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**Health Status of Army Chemical Corps Vietnam Veterans Who Sprayed  
Defoliant in Vietnam**

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Review

## ABBREVIATIONS

BMI	body mass index
CATI	computer assisted telephone interview
CI	confidence interval
IARC	International Agency for Research on Cancer
MOSC	military occupational specialty code
NAS	National Academy of Sciences
NIOSH	National Institute for Occupational Safety and Health
OR	odds ratio
p	probability
ppt	parts per trillion
RR	relative risk
SMR	standardized mortality ratio
TCDD	2, 3, 7, 8–terachlorodibenzo–p–dioxin
VA	Department of Veteran Affairs

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Running head: Army Chemical Corps Vietnam Veterans Health Study

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ABSTRACT

**Background** U.S. Army Chemical Corps veterans handled and sprayed herbicides in Vietnam resulting in exposure to Agent Orange and its contaminant 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD or dioxin). This study examined the long-term health effects associated with herbicide exposure among these Vietnam veterans.

**Methods** A health survey of these 1,499 Vietnam veterans and a group of 1,428 non-Vietnam veterans assigned to chemical operations jobs was conducted using a computer assisted telephone interview system. Exposure to herbicides was assessed by analyzing serum specimens from a sample of 897 veterans for dioxin. Logistic regression analyses were used to estimate the risk of selected medical outcomes associated with herbicide exposure.

**Results** Odds ratios for diabetes, heart disease, hypertension, and chronic respiratory disease were elevated, but not significantly ( $p>0.05$ ) for those who served in Vietnam. However, they were significantly elevated among those Vietnam veterans who sprayed herbicides: diabetes, OR=1.50 (95% CI=1.15-1.95); heart disease, OR=1.52 (1.18-1.94); hypertension, OR=1.32 (1.08-1.61), and chronic respiratory condition, OR=1.62 (1.28-2.05). Hepatitis was associated with Vietnam service, but not with herbicide application.

**Conclusions** Vietnam veterans who were occupationally exposed to herbicide experienced a higher risk of several chronic medical conditions relative to other non-Vietnam veterans. A potential selection bias is of concern. However, there were relatively high participation rates in both the Vietnam and non-Vietnam veteran groups, and the prevalence rates of some of these medical conditions among non-Vietnam veterans were comparable to general populations. Therefore, self-selection factors are considered unlikely to have biased the study results.

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KEYWORDS: Agent Orange, diabetes, dioxin, herbicide, veterans, Vietnam

Word count: 243

For Peer Review

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2 Agent Orange, an herbicide widely used as a defoliant in Vietnam, was a mixture  
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4 of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-  
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6 T) which contained dioxin contaminants. In 1994, with growing concerns for the  
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8 possible long-term health consequences of exposure to Agent Orange contaminated by  
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10 possible long-term health consequences of exposure to Agent Orange contaminated by  
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12 2, 3, 7, 8–terachlorodibenzo–p–dioxin (TCDD), a National Academy of Sciences (NAS)  
13  
14 committee recommended continued follow-up of the Air Force Ranch Hand cohort as  
15  
16 well as a study of the health of members of the Army Chemical Corps who served in  
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18 Vietnam [IOM, 1994]. Air Force Ranch Hand personnel were responsible for aerial  
19  
20 spraying of herbicides from fixed wing aircraft in Vietnam from 1962-1971, while  
21  
22 members of the Army Chemical Corps were responsible for spraying of herbicide  
23  
24 around the perimeters of base camps and aerial spraying from helicopters in Vietnam.  
25  
26 Approximately 2/3 of all herbicide used in Vietnam was Agent Orange and other  
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28 phenoxyherbicides which contained trace amounts of dioxin. The extent of herbicide  
29  
30 exposure of the Army Chemical Corps personnel who served in Vietnam was thought to  
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32 be similar to those of the Ranch Hand cohort who were involved with the fixed wing  
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34 aircraft spraying [Kahn et al., 1988; IOM, 1994].  
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40 The primary objective of the health survey was to determine the long-term  
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42 health consequences of Agent Orange exposure among Army Vietnam veterans who  
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44 were occupationally exposed to the herbicide.  
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## 49 MATERIALS AND METHODS

