

## Post-Service Mortality of Air Force Veterans Occupationally Exposed to Herbicides in Vietnam: 15 Year Follow-up

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### Introduction

The Air Force Health Study is a 20-year prospective study of the health, mortality and reproductive outcomes of veterans of Operation Ranch Hand, the unit responsible for aerially spraying herbicides in Vietnam from 1962 to 1971. The study, now in its 15<sup>th</sup> year, began in 1982 and will conclude in 2002. Here we update our first mortality report by summarizing current all-cause and cause-specific post-service mortality in veterans of Operation Ranch Hand<sup>1</sup>.

### Methods

We contrast cumulative Ranch Hand (N=1,261) mortality through December 31, 1993 (verified as of December 1995) with that expected based on the mortality experience of a Comparison population of 19,080 Air Force veterans who flew or serviced C-130 cargo aircraft in Southeast Asia during the same calendar period that the Ranch Hand unit was active in Vietnam (1962-1971). Comparison veterans were not involved with spraying herbicides in Vietnam and are demographically similar to Ranch Hand veterans. At that time, dates of military service in Southeast Asia were unavailable for 179 Comparison subjects. Rather than exclude those 179 Comparison veterans, we replaced the missing dates with randomly generated dates. Since then, we retrieved the actual dates for 148 of these 179 veterans from military personnel records, but were unable to find service dates for 31 due to missing records. We excluded the remaining 31 Comparison veterans with missing service dates from this report. Additionally, we excluded one Comparison veteran who we had erroneously included in our last report and added 11 Comparison veterans newly found and verified since our last report. Therefore, the total number of Comparison subjects is now 19,080, 21 less than previously reported. All Ranch Hand and Comparison veterans are male.

The numbers of veterans at risk and the number of person-years are summarized in table 1 by military occupation (pilots and navigators, administrative officers, enlisted flight engineers, enlisted ground personnel). All pilots and navigators were officers. We used military occupation as a surrogate to adjust for socioeconomic and inferred dioxin exposure differences among Ranch Hand veterans. Most enlisted personnel were not college educated and most officers were college graduates. Furthermore, dioxin assay results suggest that among Ranch Hand veterans, enlisted personnel were more heavily

exposed than officers and, among enlisted veterans, ground personnel were more heavily exposed than flight engineers.

Table 1 Number of veterans at risk and the number of person-years by military occupation.

Military Occupation	Ranch Hand		Comparison	
	At Risk	Person-Years	At Risk	Person-Years
Pilots and navigators	441	11,176	5,242	134,075
Administrative officers	26	658	284	7,436
Enlisted flight engineers	207	5,255	2,829	71,290
Enlisted ground personnel	587	14,845	10,725	277,991
All personnel	1261	31,934	19,080	490,792

We classified underlying causes of death in accordance with the rules and conventions of the 9<sup>th</sup> revision of the International Classification of Diseases (ICD-9). Veterans surviving to December 31, 1993, the cutoff date for these analyses, contributed the time, in years, between the dates of entry into follow-up (the date of the start of service in Southeast Asia) and the cutoff date, and those known to have died before that date contribute the time, in years, between the dates of entry into follow-up and death. We computed the Standardized Mortality Ratio (SMR), the ratio of the observed to the expected number of deaths, with adjustment for age, follow-up time and military occupation. The SMR was adjusted by stratifying on age (in 5-year intervals), follow-up time (in 5-year intervals) and military occupation and summing the observed and expected numbers of deaths across strata. The expected number of deaths within each stratum was the product of the number of Ranch Hand person-years and the Comparison death rate. We used the mid-p method derived from a Poisson model to compute confidence intervals (CIs) for the SMR. Although the confidence interval formula was based on the assumption that the Comparison death rates were constants, the Comparison rates were subject to random variation and so the widths of our confidence intervals were slightly understated. In some tables, due to small counts, we combined pilots, navigators and administrative officers into a single occupational category named "officers". We did not adjust for race because there were too few Blacks (6.1%) to permit adjustment.

## Results

Demographic characteristics of all veterans are presented in table 2. Ranch Hand and Comparison veterans were similar with regard to birth year and race. We were unable to adjust for smoking, a risk factor for cardiovascular disease, or for drinking, a risk factor for liver disease, because risk factor information was available only for the subgroup of veterans who participated in the medical follow-up arm of the study.

