725	1	0.49
1945-1949	45	777	0	0.17
Total	467	9249	5	6.99

TABLE 42 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Malignant Neoplasm Deaths

Malignant Neoplasm Deaths Among Enlisted Personnel

SMR=0.71, 95% C I: (0.18, 1.23), P=0.36

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	4	77	1	0.34
1915-1919	9	185	2	0.94
1920-1924	16	333	0	1.16
1925-1929	41	851	1	1.84
1930-1934	154	3030	2	3.14
1935-1939	117	2368	0	1.14
1940-1944	121	2486	0	0.55
1945-1949	321	6168	1	0.75
1950-1954	11	197	0	0.01
Total	794	15715	7	9.88

Malignant Neoplasm Deaths Among Flying Personnel

SMR=0.57, 95% C I: (0.12, 1.03), P=0.17

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1915-1919	9	136	1	0.41
1920-1924	35	720	1	1.70
1925-1929	53	1079	2	1.71
1930-1934	219	4435	1	4.30
1935-1939	146	2954	0	1.48
1940-1944	122	2379	1	0.61
1945-1949	64	1144	0	0.24
Total	648	12847	6	10.45

TABLE 42 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Malignant Neoplasm Deaths

Malignant Neoplasm Deaths Among Nonflying Personnel

SMR=0.93, 95% C I: (0.19, 1.68), P=0.86

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	5	99	1	0.33
1915-1919	8	179	1	0.76
1920-1924	13	264	0	0.91
1925-1929	31	639	1	1.22
1930-1934	86	1703	2	1.53
1935-1939	67	1383	0	0.59
1940-1944	90	1831	0	0.41
1945-1949	302	5822	1	0.68
1950-1954	11	197	0	0.01
Total	613	12117	6	6.44

Malignant Neoplasm Deaths Among All Ranch Hands

SMR=0.70, 95% C I: (0.40, 1.24), P=0.23

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1905-1914	5	99	1	0.29
1915-1919	17	315	2	1.14
1920-1924	48	984	1	2.74
1925-1929	84	1718	3	2.96
1930-1934	305	6138	3	5.86
1935-1939	213	4337	0	2.03
1940-1944	212	4211	1	0.99
1945-1949	366	6966	1	0.92
1950-1954	11	197	0	0.01
Total	1261	24965	12	16.95

In the one-sample adjusted analysis of all Ranch Hand malignant neoplasm deaths summarized in the last panel of Table 42, there was no survival by rank by occupation interaction ($P=0.93$). Additionally, the Ranch Hand versus all Comparison contrast on accidental deaths did not vary significantly with rank ($P=0.40$) or occupation ($P=0.94$).

TABLE 43

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Circulatory Deaths

Circulatory Deaths Among Officers

SMR=0.93, 95% C I: (0.29, 1.58), P=0.84

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	1	22	0	0.14
1915-1919	8	130	2	0.62
1920-1924	32	651	1	1.95
1925-1929	43	867	0	1.37
1930-1934	151	3108	4	3.17
1935-1939	96	1969	1	1.04
1940-1944	91	1725	0	0.26
1945-1949	45	777	0	0.02
Total	467	9249	8	8.58

Circulatory Deaths Among Enlisted Personnel

SMR=1.17, 95% C I: (0.62, 1.73), P=0.51

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	4	77	0	0.63
1915-1919	9	185	0	1.39
1920-1924	16	333	2	1.62
1925-1929	41	851	3	2.06
1930-1934	154	3030	6	5.00
1935-1939	117	2368	3	2.36
1940-1944	121	2486	1	0.79
1945-1949	321	6168	2	0.74
1950-1954	11	197	0	0.01
Total	794	15715	17	14.61

TABLE 43 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Circulatory Deaths

Circulatory Deaths Among Flying Personnel

SMR=0.76, 95% C I: (0.29, 1.23), P=0.38

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1915-1919	9	136	2	0.82
1920-1924	35	720	1	2.42
1925-1929	53	1079	0	1.99
1930-1934	219	4435	4	5.46
1935-1939	146	2954	2	1.80
1940-1944	122	2379	1	0.52
1945-1949	64	1144	0	0.18
Total	648	12847	10	13.17

Circulatory Deaths Among Nonflying Personnel

SMR=1.53, 95% C I: (0.75, 2.30), P=0.10

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1910-1914	5	99	0	0.80
1915-1919	8	179	0	1.14
1920-1924	13	264	2	1.11
1925-1929	31	639	3	1.41
1930-1934	86	1703	6	2.78
1935-1939	67	1383	2	1.41
1940-1944	90	1831	0	0.59
1945-1949	302	5822	2	0.58
1950-1954	11	197	0	0.01
Total	613	12117	15	9.83

TABLE 43 (Cont'd)

One-sample Adjusted Contrasts of Ranch Hands and
All Comparisons on Circulatory Deaths

Circulatory Deaths Among All Ranch Hands

SMR=1.09, 95% C I: (0.73, 1.61), P=0.67

Birth Year	Number At Risk	Person- years	Number Dead	Adjusted Expected Deaths
1905-1914	5	99	0	0.74
1915-1919	17	315	2	1.81
1920-1924	48	984	3	3.65
1925-1929	84	1718	3	3.42
1930-1934	305	6138	10	8.62
1935-1939	213	4337	4	3.41
1940-1944	212	4211	1	1.11
1945-1949	366	6966	2	0.77
1950-1954	11	197	0	0.01
Total	1261	24965	25	23.68

In the one-sample adjusted analysis of all Ranch Hand circulatory deaths summarized in the last panel of Table 43, there was no survival by rank by occupation interaction ($P=0.93$). Additionally, the Ranch Hand versus all Comparison contrast on accidental deaths did not vary significantly with rank ($P=0.68$) or occupation ($P=0.13$).

None of the adjusted cause-specific SMR's shown in Tables 41, 42 and 43 are statistically significantly different from unity. The overall adjusted cause-specific SMR's shown in the last panel of each of these three tables, reflect the same pattern shown in the adjusted two-sample cause-specific results in Table 40. The covariate adjusted one-sample results indicate that the relative excess number of circulatory deaths in Ranch Hand nonflyers (SMR=1.53) in Table 43 is not significantly different from the relatively favorable circulatory mortality experience of Ranch Hand flyers (SMR=0.76, $P=0.94$). Similarly, the changes in malignant neoplasm and accidental death SMR's across levels of rank and occupation are not statistically significant.

Cumulative digestive system mortality by ICD code (following ICD nomenclature and spelling) is shown in Table 44. Digestive system mortality occurring during the calendar years 1986 and 1987 are shown in Tables 45 and 46. Digestive system mortality occurring during the calendar years 1983, 1984 and 1985 is shown in the Appendix.

TABLE 44

Group Cumulative Site-Specific Nonmalignant Digestive System Mortality

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
530-537 Oesophagus, Stomach and Duodenum			
531.9 Gastric Ulcer	0	0	1
532.4 Duodenal Ulcer with Haemorrhage	0	0	1
532.5 Duodenal Ulcer with Perforation	0	1	1
533.4 Peptic Ulcer with Haemorrhage	0	0	1
540-543 Appendicitis			
540.0 Acute Appendicitis, Peritonitis	0	0	1
560-569 Intestine and Peritoneum, Other			
564.1 Irritable Colon	0	1	1
570-579 Digestive System, Other			
571.0 Alcoholic Fatty Liver	1	0	1
571.1 Acute Alcoholic Hepatitis	0	0	3
571.2 Alcoholic Cirrhosis of Liver	4	11	15
571.3 Alcoholic Liver Damage, Unspecified	0	1	4
571.5 Cirrhosis of Liver, Nonalcoholic	0	2	5
571.9 Unspecified Chronic Liver Disease Without Mention of Alcohol	0	0	1
572.9 Other Sequelae of Chronic Liver Disease	1	0	0
577.0 Acute Pancreatitis	0	2	2
Totals	6	18	37

TABLE 45

Group Site-Specific Nonmalignant Digestive System Mortality for 1986

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp.
570-579 Digestive System, Other			
571.2 Alcoholic Cirrhosis of Liver	0	1	1
Total	0	1	1

TABLE 46

Group Site-Specific Nonmalignant Digestive System Mortality for 1987

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
560-569 Intestine and Peritoneum, Other			
564.1 Irritable Colon	0	1	1
570-579 Digestive System, Other			
571.2 Alcoholic Cirrhosis of Liver	0	1	1
Total	0	2	2

Table 38 shows that the Ranch Hand nonmalignant digestive death rate is elevated, relative to that of all Comparisons (one-sample unadjusted SMR = 2.7, $P=0.01$). Five of the six Ranch Hand digestive deaths (83%) and 29 of the 37 Comparison digestive deaths (79%) were liver-related. All (100%) of the 5 Ranch Hand and 23 (79%) of the 29 Comparison liver-related digestive deaths were attributable to alcohol. The 6 Ranch Hand digestive deaths are distributed by rank and occupation as 2 flying officers, 2 flying enlisted and 2 nonflying enlisted. The 5 Ranch Hand alcohol-related digestive deaths are distributed as 2 flying officers, 1 flying enlisted and 2 nonflying enlisted. Digestive system mortality during 1986 and 1987, summarized in Tables 47 and 48, and digestive system mortality during the years 1983, 1984 and 1985, shown in Appendix Tables 13 through 15, is unremarkable since the last Ranch Hand digestive system death occurred in 1985. Digestive system deaths did not, therefore, contribute to the already noted (Table 29) increased Ranch Hand mortality during 1986 and 1987.