### 50 Selection of Study Subjects:

51  
52 Potential study subjects for the Army Chemical Corps Study were identified from  
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54 three separate sources: 1) morning reports of Army Chemical Corps detachments  
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56 assigned to Vietnam between 1966 and 1971, 2) military personnel records maintained  
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2 by the Defense Manpower Data Center of Army personnel who were on active duty  
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4 between 1971 and 1974 with a military occupation specialty code (MOSC) indicating  
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6 chemical operations, and 3) class rosters of those Army personnel who attended the  
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8 Army Chemical School, Fort McClellan, Alabama, during the Vietnam era, 1965-1973  
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10 [Kang et al., 2001; Dalager and Kang, 1997]. Military personnel records of all potential  
11  
12 study subjects were retrieved from the National Personnel Records Center in St. Louis,  
13  
14 MO and reviewed to identify men from that group who served on active duty in the US  
15  
16 Army for a minimum of 18 months during the Vietnam era. The study group was  
17  
18 selected to include those men whose permanent tour of duty included service in  
19  
20 Vietnam reflecting any chemical operation duties between July 4, 1965 and March 28,  
21  
22 1973. The non-Vietnam veteran comparison group consisted of men who had similar  
23  
24 characteristics as the Vietnam group with respect to branch of service, time period of  
25  
26 service and military occupation with the exception that their permanent tours of duty did  
27  
28 not include service in Vietnam. A total of 2,872 Vietnam veterans and 2,737 non-  
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30 Vietnam veterans were identified as potential study participants. Of these, veterans who  
31  
32 were known to be deceased as of December 1998 and those who participated in an  
33  
34 earlier pilot study were excluded from this study, which resulted in 2,247 Vietnam and  
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36 2,242 non-Vietnam veterans who were targeted for the study.  
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#### 45 Data collection:

46  
47 A computer assisted telephone interview (CATI) system was used for the data  
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49 collection because of its efficiency. Information on the veterans' military and civilian  
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51 occupational exposures, chronic health conditions, and measures of functional  
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53 impairment and limitation of activity was collected during the telephone interviews in  
54  
55 1999-2000. Military personnel records were used to supplement and validate self-  
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2 reported interview data to the extent feasible. For a selected health outcome (diabetes),  
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4 medical and hospital records were collected to document further the self-reported data.  
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7 In order to assess exposure to herbicides, serum dioxin concentration was  
8  
9 measured for 795 of 1084 (73%) Vietnam veterans and 102 of 157 (65%) non-Vietnam  
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11 veterans who were invited to participate in the serum dioxin study. An unequal number  
12  
13 of blood specimens was analyzed for the Vietnam veterans and non-Vietnam veterans  
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15 for two main reasons: 1) because of the high cost of the laboratory test (approximately  
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17 \$1,000 per specimen), only 1,000 specimens could be budgeted for analysis; and 2)  
18  
19 given the much smaller variance of TCDD values among non-Vietnam veterans  
20  
21 compared to Vietnam veterans observed in the previous study [Kang et al., 2001], it was  
22  
23 concluded that adequate statistical power could be obtained even with substantially  
24  
25 different sample sizes in the two groups. This approach allowed us to maximize the  
26  
27 limited resources and to analyze as many as a half of survey participants who were  
28  
29 potentially exposed to TCDD in Vietnam. Blood specimens were collected in 1999-2000  
30  
31 at individuals' homes by trained medical technicians using a collection device and  
32  
33 storage containers provided by the participating CDC laboratory. Serum specimens  
34  
35 were shipped to the CDC laboratory by overnight delivery service in accordance with  
36  
37 the CDC protocol. The CDC lab analyzed the serum specimens for 2, 3, 7, 8-TCDD  
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39 using the analytical protocol published elsewhere [Patterson et al., 1987]. All laboratory  
40  
41 analyses were blinded to the Vietnam service experience and the reported herbicide  
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43 exposures of the blood donors. The study protocol was approved by the Washington  
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45 DC VA Medical Center Institutional Review Board and each individual gave signed  
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47 informed consent for blood specimens.  
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56 Health outcomes:  
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2 The health interview study collected self-reported data on selected chronic  
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4 medical conditions diagnosed by medical doctors. These conditions included diabetes,  
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6 hepatitis (all types combined since veterans could provide few specifics), any type of  
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8 heart condition (including coronary heart disease, hardening of the arteries, angina  
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10 pectoris, myocardial infarction or heart attack), all cancer and leukemia (excluding non-  
11  
12 melanoma skin cancers), all chronic respiratory diseases (such as chronic bronchitis,  
13  
14 asthma, emphysema, pleurisy, or tuberculosis), and hypertension for which a doctor  
15  
16 prescribed medication. The measures of general health and functional status were  
17  
18 obtained using two items from the Medical Outcomes Study 36-Item Short Form (SF-  
19  
20 36), which is a well standardized and widely used instrument to assess health-related  
21  
22 quality of life [Ware, 1993]: 1) self-assessed general health status and 2) limitations of  
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24 work due to health problems. The possibility of over-reporting of a chronic condition by  
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26 the exposed veterans was evaluated by a review of medical records for diabetes, and  
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28 by a comparison of reported prevalence rates of selected chronic conditions in relation  
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30 to serum TCDD levels among the exposed veterans.  
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#### 37 Statistical analysis:

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39 As a measure of association between exposure and the risk of selected  
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41 diseases, the odd ratio (OR) and 95% confidence interval (CI) were calculated using a  
42  
43 multivariate logistic regression model with adjustment for covariates [SAS, 1999]. The  
44  
45 regression coefficients obtained through logistic regression indicated the effect of an  
46  
47 individual variable on the log odds of the outcome event with all the remaining variables  
48  
49 held constant. For a cohort study, this is often referred to as the incidence odds ratio.  
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51 Because the risk of disease is relatively small over the period of observation, the values  
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53 of the odds ratio should approximate that of the risk ratio [Kelsey, 1986].  
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2 Interview data were used to examine selected disease outcomes and to provide  
3 demographic and military data used as covariates in the logistic modeling. Final logistic  
4 models included the following covariates: Vietnam service (yes=1, no=0), race  
5 (white=0, nonwhite=1), body mass index (BMI) (normal, <25.0; overweight, 25.0-29.9;  
6 obese, ≥ 30.0), military rank (enlisted or officer), current cigarette smoking (yes=1,  
7 no=0), age at time of interview, and a history of spraying herbicides in the military  
8 (yes=1, no=0). Frequency and duration of herbicide exposure were also examined in  
9 the logistic models for major health outcomes. Since the inclusion of frequency and/or  
10 duration of herbicide exposure in the logistic models did not significantly change the  
11 results, they were not included in the final model.  
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## 28 RESULTS

### 29 Demographic and military characteristics:

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32 Of the 4,119 veterans whose current residences could be determined for the study,  
33 1,499 Vietnam veterans and 1,428 non-Vietnam veterans completed the telephone  
34 interview resulting in an interview rate of 72.9 % and 69.2 %, respectively. Table I  
35 provides the military and demographic characteristics of the 2927 veterans who  
36 completed the telephone interview by their Vietnam service status. There were small  
37 but statistically significant differences ( $p < 0.05$ ) between the Vietnam and non-Vietnam  
38 veterans who completed the interview with respect to selected characteristics. Because  
39 of these differences, adjustment for these covariates was made in the multivariate  
40 analyses.  
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### 53 Vietnam service and chronic health conditions:

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56 Table II shows the prevalence of selected chronic health conditions among 1,499  
57 Vietnam veterans and 1,428 non-Vietnam veterans who participated in the study. The  
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2 odds ratios, adjusted for age, race, BMI and current smoking status, were significantly  
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4 elevated for hepatitis, all cancer, respiratory problems, “poor” current health status, and  
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6 work limitation among Vietnam veterans as compared to non-Vietnam veterans. The  
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8 other outcomes such as diabetes, heart conditions, and hypertension were also  
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10 elevated, but were not statistically significant ( $p > 0.05$ ).  
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#### 16 Serum TCDD concentrations and a history of spraying herbicides:

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18 As shown in Table III, analyses of serum samples for TCDD concentrations  
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20 among the Vietnam veterans revealed a significant difference in mean serum TCDD  
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22 concentrations by a self-reported history of spraying herbicides while in Vietnam ( $p < 0.$   
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24 001). Because a history of Agent Orange exposure reported by a veteran was  
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26 supported by a serum TCDD level, a veteran’s reported history of spraying Agent  
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28 Orange in Vietnam was used for the purpose of classifying veterans into an exposure  
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30 status.  
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#### 35 Herbicide exposure and chronic health conditions among Vietnam veterans:

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37 Table IV shows the prevalence and adjusted odds ratios for selected health  
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39 conditions among Vietnam veterans who reported a history of spraying herbicides  
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41 (n=662) relative to Vietnam veterans who did not report a history of spraying herbicides  
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43 (n=811). The prevalence of each of the outcomes presented was greater among the  
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45 Vietnam veteran sprayers than among the Vietnam veteran non-sprayers. Adjustment  
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47 for age, race, BMI, military rank, and smoking status in a multiple logistic model showed  
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49 a significantly increased risk for diabetes, heart conditions, chronic respiratory  
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51 conditions, hypertension requiring medication, and self-reported poor health status.  
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55 Adjusted relative risks for all cancers and for hepatitis, which were significantly elevated  
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2 with Vietnam service compared to non-Vietnam service, were not statistically elevated  
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4 when comparing herbicide spray status among veterans serving in Vietnam.  
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7 Logistic regression analysis of chronic health conditions:  
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9 To evaluate the effects of both Vietnam service and a history of spraying  
10 herbicides while in the military, these covariates were examined in a multiple logistic  
11 regression model that also included the other covariates from the earlier models. Table  
12 V shows the adjusted odds ratios for each covariate for each selected disease  
13 condition. The first page of Table V shows the relative risks associated with the  
14 covariates from the logistic models for diabetes, heart disease, hypertension, and  
15 respiratory diseases. There was no statistically significant effect due to Vietnam service  
16 in general for each of these four conditions when adjustments were made for the other  
17 covariates. However, each of these four conditions was significantly associated with a  
18 history of spraying herbicide: diabetes OR=1.50(95% CI=1.15-1.95); heart disease  
19 OR=1.52 (95% CI=1.18-1.94); hypertension OR=1.32(95% CI=1.08-1.61); and chronic  
20 respiratory disease OR=1.62(95% CI=1.28-2.05). There was a significant association of  
21 non-white race with diabetes and hypertension. BMI was significantly associated with  
22 diabetes, heart disease, and hypertension, but not with respiratory disease. Cigarette  
23 smoking was significantly associated with heart disease and respiratory disease. Being  
24 an officer was inversely associated with each of these four conditions. Of those study  
25 participants who had diabetes, 56 % had hypertension and 28 % had heart disease.  
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49 The balance of Table V shows the results of the logistic analyses for cancer,  
50 hepatitis, poor health status, and health problems that limit the kind and amount of work  
51 that can be done. When controlling for all the covariates, the category of all cancer was  
52 only significantly associated with increasing age (OR=1.11, 95% CI=1.08-1.13). The  
53 risk for all cancers associated with Vietnam service or a history of spraying herbicide  
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2 was slightly elevated but not statistically significant. Hepatitis was significantly  
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4 associated with Vietnam service, non-whites, and regular smoking but not with a history  
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6 of spraying herbicide. Self perceived poor health was significantly associated with  
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8 Vietnam service, non-whites, regular smoking, and a history of spraying herbicide.  
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10 Likewise, self reported functional limits were significantly associated with Vietnam  
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12 service, age and a history of spraying herbicide.  
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#### 18 Documentation of a self-reported chronic health condition:

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20 A total of 362 veterans reported having diabetes. Overall, 79.2% (n=287) of reported  
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22 conditions were documented in individual medical records (n=128), Veterans Affairs  
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24 hospital discharge records (n=82), and/or use of prescription medications for diabetes  
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26 (n=77). The documentation rate was not significantly different between the Vietnam  
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28 veterans and non-Vietnam veteran controls. Of the 75 non-confirmed conditions, 36  
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30 were due to not having the medical records for review for various reasons, and 39 were  
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32 due to the absence of confirmatory information in the records received from a medical  
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34 facility. The reasons for not having the records may include: 1) veterans' refusal to mail  
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36 in a written informed consent form, 2) delay in sending in the signed form in time for the  
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38 study, 3) records not found by the medical facility, and 4) delay in sending in the record  
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40 by a medical facility. Reasons for non-confirmation may include an over-reporting by a  
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42 veteran or not having obtained relevant medical records for review.  
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#### 51 Evaluation of reporting bias:

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53 The possibility of over-reporting of chronic health conditions was evaluated  
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55 among 357 Vietnam veterans who reported spraying herbicide and subsequently  
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57 donated blood samples for dioxin measurement. At the time of the health interview,  
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2 which preceded the collection of the blood samples by several weeks, the concentration  
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4 of serum dioxin was not known to either the interviewer or the veteran. Nonetheless,  
5  
6 those who were found to have a higher level of serum dioxin (TCDD concentrations at  
7  
8 or above median level for the group) reported higher prevalence of these chronic health  
9  
10 conditions than those who had lower serum dioxin level (TCDD concentrations below  
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12 the median for the group) ( $p < 0.05$ , the Wilcoxon signed-ranks test) [Lehmann, 1975]  
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14 (Table VI). There was a significant association among selected medical conditions and  
15  
16 objective measure of exposure to herbicides (i.e., serum dioxin levels), which is  
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18 inconsistent with a suggestion of a random over-reporting of a chronic health condition  
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20 by Vietnam veterans who reported spraying herbicides.  
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## 28 DISCUSSION