Table 2 Distribution of demographic characteristics.

Characteristic	Ranch Hand	Comparison
Median Birth year (Range)	1938 (1911 to 1950)	1942 (1907 to 1952)
Black (%)	6.1	6.9
Military Occupation:		
Pilots and navigators (%)	35.0	27.5
Administrative officers (%)	2.0	1.5
Enlisted flight engineers (%)	16.4	14.8
Enlisted ground personnel (%)	46.6	56.2

Ranch Hand mortality is summarized in table 3. Overall, the observed and expected number of Ranch Hand deaths did not differ significantly (SMR=1.0, 95% CI=0.8-1.2). We could not analyze deaths caused by suicide, homicide, infectious or parasitic diseases, endocrine diseases, respiratory diseases and ill-defined and unknown causes due to small numbers. There were no significant excesses of deaths caused by cancer (SMR=0.9) and circulatory diseases (SMR=1.0). The number of deaths caused by digestive diseases (observed number=9) was greater than the expected number (5.1); SMR=1.8, 95% CI 0.9-3.2.

Table 3 Cause-specific and all-cause mortality.

Cause of Death	ICD-9		Observed	Expected	SMR	95% CI
	Definition					
Infectious or parasitic diseases	001-139		2	1.3	1.5	
Cancer	140-208, 230-234		30	33.2	0.9	0.6-1.3
Endocrine diseases	240-279		1	1.1	0.9	
Circulatory diseases	390-459		39	39.6	1.0	0.7-1.3
Respiratory diseases	460-519		2	4.1	0.5	
Digestive diseases	520-579		9	5.1	1.8	0.9-3.2
Ill Defined or Unknown	780-799		3	2.4	1.3	
Accident	800-949		26	22.3	1.2	0.8-1.7
Suicide	950-959		4	5.8	0.7	
Homicide	960-969		2	1.7	1.2	
All causes	001-969		118	120.0	1.0	0.8-1.2

All-cause mortality and mortality due to cancer and circulatory diseases are summarized in table 4 by military occupation. The risk of death from cancer was not increased among pilots and navigators (SMR=0.9), enlisted flight engineers (SMR=1.0) or enlisted ground personnel (SMR=0.8). The risk of death caused by diseases of the circulatory system was increased among Ranch Hand enlisted ground personnel (SMR=1.5, 95% CI 1.0-2.2).

Table 4 All-cause, cancer and circulatory disease mortality by military occupation.

a) All causes

Military Occupation	Observed	Expected	SMR	95% CI
Pilots and navigators	39	40.0	1.0	0.7-1.3
Enlisted flight engineers	21	28.4	0.7	0.5-1.1
Administrative officers	2	2.5	0.8	
Enlisted ground personnel	56	49.1	1.1	0.9-1.5

b) Cancer

Military Occupation	Observed	Expected	SMR	95% CI
Pilots and navigators	10	11.5	0.9	0.4-1.6
Enlisted flight engineers	8	7.9	1.0	0.5-1.9
Administrative officers	1	0.6	1.7	
Enlisted ground personnel	11	13.3	0.8	0.4-1.4

c) Circulatory disease

Military Occupation	Observed	Expected	Ratio	Interval
Pilots and navigators	12	13.0	0.9	0.5-1.6
Enlisted flight engineers	3	9.2	0.3	
Administrative officers	0	1.4		
Enlisted ground personnel	24	16.1	1.5	1.0-2.2

**Discussion**

The cumulative all-cause mortality experience of Ranch Hand veterans was not different from that expected; SMR=1.0. Overall, cause-specific mortality was not different from that expected with regard to deaths caused by accidents, cancer or circulatory system diseases, but we found an increase in digestive disease deaths (SMR=1.8, 95% CI 0.9-3.2) and an increase in deaths due to circulatory system diseases in enlisted ground personnel (SMR=1.5, 95% CI 1.0-2.2), the subgroup with the highest dioxin levels. Most of the increase in digestive disease deaths was caused by chronic liver disease and cirrhosis and half of the increase in circulatory disease deaths was caused by atherosclerotic heart disease.

**Reference**

1. Michalek, JE, Ketchum, NS and Akhtar FZ. Post-service mortality of Air Force veterans occupationally exposed to herbicides in Vietnam: 15 year follow-up. *Am. J. Epidemiol.* (In press).