Table 47 shows cumulative site-specific malignant neoplasm mortality by group.

TABLE 47

Group Cumulative Site-Specific Neoplasm Mortality

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
140-149 Lip, Oral Cavity and Pharynx			
140.9 Lip, Unspecified	0	1	1
141.9 Tongue, Unspecified	0	1	3
144.9 Floor of Mouth, Unspecified	0	1	1
145.9 Mouth, Unspecified	0	1	2
146.0 Tonsil	0	1	1
147.9 Nasopharynx, Unspecified	0	1	1
148.1 Pyriform Sinus	0	0	2
150-159 Digestive Organs and Peritoneum			
150.3 Oesophagus, Upper Third	0	1	1
150.5 Oesophagus, Lower Third	0	0	1
150.9 Oesophagus, Unspecified	1	3	6

TABLE 47 (Cont'd)

Group Cumulative Site-Specific Neoplasm Mortality

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
150-159 Digestive Organs and Peritoneum			
151.9 Stomach, Unspecified	1	2	4
153.4 Colon, Caecum	0	0	1
153.5 Colon, Appendix	0	1	1
153.9 Colon, Unspecified	0	7	19
154.0 Rectosigmoid Junction	0	0	2
154.1 Rectum	0	1	2
154.3 Anus, Unspecified	0	0	1
157.4 Islets of Langerhans	0	1	1
157.9 Pancreas, Unspecified	1	3	10
159.0 Intestinal Tract, Unspecified	0	1	1
160-165 Respiratory and Intrathoracic Organ			
160.9 Accessory Sinus, Unspecified	0	1	1
161.1 Supraglottis	0	0	1
161.9 Larynx, Unspecified	0	0	2
162.2 Main Bronchus	0	0	1
162.3 Upper Lobe, Bronchus or Lung	0	1	2
162.4 Middle Lobe, Bronchus or Lung	0	1	1
162.9 Bronchus and Lung, Unspecified	4	32	76
163.9 Pleura, Unspecified	0	0	1
164.9 Mediastinum, Unspecified	1	0	0
170-175 Bone, Connective Tissue, Skin and Breast			
170.9 Bone and Articular Cartilage, Unspecified	0	0	1
171.3 Connective, Soft Tissue, Lower Limb, Hip	1	0	0
171.8 Connective, Soft Tissue, Other	0	0	1
171.9 Site Unspecified	0	0	1
172.5 Skin, Trunk	0	0	1
172.9 Skin, Unspecified	0	2	8
179-189 Genitourinary Organs			
185.0 Prostate	0	0	1
188.9 Bladder, Unspecified	0	1	2
189.0 Kidney, Except Pelvis	1	3	5
190-199 Other and Unspecified Sites			
191.1 Brain, Frontal Lobe	0	1	1
191.7 Brain Stem	0	0	2
191.9 Brain, Unspecified	1	3	12
195.0 Head, Face and Neck	0	2	3
197.5 Large Intestine and Rectum	0	0	1
199.0 Disseminated, Unspecified	0	0	1
199.1 Other, Unspecified	1	2	18
200-208 Lymphatic and Haematopoietic Tissue			
200.1 Lymphosarcoma	0	1	1
200.8 Reticulolymphosarcoma	0	0	1
201.9 Hodgkin's Disease, Unspecified	0	2	2

TABLE 47 (Cont'd)

Group Cumulative Site-Specific Neoplasm Mortality

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
200-208 Lymphatic and Haematopoietic Tissue			
202.8 Other Lymphomas	0	1	6
203.0 Multiple Myeloma	0	0	4
204.0 Acute Lymphoid Leukaemia	0	0	1
204.1 Chronic Lymphoid Leukaemia	0	0	1
204.9 Lymphoid Leukaemia, Unspecified	0	0	1
205.0 Acute Myeloid Leukaemia	0	1	2
206.0 Acute Monocytoid Leukaemia	0	0	1
207.8 Lymphosarcoma Cell Leukaemia	0	0	1
208.0 Acute Leukaemia, Unspecified	0	0	1
210-229 Benign Neoplasms			
213.0 Bones of Skull and Face	0	1	1
239 Neoplasms of Unspecified Nature			
239.6 Neoplasm, Brain, Unspecified	0	2	2
Total	12	83	229

Site specific summaries of malignant neoplasm deaths occurring during 1986 are shown in Table 48. The corresponding summary for 1987 is shown in Table 49. Site-specific summaries of malignant neoplasm deaths occurring 1983, 1984, and 1985 are shown in the Appendix.

TABLE 48

Group Site-Specific Malignant Neoplasm Mortality for 1986

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
150-159 Digestive Organs and Peritoneum			
150.3 Oesophagus, Upper Third	0	1	1
150.9 Oesophagus, Unspecified	1	1	2
151.9 Stomach, Unspecified	0	0	1
153.9 Colon, Unspecified	0	3	7
157.9 Pancreas, Unspecified	1	0	0
160-165 Respiratory and Intrathoracic Organs			
162.9 Bronchus and Lung, Unspecified	0	4	12
170-175 Bone, Connective Tissue, Skin and Breast			
172.9 Skin, Unspecified	0	1	3

TABLE 48 (Cont'd)

Group Site-Specific Malignant Neoplasm Mortality for 1986

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
179-189 Genitourinary Organs			
188.9 Bladder, Unspecified	0	1	1
190-199 Other and Unspecified Sites			
191.9 Brain, Unspecified	1	0	1
199.1 Other, Unspecified	0	0	2
Total	3	11	30

TABLE 49

Group Site-Specific Malignant Neoplasm Mortality for 1987

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
140-149 Lip, Oral Cavity and Pharynx			
144.9 Floor of Mouth, Unspecified	0	1	1
145.9 Mouth, Unspecified	0	1	1
148.1 Pyriform Sinus	0	0	1
150-159 Digestive Organs and Peritoneum			
151.9 Stomach, Unspecified	0	1	2
153.9 Colon, Unspecified	0	1	2
154.1 Rectum	0	0	1
154.3 Anus, Unspecified	0	0	1
157.9 Pancreas, Unspecified	0	0	1
160-165 Respiratory and Intrathoracic Organs			
162.2 Main Bronchus	0	0	1
162.4 Middle Lobe, Bronchus or Lung	0	1	1
162.9 Bronchus and Lung, Unspecified	1	4	10
170-175 Bone, Connective Tissue, Skin and Breast			
171.3 Connective, Soft Tissue, Lower Limb, Hip	1	0	0
171.9 Site Unspecified	0	0	1
172.9 Skin, Unspecified	0	0	1
179-189 Genitourinary Organs			
189.0 Kidney, Except Pelvis	0	0	1
190-199 Other and Unspecified Sites			
191.7 Brain Stem	0	0	1
191.9 Brain, Unspecified	0	0	2
199.1 Other, Unspecified	0	1	1

TABLE 49 (Cont'd)

Group Site-Specific Malignant Neoplasm Mortality for 1987

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
200-208 Lymphatic and Haematopoietic Tissue			
202.8 Other Lymphomas	0	0	1
204.9 Lymphoid Leukaemia, Unspecified	0	0	1
208.0 Acute Leukaemia, Unspecified	0	0	1
210-229 Benign Neoplasms			
213.0 Bones of Skull and Face	0	1	1
Total	2	11	33

Table 47 shows that the malignant neoplasm deaths appear to be widely distributed by site with approximately one-third (33%) occurring in the lung in all three groups. Within-year patterns, shown in Tables 48 and 49 and Appendix Tables 7 through 9, also appear to be similarly distributed.