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30 The Army Chemical Corps is one of the few groups of Vietnam veterans who  
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32 were occupationally exposed to phenoxyherbicide and its contaminant TCDD. It is  
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34 considered, therefore, an appropriate group for the study of long-term health effects of  
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36 phenoxyherbicide exposure [IOM, 1994; IOM, 2001; IOM, 2003]. In the current study, we  
37  
38 could not measure serum dioxin concentrations for all 2,927 study participants because  
39  
40 of the expense of the laboratory tests. Alternatively, we measured the serum TCDD  
41  
42 concentrations in a sample of 795 Vietnam veterans and 102 non-Vietnam veteran  
43  
44 controls and demonstrated that those veterans who reported spraying herbicides in  
45  
46 Vietnam had a significantly higher concentration of dioxin in their serum than those who  
47  
48 did not serve in Vietnam and who never sprayed herbicides. This finding replicated the  
49  
50 results from the earlier feasibility study [Kang et al., 2001]. In both the feasibility study  
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52 and the current study, a self-reported history of herbicide spraying in Vietnam was found  
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2 to be a good surrogate measure of dioxin exposure that could be applied to all the Army  
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4 Chemical Corps veterans who completed the health interview survey.  
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7 We observed statistically significant associations between a reported history of  
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9 spraying herbicide while in the military and the self-reported history of physician  
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11 diagnosed diabetes, heart disease, hypertension, and chronic respiratory diseases  
12  
13 among this cohort of Army Chemical Corps personnel. These findings were  
14  
15 independent from any Vietnam service effect. The significant association between  
16  
17 diabetes and a history of spraying herbicides is consistent with data from the Air Force  
18  
19 Ranch Hand Study [Henriksen et al., 1997]. Among the Air Force Ranch Hand  
20  
21 personnel, dioxin exposure increased risk of diabetes and decreased time-to-onset of  
22  
23 diabetes. A study of industrial cohorts heavily exposed to dioxin (IARC cohorts) also  
24  
25 reported a high risk of diabetes among dioxin-exposed workers, especially those with 10  
26  
27 or more years of latency and duration of exposure [Vena et al., 1998]. However, a  
28  
29 recent analysis of the combined NIOSH [Steenland et al., 1999] and Ranch Hand data  
30  
31 showed little overall evidence that the exposed individuals were at higher risk of  
32  
33 diabetes or abnormal fasting glucose concentration than non-exposed individuals  
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35 [Steenland et al., 2001]. The study did report that there was an increasing trend in  
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37 prevalence of diabetes with increased serum TCDD concentrations among the Ranch  
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39 Hand population.  
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47 The positive finding of an association between phenoxyherbicide exposure and  
48  
49 circulatory diseases (including hypertension requiring medication) is also consistent with  
50  
51 the results reported in other occupational/community cohorts. An increased risk of death  
52  
53 due to heart diseases was reported in the expanded IARC international cohorts  
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55 (RR=1.7, 95% CI=1.2-2.3), the NIOSH occupational cohort (SMR=1.1, 95%CI=1.0 -1.2),  
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57 enlisted Ranch Hand personnel, 15-year follow-up (SMR=1.5, 95%CI=1.0-2.2), 20-year  
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2 follow-up (RR=1.7, 95%CI=1.2-2.4), and the Seveso community cohort (heart disease  
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4 RR=3.0, 95%CI=1.2-7.3; hypertensive disease RR=3.6, 95%CI=1.2-11.4) [(Vena et al.,  
5  
6 1998; Steenland et al., 1999; Michalek, et al., 1998; Ketchum and Michalek, 2005;  
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8 Pesatori et al., 1998)]. In animal studies, dioxin was reported to cause disturbances in  
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10 lipid metabolism and cardiovascular functions, and morphologic changes in peripheral  
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12 vessels [Schiller et al., 1985; Hermansky et al., 1988; Kociba et al., 1978]. In a group of  
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14 12 former workers heavily exposed to dioxin more than 35 years ago, nine had elevated  
15  
16 levels of triglycerides and/or cholesterol, six were treated for hyperlipidemia, six with  
17  
18 hypertension, four with ischemic heart disease, and two still presented with chloracne.  
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20 The dioxin levels of these 12 persons were correlated with the highest level of  
21  
22 triglycerides (p=0.02) and cholesterol (p=0.01) [Pelclova et al., 2002]. The results of this  
23  
24 study should be considered tentative, however, because of the small sample size  
25  
26 (n=12) and the lack of a comparison group in the study. Another study of 133 workers  
27  
28 at municipal-waste incinerator plants in Taiwan showed significant variation in  
29  
30 cholesterol by a dichotomous measure of TCDD. Workers with serum TCDD  
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32 concentrations above the median had higher average cholesterol and were more likely  
33  
34 to have cholesterol above 220 mg/dL (p< 0.05). However, the relationship was not  
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36 statistically significant when TCDD was measured by tertiles, quartiles or as a  
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38 continuous variable [Hu et al., 2003].  
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47 An association between dioxin exposure and the risk of non-malignant lung  
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49 diseases has been rarely reported. In the 15-year period after the Seveso accident,  
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51 increased deaths from chronic obstructive pulmonary disease (RR=3.7, 95% CI=1.4-  
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53 9.9) were found in the male residents of the area where dioxin contamination was the  
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55 highest (Zone A) [Pesatori et al., 1998]. Reporting of poor health and functional  
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57 limitation by herbicide sprayers is consistent with an observation among the 158 BASF  
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2 chemical plant workers accidentally exposed to dioxin in 1953. Their overall illness rates  
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4 were positively correlated with serum dioxin concentrations and the increased illness  
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6 rates were observed throughout the 36 year period and not just in the early years after  
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8 the exposure [Zober et al., 1994].  
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11 Our findings among the Army Chemical Corps Vietnam veterans who sprayed  
