

MORTALITY IN US AIR FORCE VETERANS OF OPERATION RANCH HAND

Pavuk M¹, Ketchum NS², and Fox KA³

¹SPecpro Inc., San Antonio, TX 78216, USA; ²Air Force Research Laboratory, Brooks City-Base, TX 78235, USA; ³USAF School of Aerospace Medicine, Brook City-Base, TX 78235, USA

Introduction

Studies of the post-service mortality experience of Vietnam veterans¹⁻⁶ have given mixed but mostly negative results. No increase or deficit in all causes mortality were reported,^{1,4} as were no increases in the relative risk of death from diseases of circulatory system.¹⁻³ An increased risk of death due to digestive diseases,^{1,3} non-significant increases in the risk of death from cancer overall¹ and non-Hodgkin's lymphoma,⁶ or no increases due to cancer were observed.² In contrast, several highly exposed chemical workers studies found increases in the risk of death due to cancer^{7-8, 10-12} or circulatory diseases.⁹⁻¹²

The Air Force Health Study (AFHS) is a prospective epidemiological study of the health, mortality, and reproductive outcomes of veterans of Operation Ranch Hand, the unit responsible for aerial spraying herbicides in Vietnam from 1962 to 1971.¹³ The study began in 1982 and concludes in 2006. This report updates our earlier mortality findings¹⁴⁻¹⁵ by summarizing current all-cause and cause-specific post-service mortality in veterans of Operation Ranch Hand through December 31, 2003.

Methods

We contrast cumulative Ranch Hand (N=1,263) post-service mortality through December 31, 2003 with that of a Comparison population of 19,080 Air Force veterans who flew or serviced C-130 cargo aircraft in Southeast Asia between 1962 and 1971. All of the 20,343 veterans studied were male. Comparison veterans were stationed throughout Southeast Asia, did not spray herbicides, and were demographically similar to Ranch Hand veterans. Twenty-two Ranch Hand and 109 Comparison veterans were killed in action in Vietnam and were excluded from the analysis. The numbers of veterans at risk are summarized in Table 1 by military occupation - pilots and navigators, administrative officers, enlisted flight crew, and enlisted ground crew.

Table 1. Number of veterans by exposure group and military occupation among US Air Force veterans who served in Southeast Asia from 1962 to 1971.

Military Occupation	Ranch Hand	Comparison
Pilots and navigators	441	5,243
Administrative officers	26	284
Enlisted flight crew	209	2,828
Enlisted ground crew	587	10,725
All personnel	1263	19,080

In analysis that included all 20,343 veterans, we computed the relative risk (RR), a 95% confidence interval (CI) for the RR, and a p-values using a proportional hazards model with adjustment for birth year and military occupation. We did not adjust for race because there were too few Blacks (6.2% of the Ranch Hand cohort) to permit adjustment. We classified underlying causes of death in accordance with the rules and conventions of the 9th revision of the International Classification of Diseases (ICD-9). Analysis with serum dioxin measurement were restricted to 2,551 veterans who attended at least one physical examination (Ranch Hand: N=1,027, Comparison:

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N=1,524). These analyses were adjusted for the potential risk factors. Most veterans had their dioxin levels measured in parts per trillion (ppt) on a lipid weight basis in 1987, with additional measurements made in 1992, 1997 and 2002. We assigned each veteran to one of four dioxin exposure categories based on his cohort (Ranch Hand, Comparison), dioxin concentration, and half-life extrapolated initial dioxin concentration. Ranch Hand veterans with dioxin levels exceeding 10 ppt had their initial dioxin at the end of service in Vietnam estimated using a first-order kinetics model with a constant half-life of 7.6 years. Four dioxin exposure categories were labeled as: "Comparison" – Comparison veterans, "Background" – Ranch Hand veterans with a dioxin not exceeding 10 ppt, "Low" – Ranch Hand veterans with a dioxin body burden exceeding 10 ppt and an initial dioxin less than or equal to 117.6 ppt (the median initial dioxin in this subgroup); and "High" – Ranch Hands with an initial dioxin greater than 117.6 ppt). We report deaths from all causes, cancer and circulatory disease contrasting each of the three Ranch Hand dioxin exposure categories with the Comparison category using proportional hazards models. Survival time for dead veterans was the time in years between the beginning of their tour in Vietnam (Ranch Hands), or qualifying tour in Southeast Asia (Comparisons), and death. For living veterans, survival time was the time, in years, between the beginning of their tour of duty in Vietnam (Ranch Hands), or qualifying tour in Southeast Asia (Comparisons), and 31 December 2003.

Results

Ranch Hand and Comparison cause specific mortality in analysis including all 20,431 veterans is summarized in Table 2. The all-cause relative risk of death was significantly increased (RR=1.25, 95% CI: 1.1, 1.4, $p<0.001$) mostly from increase in diseases of the circulatory system (RR=1.4, 95% CI: 1.1, 1.8, $p=0.001$). The relative risk of death from cancer was not significantly increased. The relative risks of death caused by diseases of the respiratory, digestive and endocrine systems were based on small numbers of Ranch Hand deaths (10, 12 and 7 respectively) and were significantly increased only for endocrine diseases. By military occupation, the relative risk of death among enlisted ground crew was significantly increased for all causes (RR=1.4 95% CI: 1.1, 1.7, $p=0.001$) and for the circulatory system (RR=1.8, 95% CI: 1.3, 2.4, $p<0.001$). No statistically significant increases or decreases were found for officers or enlisted flyers for all cause, circulatory or cancer mortality (data not shown).