The morphology of cumulative malignant neoplasm deaths is summarized in Table 50.

TABLE 50

Morphology of Cumulative Malignant Neoplasm Deaths by Group

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
M800 Neoplasms NOS			
140-149 Lip, Oral Cavity and Pharynx	0	0	1
150-159 Digestive Organs and Peritoneum	1	8	20
160-165 Respiratory and Intrathoracic Organs	2	15	32
179-189 Genitourinary Organs	0	1	3
190-199 Other and Unspecified Sites	1	2	13
235-238 Neoplasms, Uncertain	0	1	1
M801-M804 Epithelial Neoplasms NOS			
140-149 Lip, Oral Cavity and Pharynx	0	2	3
150-159 Digestive Organs and Peritoneum	1	4	13
160-165 Respiratory and Intrathoracic Organs	2	13	38
179-189 Genitourinary Organs	1	1	2
190-199 Other and Unspecified Sites	1	2	6
M805-M808 Papillary and Squamous Cell Neoplasms			
140-149 Lip, Oral Cavity and Pharynx	0	4	7
150-159 Digestive Organs and Peritoneum	0	1	1
160-165 Respiratory and Intrathoracic Organs	0	2	6
190-199 Other and Unspecified Sites	0	1	2
M814-M838 Adenomas and Adenocarcinomas			
150-159 Digestive Organs and Peritoneum	1	7	16
160-165 Respiratory and Intrathoracic Organs	0	4	7

TABLE 50 (Cont'd)

Morphology of Cumulative Malignant Neoplasm Deaths by Group

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
M814-M838 Adenomas and Adenocarcinomas			
179-189 Genitourinary Organs	0	2	3
190-199 Other and Unspecified Sites	0	0	3
M856-M858 Complex Epithelial Neoplasms			
190-199 Other and Unspecified Sites	0	0	1
M872-M879 Naevi and Melanomas			
160-165 Respiratory and Intrathoracic Organs	1	0	0
170-175 Bone, Connective Tissue, Skin and Breast	0	2	9
M881-M883 Fibromatous Neoplasms			
170-175 Bone, Connective Tissue, Skin and Breast	1	0	0
M885-M888 Lipomatous Neoplasms			
170-175 Bone, Connective Tissue, Skin and Breast	0	0	1
M905 Mesothelial Neoplasms			
160-165 Respiratory and Intrathoracic Organs	0	1	2
M906-M909 Germ cell Neoplasms			
190-199 Other and Unspecified Sites	0	0	1
M921-M924 Chondromatous Neoplasms			
210-229 Benign Neoplasms	0	1	1
M926 Miscellaneous Brain Tumors			
170-175 Bone, Connective Tissue, Skin and Breast	0	0	1
M935-M937 Miscellaneous Tumors			
239 Neoplasms of Unspecified Nature	0	1	1
M938-M948 Gliomas			
190-199 Other and Unspecified Sites	0	3	12
M949-M952 Neuroepitheliomatous Neoplasms			
170-175 Bone, Connective Tissue, Skin and Breast	0	0	1
M959-M963 Lymphomas NOS or Diffuse			
200-208 Lymphatic and Haematopoietic Tissue	0	1	7
M964 Reticulosarcomas			
200-208 Lymphatic and Haematopoietic Tissue	0	1	1
M965-M966 Hodgkin's Disease			
200-208 Lymphatic and Haematopoietic Tissue	0	2	2
M973 Plasma Cell Tumors			
200-208 Lymphatic and Haematopoietic Tissue	0	0	4
M980 Leukaemia NOS			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
M982 Lymphoid Leukaemias			
200-208 Lymphatic and Haematopoietic Tissue	0	0	3
M985 Lymphosarcoma Cell Leukaemias			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
M986 Myeloid Leukaemias			
200-208 Lymphatic and Haematopoietic Tissue	0	1	2
M989 Monocytic Leukaemias			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
Total	12	83	229

Tables 51 and 52 show morphology of malignant neoplasm deaths occurring during 1986 and 1987.

TABLE 51

Morphology of Malignant Neoplasm Deaths by Group for 1986

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
M800 Neoplasms NOS			
150-159 Digestive Organs and Peritoneum	1	3	8
160-165 Respiratory and Intrathoracic Organs	0	4	6
179-189 Genitourinary Organs	0	1	1
190-199 Other and Unspecified Sites	1	0	1
M801-M804 Epithelial Neoplasms NOS			
150-159 Digestive Organs and Peritoneum	0	0	1
160-165 Respiratory and Intrathoracic Organs	0	0	5
M805-M808 Papillary and Squamous Cell Neoplasms			
150-159 Digestive Organs and Peritoneum	0	1	1
160-165 Respiratory and Intrathoracic Organs	0	0	1
M814-M838 Adenomas and Adenocarcinomas			
150-159 Digestive Organs and Peritoneum	1	1	1
190-199 Other and Unspecified Sites	0	0	1
M872-M879 Naevi and Melanomas			
170-175 Bone, Connective Tissue, Skin and Breast	0	1	3
M938-M948 Gliomas			
190-199 Other and Unspecified Sites	0	0	1
Total	3	11	30

TABLE 52

Morphology of Malignant Neoplasm Deaths by Group for 1987

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
M800 Neoplasms NOS			
150-159 Digestive Organs and Peritoneum	0	0	1
160-165 Respiratory and Intrathoracic Organs	1	2	3
179-189 Genitourinary Organs	0	0	1
M801-M804 Epithelial Neoplasms NOS			
150-159 Digestive Organs and Peritoneum	0	1	5
160-165 Respiratory and Intrathoracic Organs	0	2	6
190-199 Other and Unspecified Sites	0	1	2
M805-M808 Papillary and Squamous Cell Neoplasms			
140-149 Lip, Oral Cavity and Pharynx	0	2	3

TABLE 52 (Cont'd)

Morphology of Malignant Neoplasm Deaths by Group for 1987

Category	Number of Deaths		
	Ranch Hand	C1-C5	All Comp
M814-M838 Adenomas and Adenocarcinomas			
150-159 Digestive Organs and Peritoneum	0	1	1
160-165 Respiratory and Intrathoracic Organs	0	1	3
M872-M879 Naevi and Melanomas			
170-175 Bone, Connective Tissue, Skin and Breast	0	0	1
M881-M883 Fibromatous Neoplasms			
170-175 Bone, Connective Tissue, Skin and Breast	1	0	0
M885-M888 Lipomatous Neoplasms			
170-175 Bone, Connective Tissue, Skin and Breast	0	0	1
M921-M924 Chondromatous Neoplasms			
210-229 Benign Neoplasms	0	1	1
M938-M948 Gliomas			
190-199 Other and Unspecified Sites	0	0	2
M959-M963 Lymphomas NOS or Diffuse			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
M980 Leukaemia NOS			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
M982 Lymphoid Leukaemias			
200-208 Lymphatic and Haematopoietic Tissue	0	0	1
Total	2	11	33

With regard to morphology, the 12 Ranch Hand malignant neoplasm deaths appear widely distributed and as expected relative to the mortality experience of all Comparisons, both cumulatively (Table 50) and within calendar year (Tables 51 and 52 and Appendix Tables 10 through 12).

In summary, an elaboration of Ranch Hand and Comparison digestive deaths by site and malignant neoplasm deaths by site and morphology revealed no unusual pattern of Ranch Hand deaths relative to the mortality experience of all Comparisons.

5. RANCH HAND EXPOSURE ANALYSES

The exposure of a Ranch Hand to dioxin has been estimated as being proportional to the number of gallons sprayed and inversely proportional to the number of men in the subject Ranch Hand's occupational category during his tour. This index has been categorized to "low", "medium" and "high" levels and has been considered a surrogate for a direct body measurement of exposure. Actual body burdens of dioxin are currently being determined for 2000 of the participants in the morbidity phase of this study, but this procedure is not feasible for use in the mortality phase. The effect of dioxin exposure on Ranch Hand mortality was assessed within the Ranch Hand group via loglinear analysis. Additionally, the one-sample person-years approach has been applied to assess whether the Ranch Hand versus all Comparison mortality contrast changes with levels of dioxin exposure within the Ranch Hands.