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13 herbicide are not always supported by other studies. Notably, the NIOSH medical study  
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15 of workers exposed to chemicals contaminated with dioxin did not find elevated  
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17 prevalence of chronic bronchitis, COPD, cardiovascular diseases including  
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19 hypertension, and abnormal pulmonary function parameters [Sweeney et al., 1997]. A  
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21 mortality update of the same NIOSH cohort, however, reported an increased overall  
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23 cancer mortality (SMR=1.13, 95%CI=1.02-1.25) and ischemic heart disease (SMR=1.1,  
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25 95%CI=1.0 -1.2). While statistically significant trends for cancer (15-year lag time) and  
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27 heart disease (no lag time) with increasing exposure were also reported, diabetes  
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29 showed a negative exposure-response trend [Steenland et al., 1999].  
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35 The lack of a significant association between cancer and herbicide exposure  
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37 observed in the study may be due to many reasons including the study design, the  
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39 statistical power and the exposure level. A prevalence study may not be the best study  
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41 design for a rare disease with a short survival time, such as cancer. Also, the number  
42  
43 of prevalent cancer cases was too small, which contributed to the low statistical power  
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45 of the study. When a comparison was made between Vietnam veterans and non-  
46  
47 Vietnam veteran controls, the risk for all cancer combined was significantly higher  
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49 among Vietnam veterans (OR=1.46, 95%=1.02-2.10). However, when a comparison  
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51 was among a subgroup of Vietnam veterans, although those who sprayed herbicide  
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53 demonstrated a higher prevalence of cancer (8.6%) than non-sprayers (6.2%) or non-  
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55 Vietnam veterans (3.7%), the risk was not statistically significant (OR=1.36,  
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2 95%CI=0.91-2.04). A site-specific analysis was precluded by the small numbers of  
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4 specific cancer types. There were only 7 lung cancer cases observed in the entire  
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6 study population of Army Chemical Corps personnel. In addition, the level of dioxin  
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8 exposure of Vietnam veterans who sprayed Agent Orange is considered only a fraction  
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10 of the amount experienced by industrial workers who manufactured phenoxyherbicides  
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12 [Mocarelli et al., 1991]. While no increase in cancer mortality or morbidity was reported  
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14 [Mocarelli et al., 1991]. While no increase in cancer mortality or morbidity was reported  
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16 among the Ranch Hand personnel after 5 and 15 years of follow-up [Michalek et al.,  
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18 1990; Michalek et al., 1998; Ketchum et al., 1999], a more recent study of 1482 Air  
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20 Force veterans who served in Southeast Asia indicated an increasing cancer risk with  
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22 TCDD (RR=1.6, 95%CI=1.2-2.2) [Pavuk et al., 2005].  
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26 Another limitation of this analysis was the reliance on self-reported data for  
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28 health outcomes. As in any survey, the possibility of recall bias is of concern. We  
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30 evaluated this possibility by two different methods: medical records review and analysis  
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32 of a reported health outcome by dioxin body burden. In reviewing medical records for  
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34 362 veterans who reported having physician diagnosed diabetes, we were able to  
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36 document 79.2% of reported cases. More importantly, the documentation rate was  
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38 almost the same between Vietnam veterans and non-Vietnam veterans. Furthermore,  
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40 among the 357 Vietnam veterans who reported spraying herbicide, there was a  
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42 consistent pattern of a higher prevalence of certain medical conditions in the “High”  
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44 exposure group than in the “Low” exposure group. At the time of the survey, although  
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46 all reported having sprayed herbicides in Vietnam, neither the interviewer nor the  
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48 veteran knew the concentration of serum dioxin which was the basis of classifying the  
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50 respondents into two exposure groups.  
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57 A potential selection bias is of concern in this survey. The effects of selection bias  
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59 on measures of association (e.g., relative risk, or odds ratio) depend on both the size of  
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2 the non-participant group and its specific characteristics. If the participation rates differ  
3 only by exposure status (e.g., Vietnam service), or only by outcome status (e.g.,  
4 presence of a chronic health condition), the value of the relative risk (or odds ratio) will  
5 remain unbiased. However, if the participation rates vary by specific combinations of  
6 exposure and outcome, it may render a significant impact on the study results. For  
7 example, if a group of Vietnam veterans with hypertension is more (or less) likely to  
8 participate in the study than a group of non-Vietnam veterans with the same condition,  
9 the study results, i.e., estimates of odds ratio, are likely to be biased. Given the  
10 relatively high participation rates by both groups (Vietnam veterans, 79.2%; non-  
11 Vietnam veterans, 69.2%), absence of direct evidence of differential participation rates  
12 by a combination of exposure status and disease outcome, and a similarity of the  
13 prevalence rate of hypertension or diabetes among non-Vietnam veterans to other  
14 comparable general populations, we considered a significant selection bias was unlikely  
15 to have contributed to the study results. The CDC Health Data for 1997-2003 indicates  
16 that 36% and 10% of US males aged 45 to 64 have confirmed hypertension and  
17 diabetes, respectively (source: NHANES). The corresponding self reported data for non-  
18 Vietnam veterans in our study are 30% and 12%, respectively.