Table 2. Cause-specific and all-causes mortality of 20,343 US Air Force veterans who served in Southeast Asia from 1962 to 1971.

Cause of Death (ICD)	Number of Deaths (%)		RR	95% CI	p
	Ranch Hand	Comparison			
All causes (001-969)	240 (19)	2734 (14.3)	1.25	1.1, 1.4	<0.001
Infectious diseases (001-139)	2 (0.2)	29 (0.2)	1.0	0.2, 4.0	0.96
Cancer	68 (5.4)	854 (4.5)	1.1	0.9, 1.4	0.38
Endocrine diseases	7 (0.6)	46 (0.2)	2.2	1.0, 4.9	0.05
Nervous system diseases	2 (0.2)	54 (0.3)	0.5	0.1, 2.1	0.34
Circulatory diseases	89 (7.0)	874 (4.6)	1.4	1.1, 1.8	0.001
Respiratory diseases	10 (0.8)	126 (0.7)	1.1	0.6, 2.1	0.74
Digestive diseases	12 (0.9)	101 (0.5)	1.7	0.9, 3.0	0.10
Ill defined or unknown	10 (0.8)	92 (0.5)	1.8	0.9, 3.4	0.09
Accident	31 (2.4)	370 (1.9)	1.2	0.9, 1.8	0.26
Suicide	5 (0.4)	113 (0.6)	0.7	0.3, 1.6	0.38
Homicide	3 (0.2)	27 (0.1)	1.8	0.5, 5.8	0.36

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In the analysis of veterans that had a valid dioxin measurement and attended at least one physical examination, of the 124 deceased Ranch Hands, 40 died of malignant neoplasm, 50 died of circulatory disease, 8 died of respiratory disease, 5 died of digestive disease, 5 died of endocrine disorders, 2 died of nervous system disease, 1 died of genitourinary disease, 5 died of accidents, 2 committed suicide and 6 died of unknown or ill-defined conditions. All-cause mortality and mortality due to cancer and circulatory diseases, adjusted for risk factors, are summarized in Table 3 by dioxin exposure category. Non-significant increase in the relative risk of death from all causes combined was observed (Background: RR= 1.0, Low: RR= 1.2, High: RR= 1.3; trend=0.07). There was no significant increase in the risk of cancer, but deaths due to circulatory disease were significantly increased in the Low category (RR=1.9, 95% CI 1.1,3.3, p=0.02), and in the High category (RR=2.3, 95% CI 1.3,4.0, p=0.005), resulting in a significant increasing trend (p<0.001).

Table 3. Mortality of 2,551 US Air Force Veterans with dioxin assay results who attended at least one physical examination.

	Number Deaths (%)	Relative Risk ^b	95% CI	P value
All causes				
Comparison	161(10.6)			
Background	51 (11.3)	1.0	0.8, 1.4	0.81
Low	38 (13.2)	1.2	0.8, 1.7	0.35
High	35 (12.1)	1.3	0.9, 2.0	0.12
Cancer				
Comparison	64 (4.2)			
Background	21 (4.6)	1.0	0.6, 1.7	0.95
Low	11(3.8)	0.8	0.4, 1.5	0.42
High	8 (2.8)	0.9	0.4, 1.9	0.74
Circulatory diseases				
Comparison	47 (3.1)			
Background	14 (3.1)	1.0	0.6, 1.9	0.96
Low	18 (6.3)	1.9	1.1, 3.3	0.02
High	18 (6.3)	2.3	1.3, 4.0	0.005

^aAdjusted for military occupation, birth year, smoking, drinking and family history of heart disease.

^bAdjusted for military occupation, birth year, smoking, reaction to sun exposure and eye color.

^cAdjusted for military occupation, birth year, smoking, and family history of heart disease.

Discussion

An evaluation of post-service mortality through December 31, 2003 found an increased relative risk of all causes and circulatory system mortality in all Ranch Hands and in enlisted ground crew, the subgroup with highest dioxin levels. These results were consistent with the last AFHS mortality report,¹⁵ but increases for all Ranch Hands and not only enlisted ground crew were statistically significant in results presented here. No increase in cancer mortality was observed. These analyses that included all 20,343 veterans were adjusted only for age and military occupation. Results for 2,551 veterans with dioxin assay who attended at least one physical examination showed no statistically significant elevated risk of death from all causes in the Low and High dioxin categories. No increased in risk of cancer deaths by dioxin categories was observed, but a significantly increased risk of death due to circulatory disease was observed in the Low (RR=1.9) and High (RR=2.3) categories, resulting in a significant increasing trend

with dioxin ($p < 0.001$) adjusted for age, military occupation, smoking, alcohol consumption, and family history of circulatory disease. Further adjustment for diabetes did not change the direction or the magnitude of risk estimates. These findings support the increased risk of death from circulatory diseases observed in Ranch Hand and Ranch Hand enlisted ground crew in the analysis of all AFHS participants.

The study was limited by relatively small Ranch Hand veterans group sample size, the lack of risk factor measurements in the entire Comparison cohort, and the relatively moderate, compared to industrial cohorts, dioxin body burdens in Ranch Hand veterans. The strengths of this study included a large comparison population demographically similar to the Ranch Hand group, comprehensive determination of the mortality status of all subjects, and serum dioxin levels measured in over 2,500 study veterans enabling assessment of dose-response relationships between dioxin and mortality.

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