The loglinear analysis included rank (Officer, Enlisted), tour (early, late), exposure (low, medium, high) and mortality (dead, alive). The data are summarized in Table 53.

TABLE 53

Survival versus Air Force Exposure Index Levels within
the Ranch Hands with Adjustment for Rank and Tour

		Exposure				
Rank	Tour	Survival	Low	Medium	High	Total
Officer	Early	Dead	3	9	9	21
		Alive	54	106	137	297
		Total	57	115	146	318
	Late	Dead	4	1	0	5
		Alive	91	33	20	144
		Total	95	34	20	149
Enlisted	Early	Dead	11	11	18	40
		Alive	104	226	197	527
		Total	115	237	215	567
	Late	Dead	6	2	0	8
		Alive	143	36	40	219
		Total	149	38	40	227

There is no significant association between exposure level and mortality in these data with ($P=0.51$) or without ($P=0.82$) adjustment for rank and tour date. There is a strong marginal association between tour date and exposure ($P<.001$) which is expected because the spraying was more intense during late

tours than during early tours. Prior to 1965, only 3 aircraft were assigned to the Ranch Hand mission and this number increased to 36 by 1968.

The one-sample person-years analysis was carried out within each level of rank (Officer, Enlisted) to assess whether the Ranch Hand versus all Comparison mortality contrast changed with levels of exposure. Person-years were computed from tour start date. The results are summarized in Table 54.

TABLE 54

Ranch Hand Exposure within Officers and within Enlisted
One-sample Person-years Assessment Relative to
All Comparisons

Analysis within the Officers

Exposure	Number of Deaths	Adjusted Expected Deaths	Adjusted SMR
Low	7	7.52	0.93
Medium	10	10.16	0.98
High	9	9.69	0.93

Contrast	Relative Risk	P-value
Medium versus Low and High	1.06	0.91
High versus Low and Medium	1.00	1.00

Analysis within the Enlisted Personnel

Exposure	Number of Deaths	Adjusted Expected Deaths	Adjusted SMR
Low	17	14.70	1.16
Medium	13	13.78	0.94
High	18	17.56	1.03

Contrast	Relative Risk	P-value
Medium versus Low and High	0.82	0.58
High versus Low and Medium	0.89	0.72

Both the loglinear and one-sample person-year analysis fail to reveal any relationship between mortality and the exposure index.

Unpublished dioxin assay results suggest that the Air Force exposure index is not a valid measure of exposure to TCDD. The relationship between this index and dioxin body burden in living Ranch Hands will be described in a forthcoming report.

6. CONCLUSION

An evaluation of total and cause-specific mortality revealed no statistically significant differences between Ranch Hands and C1-C5 Comparisons or all Comparisons. The many non-cause specific analyses are summarized in Table 55, which displays the results of only the most fully adjusted one and two-sample analyses.

TABLE 55

Non-cause Specific Summary

Odds Ratio (or SMR) and 95% Confidence Interval

Analysis	Ranch Hand versus C1-C5	Ranch Hand versus All Comp
Two-sample		
Logistic reg-discrete	1.00 (0.88, 1.14)	****
Logistic reg-continuous	1.00 (0.87, 1.14)	1.00 (0.88, 1.13)
One-sample SMR, adjusted		1.01 (0.80, 1.26)

None of the odds ratios, or the one-sample SMR, reported in Table 55 are statistically different from unity. The two-sample logistic regression analysis with continuous covariates was adjusted for rank, occupation, date of birth and tour start date, with date of birth and tour start date continuously distributed. The two-sample logistic regression analysis with discrete covariates was adjusted for rank, occupation, date of birth and tour start date, with date of birth dichotomized at 1 January 1935 and tour start date dichotomized at 2 October 1968. The one-sample SMR analysis was adjusted for rank, occupation, date of birth and calendar time in 5 year intervals, and survival time via person-years. Interactions were investigated in the one and two-sample analyses by including all pairwise covariate by covariate interactions in each model. Date of birth contributed significantly ($P < 0.001$) to the fit of the model in all two-sample non-cause specific analyses.

In the single observed covariate by survival by group interaction, indicated with asterisks in Table 55, there was a significant group by survival by tour date (early, late) interaction due to a change in the group by survival odds ratio with levels of tour. Early tours were defined as those having a tour start date before 1 October 1968; late tours were defined as those starting after that date. For veterans with early tours, the adjusted odds ratio was 1.10 and the adjusted odds ratio for late tours was 0.93. This interaction was not detected in any of the other discrete or continuous adjusted analyses and indicates a reduced Ranch Hand risk of death in late tours and a slightly higher risk of death in early tours. Further, if tour is trichotomized, the interaction is not significant and the pattern of odds ratios is not suggestive of an exposure effect. This interaction remains unexplained at this time.

The adjusted cause specific analyses are summarized in Table 56. Only accidental, malignant neoplasm and circulatory deaths were numerous enough to permit adjusted analyses. None of the adjusted odds ratios shown in Table 56 are statistically different from unity.

TABLE 56

Adjusted Odds Ratio, Cause-specific Summary
Ranch Hand versus C1-C5 and All Comparison

Accidental, Malignant Neoplasm and Circulatory Deaths

Cause	C1-C5 Two-sample		All Comparison		
	Disc	Cont	Two-sample	One-sample	
Accidental	1.02	1.02	1.05	1.05	1.16
Neoplasms, malignant	0.85	0.85	0.82	0.83	0.70
Circulatory system	1.07	1.07	1.06	1.05	1.09

The Ranch Hand digestive system death rate was significantly elevated relative to that of all Comparisons (unadjusted SMR = 2.7, $P=0.01$). However, 5 of the 6 Ranch Hand digestive system deaths were attributable to alcohol consumption and, therefore, this finding is considered unrelated to herbicide exposure.

Two statistically significant interactions reported in the 1984 update were also investigated with current data. The first, a group by survival by date of birth interaction, was not statistically significant in any analysis of Ranch Hands versus C1-C5 Comparison mortality or versus all Comparison mortality. A second interaction reported in the 1984 update, a significant group by survival-to-age-35 by rank interaction, remained statistically significant in Ranch Hand and C1-C5 mortality data and appears to be due to an excess of non-disease deaths in Ranch Hand officers under the age of 35. The observed number of such deaths in that cell is 7 and the expected number is 3. Of the seven deaths, 6 were accidental and one was a suicide. The same interaction was not statistically significant in the corresponding Ranch Hand versus all Comparison analysis or in similar analyses restricted to accidents. These patterns seem unrelated to herbicide exposure and are probably spurious.

Statistically significant increasing trends in the SMR, relative to the mortality experience of all Comparisons, during the years 1983 through 1987 were noted in flying officers, flyers, officers, and all personnel. The trends in flyers, officers and all personnel are attributed to the increasing trend among flying officers wherein the calendar year-specific SMR's were 0.00 in 1983, 0.59 in 1984, 0.69 in 1985, 2.80 in 1986 and 1.75 in 1987. This pattern is due to unusually low Ranch Hand death rates prior to 1986 and increased number of Ranch Hand circulatory and malignant neoplasms deaths during 1986 and 1987. However, Ranch Hand malignant neoplasm deaths in this stratum during 1986 and 1987 are not restricted to a particular anatomic site or morphology, as might be expected if dioxin was exerting a direct effect on malignant disease.

Additionally, current TCDD assay results suggest that flying officers were among the least exposed of all Ranch Hand personnel. These trends were not assessed relative to the Air Force exposure index due to data sparseness. Although they are not suggestive of a herbicide effect, these results remain unexplained at this time and emphasize the need for continued surveillance.

An analysis of Ranch Hand mortality versus dioxin exposure, as estimated by the Air Force exposure index, revealed no association between mortality and exposure.

In conclusion, the overall cumulative mortality of the Ranch Hands remains statistically indistinguishable from that of both their matched Comparisons and the entire Comparison population, although there is a statistically significant increasing trend in post-1983 death rates among Ranch Hand flying officers and a statistically significant increase in Ranch Hand digestive system deaths relative to the Comparison population; these findings are not suggestive of a herbicide effect. Ranch Hands are equivalent to all Comparisons in cumulative accidental, malignant neoplasm and circulatory system mortality.