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43 A major strength of the study is in the selection of a study group which included a  
44 sample of Vietnam veterans with documented occupational exposure to herbicide. One  
45 of many limitations of studying the long-term health consequences of herbicide  
46 exposure in Vietnam had been the difficulty in identifying a large number of Vietnam  
47 veterans with documented exposure. In this study, the exposure status of veterans was  
48 carefully characterized by a combination of military occupational history recorded in  
49 personnel documents and measurement of 2,3,7,8-TCDD in serum for 30% of the study  
50 participants. Another strength is the study design which included a veteran control  
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2 group that was similar to the study group except for service in Vietnam. Having the non-  
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4 Vietnam control group enabled us to identify the health outcomes associated with  
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6 Vietnam service in general and with the outcomes associated with herbicide exposure in  
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8 particular.  
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11 In summary, almost three decades after Vietnam service, U.S. Army veterans  
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13 who were occupationally exposed to phenoxyherbicide in Vietnam experienced  
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15 significantly higher risks of diabetes, heart disease, hypertension and non-malignant  
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17 lung diseases than other veterans who were not exposed to herbicides. The risk of all  
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19 cancers combined among these veterans was increased but it was not statistically  
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21 significant.  
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**REFERENCES**

1. Dalager N, Kang H. 1997. Mortality among Army Chemical Corps Vietnam veterans. *Am J Indust Med* 31:719-726.
2. Henriksen G, Ketchum N, Michalek J, Swaby JA. 1997. Serum dioxin and diabetes mellitus in veterans of Operation Ranch Hand. *Epidemiology* 8:252-258.
3. Hermansky S, Holcslaw T, Murray W, Markin R, Stohs S. 1988. Biochemical and functional effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) on the heart of female rats. *Toxicol Appl Pharmacol* 95:175-184.
4. Hu SW, Cheng TJ, ChangChien GP, Chan CC. 2003. Association between dioxins/furans exposures and incinerator workers' hepatic function and blood lipids. *J Occup Environ Med* 45:601-608.
5. Institute of Medicine. Veterans and Agent Orange. 2003. Update 2002. Washington, DC: National Academy Press.
6. Institute of Medicine, Veterans and Agent Orange. 2001. Update 2000. Washington, DC: National Academy Press.
7. Institute of Medicine, Veterans and Agent Orange. 1994. Health effects of herbicides used in Vietnam. Washington, DC: National Academy Press.
8. Kahn PC, Gochfeld M, Nygren M, Hansson M, Rappe C, Velez H, Gjent-Guenther T, Wilson, WP. 1988. Dioxins and dibenzofurans in blood and adipose tissue of Agent Orange-exposed Vietnam veterans and matched controls. *JAMA* 259:1661-1667.
9. Kang H, Dalager N, Needham L, Patterson DG, Matanoski GM, Kanchanaraksa S, Lees P. 2001. U.S. Army Chemical Corps Vietnam veterans health study: preliminary results. *Chemosphere* 43: 943-949.