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APPENDIX

Figure 1

Survival Curve Estimates All Ranch Hands and
C1-C5 Comparisons Survival from Birth

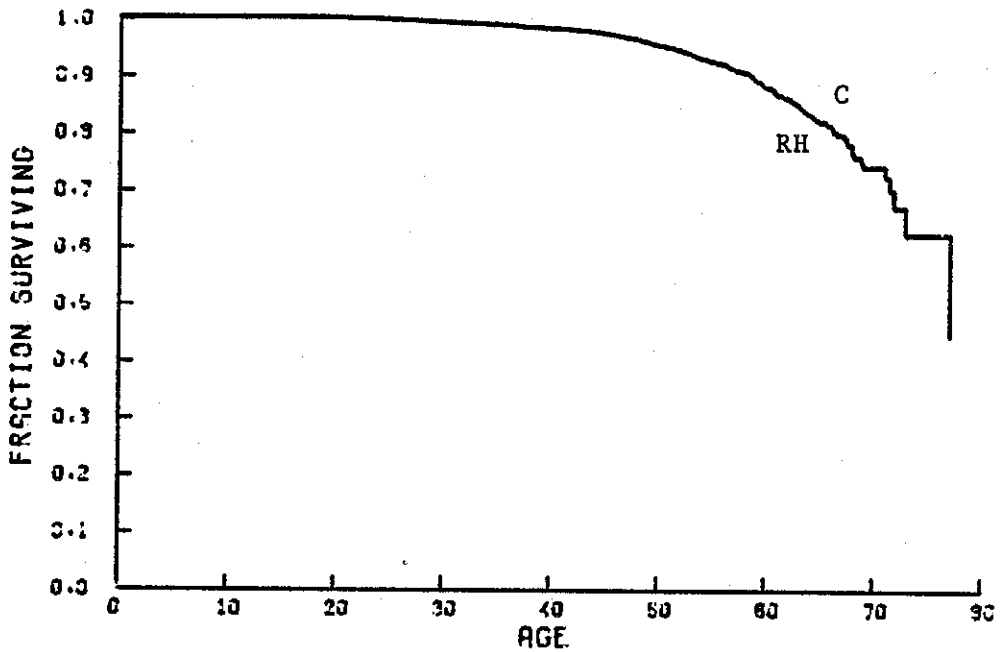


Figure 2

Survival Curve Estimates Ranch Hand
and C1-C5 Comparison Officers Survival from Birth

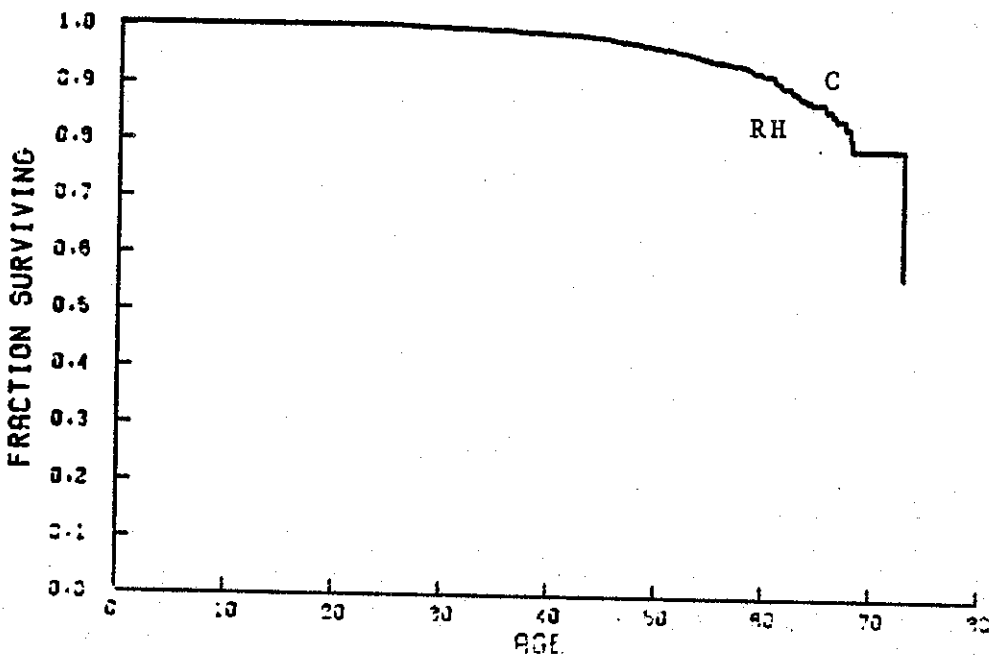


Figure 3
Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Enlisted Personnel
Survival from Birth

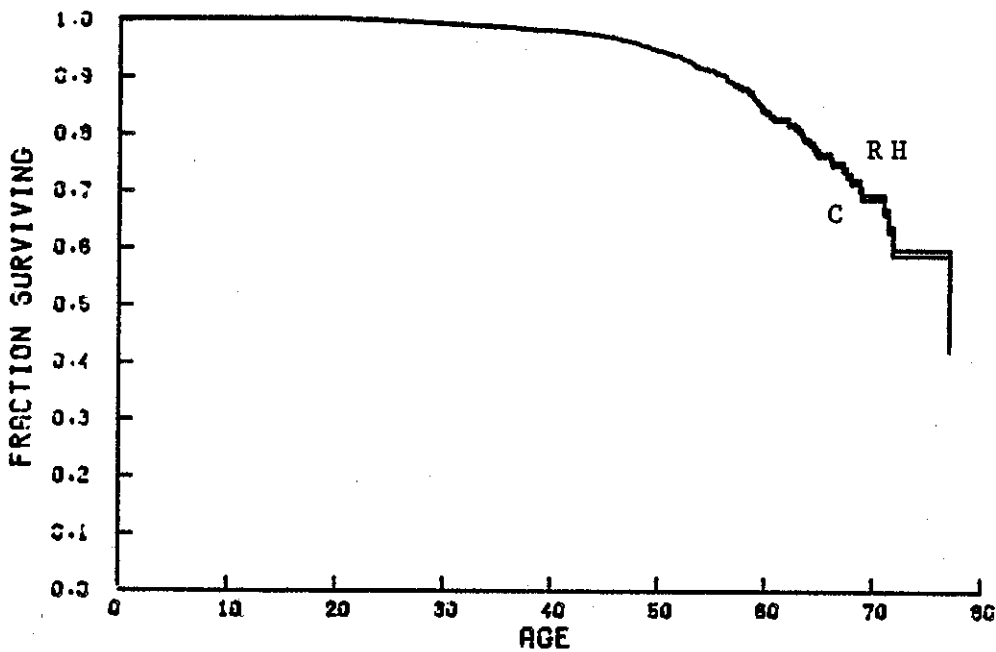


Figure 4
Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Flying Personnel
Survival from Birth

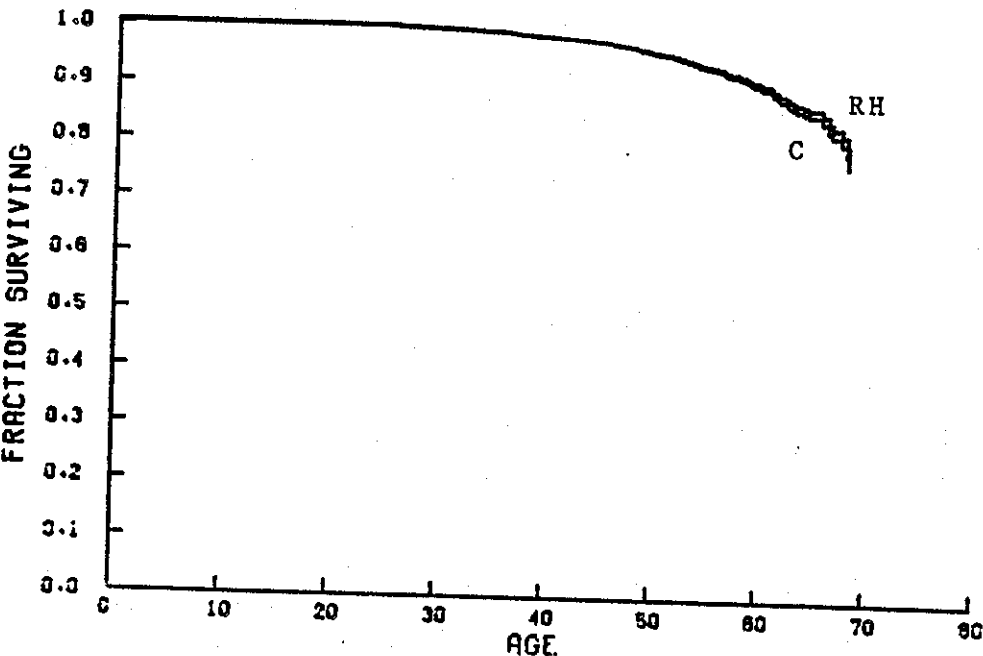


Figure 5

Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Nonflying Personnel
Survival from Birth

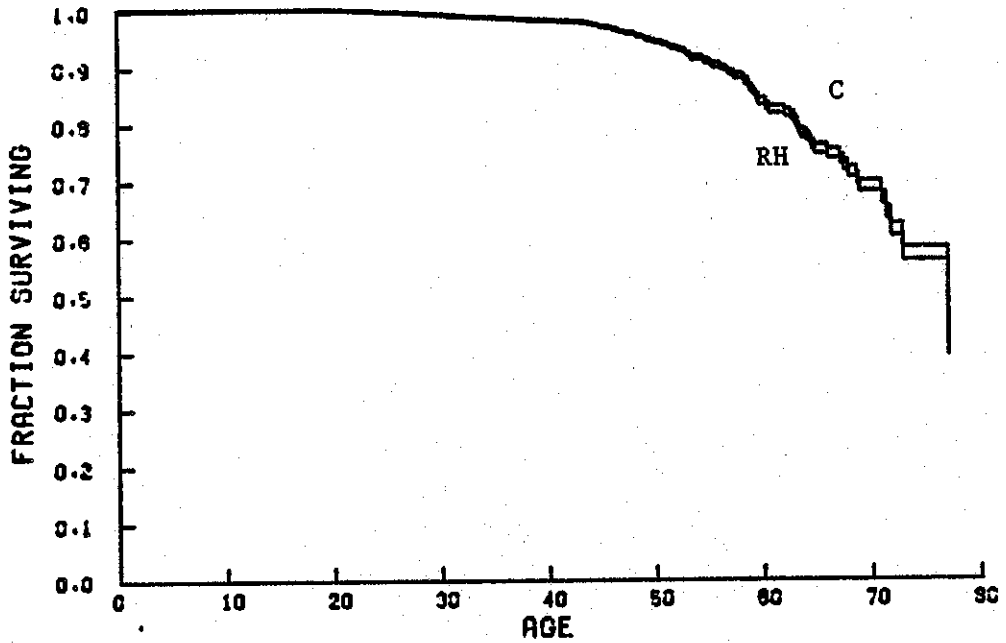


Figure 6

Survival Curve Estimates
All Ranch Hands and All Comparisons
Survival from Birth

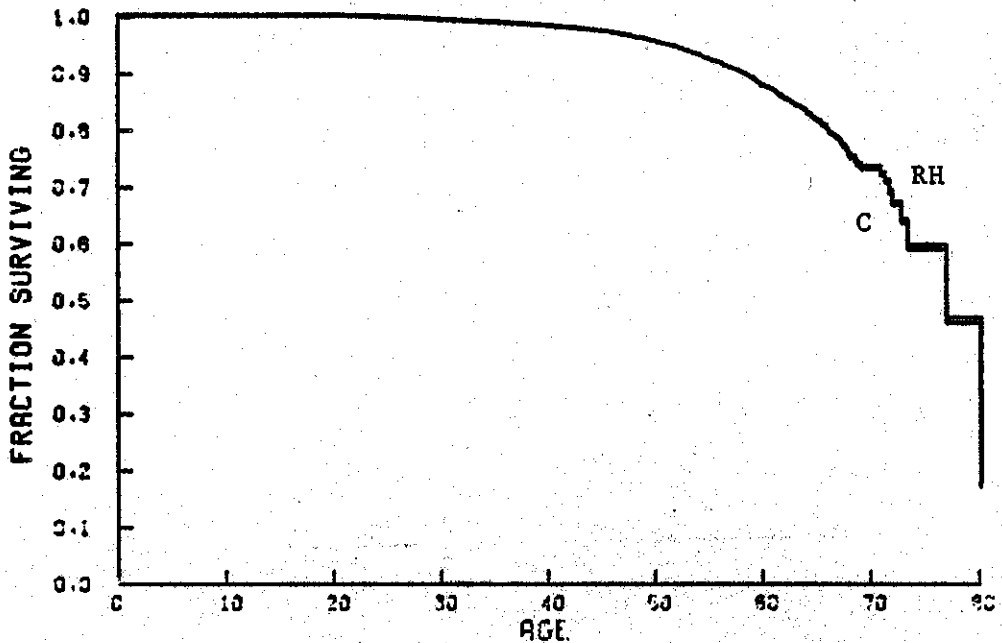


Figure 7

Survival Curve Estimates
Ranch Hand and All Comparison Officers
Survival from Birth

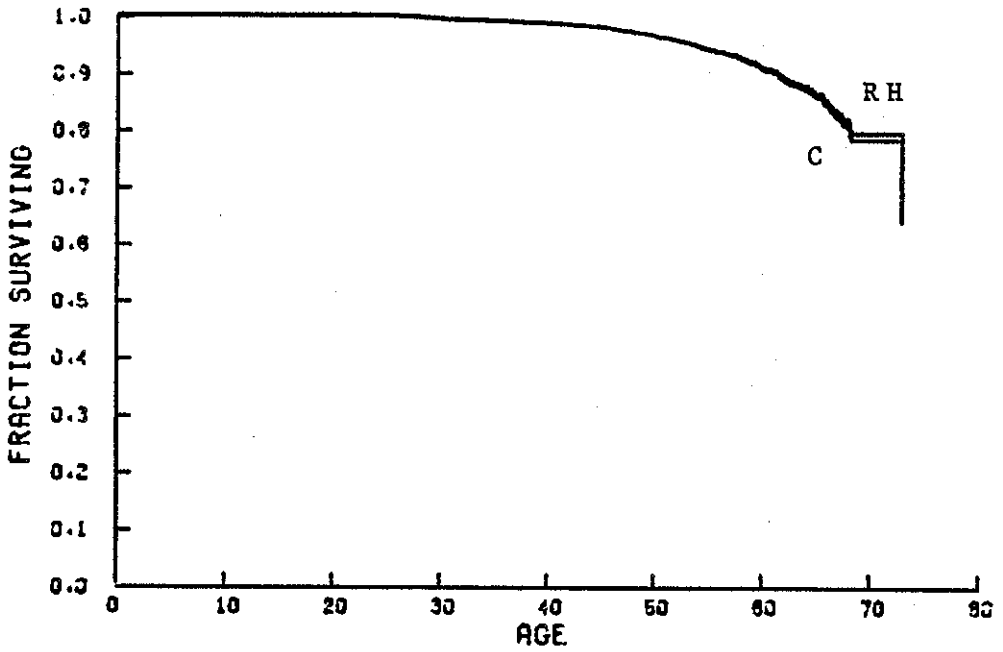


Figure 8

Survival Curve Estimates
Ranch Hand and All Comparison Enlisted Personnel
Survival from Birth

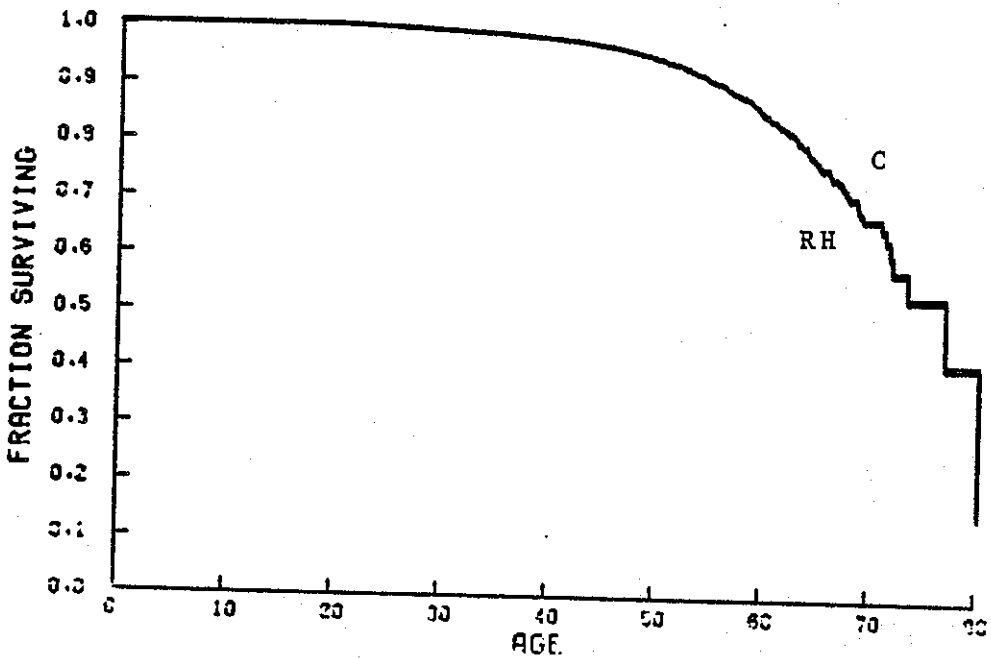


Figure 9

Survival Curve Estimates Ranch Hand and
All Comparison Flying Personnel Survival from Birth

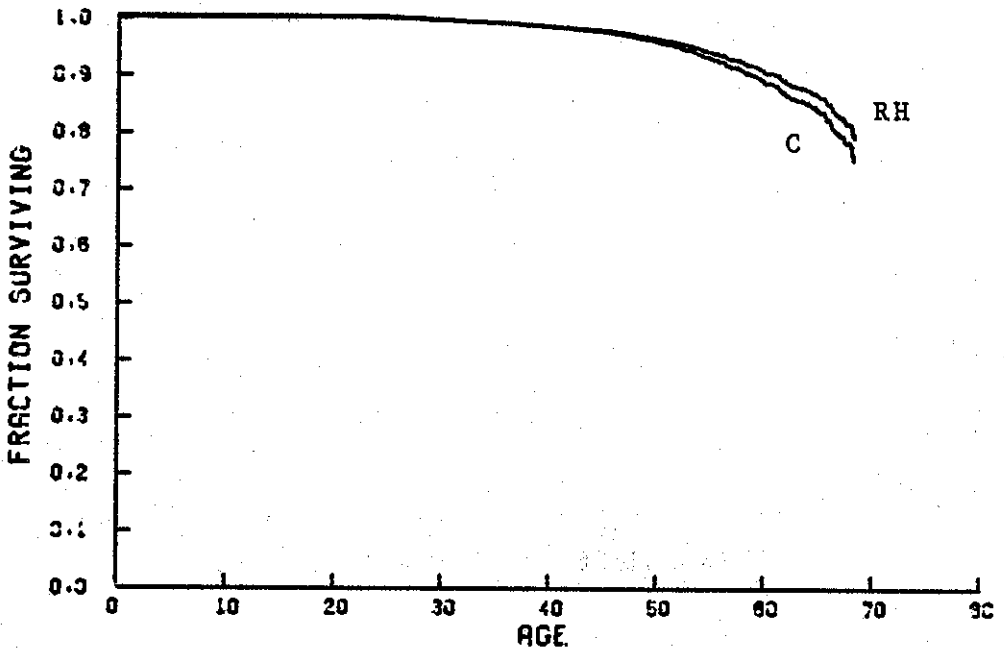


Figure 10

Survival Curve Estimates Ranch Hand and
All Comparison Nonflying Personnel Survival from Birth

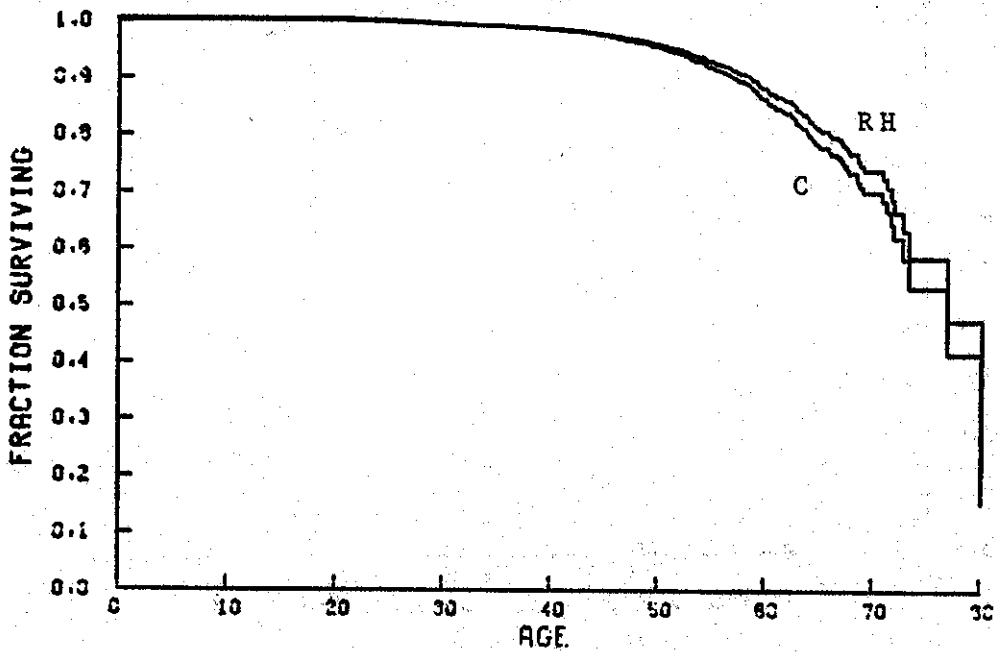


Figure 11

Nonparametric Survival Curve Estimates
All Ranch Hands and C1-C5 Comparisons
Survival from Start of Tour

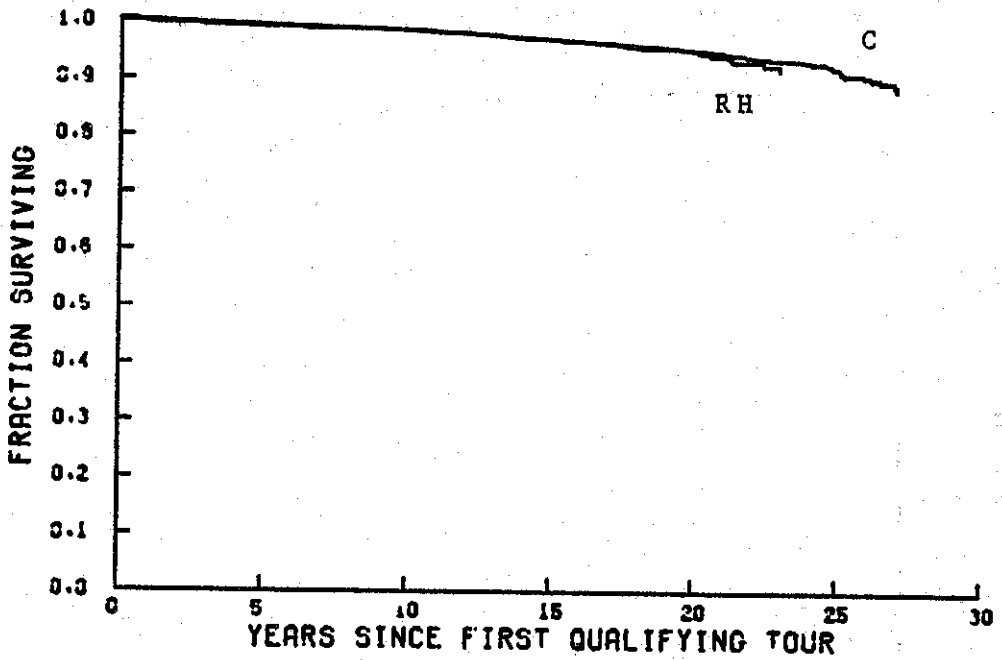


Figure 12

Nonparametric Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Officers
Survival from Start of Tour

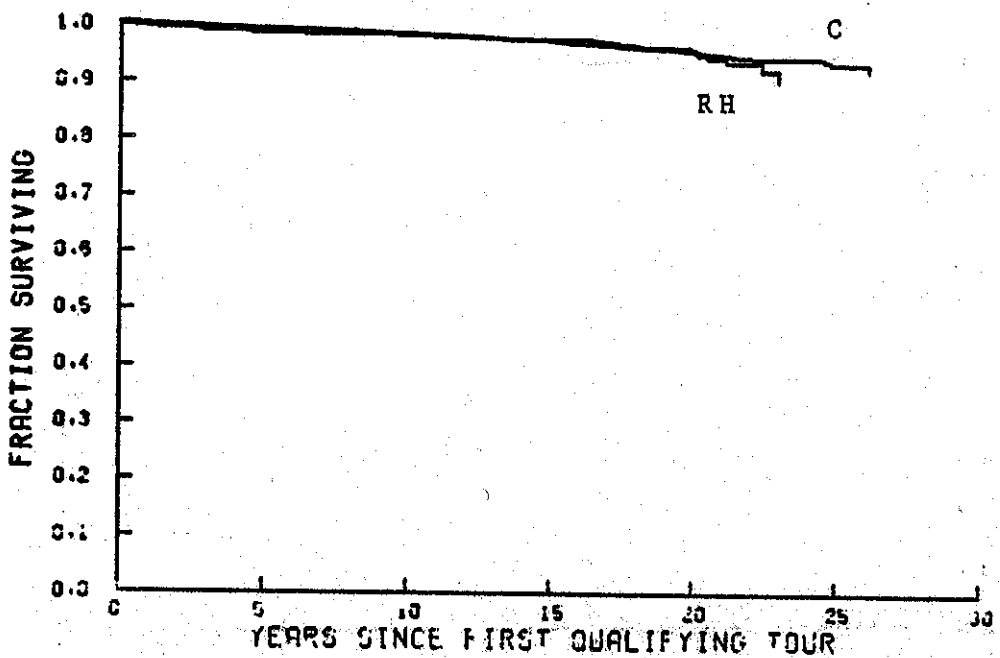


Figure 13

Nonparametric Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Enlisted Personnel
Survival from Start of Tour

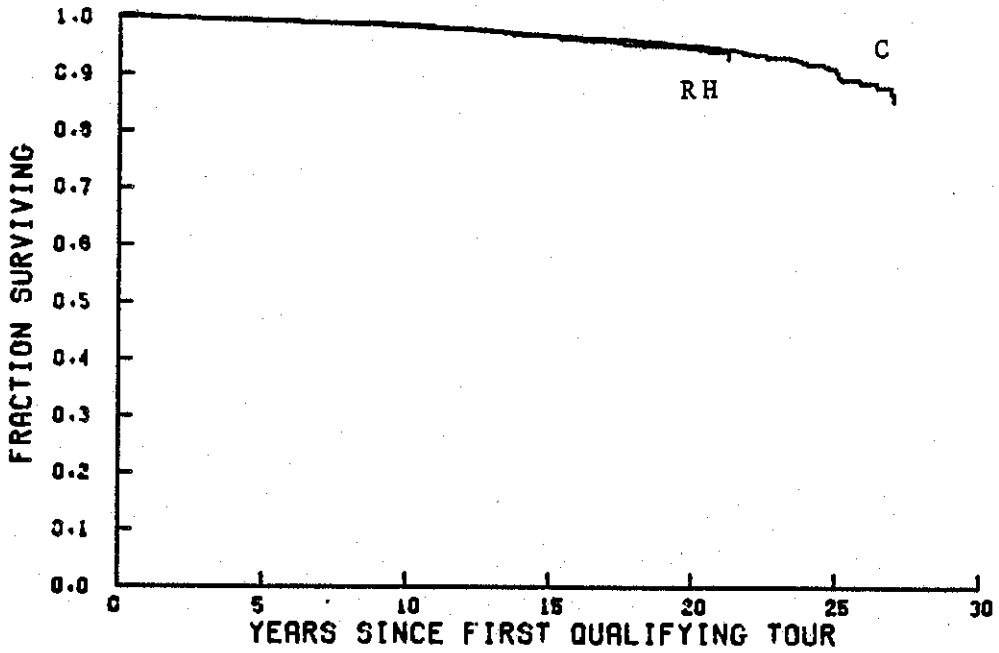


Figure 14

Nonparametric Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Flying Personnel
Survival from Start of Tour

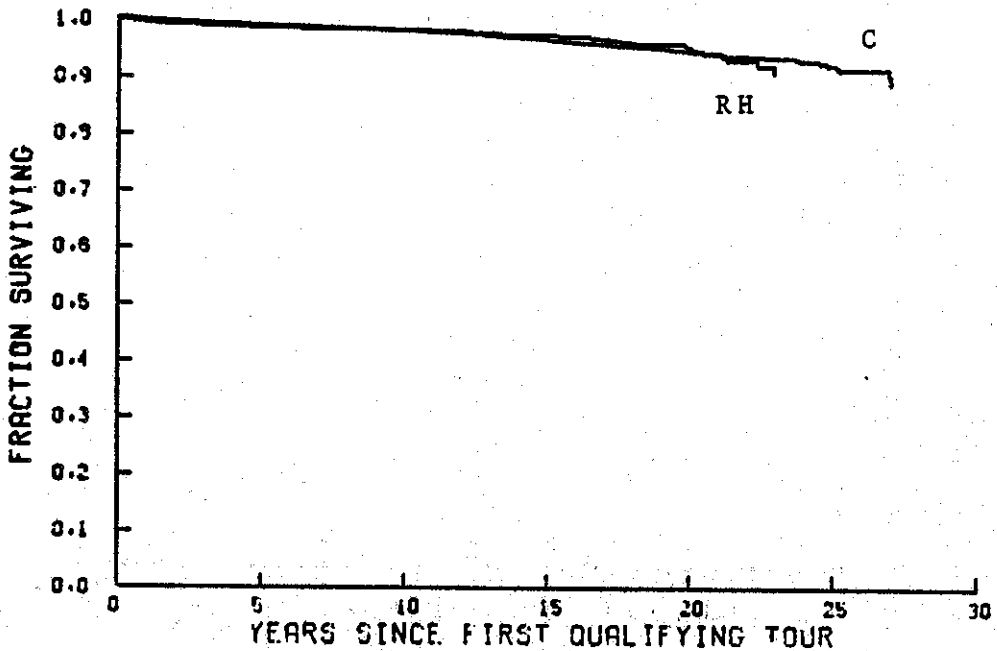


Figure 15

Nonparametric Survival Curve Estimates
Ranch Hand and C1-C5 Comparison Nonflying Personnel
Survival from Start of Tour

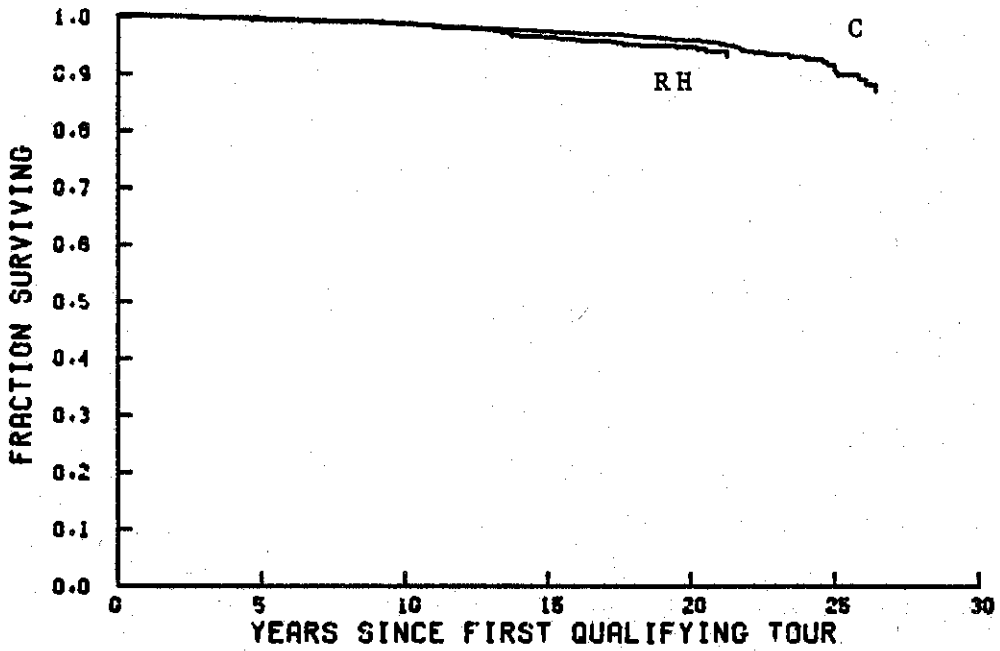


Figure 16

Nonparametric Survival Curve Estimates
All Ranch Hands and All Comparisons
Survival from Start of Tour