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10. Kelsey J, Thompson W, Evans A. 1986. *Methods in Observational Epidemiology*: New York, Oxford University Press 36-38.
11. Ketchum N, Michalek J. 2005. Post service mortality of Air Force veterans occupationally exposed to herbicide during the Vietnam War: 20-year follow-up results. *Mil Med* 170:406-413.
12. Ketchum N, Michalek J, Burton E. 1999. Serum dioxin and cancer in veterans of operation Ranch Hand. *Am J Epidemiol* 149:630-639.
13. Kociba R, Keyes D, Beyer J, Carcon R, Wade C, Dittenher D, Kalnins R, Prauson L, Park, C, Barnar S, Hummel R, Humiston C. 1978. Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. *Toxicol Appl Pharmacol* 46:279-303.
14. Lehmann E. *Nonparametrics: 1975. Statistical Methods Based on Ranks*: San Francisco, CA, Holden-Day Inc. 125.
15. Michalek J, Ketchum N, Akhtar F. 1998. Postservice mortality of US Air Force veterans occupationally exposed to herbicides in Vietnam: 15-year follow-up. *Am J Epidemiol* 148:786-792.
16. Michalek J, Wolfe W, Miner J. 1990. Health status of Air Force veterans occupationally exposed to herbicides in Vietnam, II. Mortality. *JAMA* 264:1832-1836.
17. Mocarelli P, Needham L, Marocchia A, Patterson DG Jr, Brambilla P, Gerthoux PM, Meazza L, Carreri V. 1991. Serum concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin and test results from selected residents of Sevaso, Italy. *J Toxicol Environ Health* 32:357-366.

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18. Patterson D, Hampton L, Lapeza CR Jr, Belser WT, Green V, Alexander L. Needham LL. 1987. High resolution gas chromatographic/high resolution mass spectrometer analysis of human serum on a whole-weight and lipid basis for 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Anal Chem* 59:2000-2005.
19. Pavuk M, Michalek J, Schecter A, Ketchum N, Akhtar F, Fox K. 2005. Did TCDD exposure or service in Southeast Asia increase the risk of cancer in Air Force Vietnam veterans who did not spray Agent Orange? *J Occup Environ Med* 47:335-342.
20. Pelclova D, Fenclova Z, Preiss J, Prochazka B, Dubska Z, Okrouhlik B, Lucas E, Urban P. 2002. Lipid metabolism and neuropsychological follow-up study of workers exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Int Arch Occup Environ Health* 75 Suppl 1:S60-S66.
21. Pesatori AC, Zocchetti C, Guercilena S, Consonni D, Turrini D, Bertazzi PA. 1998. Dioxin exposure and non-malignant health effects: a mortality study. *Occup Environ Med* 55:126-131.
22. SAS Institute Inc. 1999. SASOnlineDoc® . Version 8. Cary NC: SAS Institute Inc.
23. Schiller C, Adcock C, Moore R, Walden R. 1985. Effect of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and fasting on body weight and lipid parameters in rats. *Toxicol Appl Pharmacol* 81:356-361.
24. Steenland K, Piacitelli L, Deddens J, Fingerhut M, Chang L. 1999. Cancer, heart disease, and diabetes in workers exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *J Natl Cancer Inst* 91:779-786.
25. Steenland K, Calvert G, Ketchum N, Michalek J. 2001. Dioxin and diabetes mellitus: an analysis of the combined NIOSH and Ranch Hand data. *Occup Environ Med* 58: 641-648.

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26. Sweeney M, Calvert G, England G, Fingerhut M, Halperin W, Piacitelli L. 1997. Review and update of the results of the NIOSH medical study of workers exposed to chemicals contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Teratog Carcinog Mutagen* 17:241-247.
  27. Vena J, Boffetta P, Becher H, Benn T, Bueno de Mesquita HB, Coggon D, Flesch-Janys D, Green L, Kauppinen T, Littorin M, Lynge E, Mathews JD, Neuberger M, Pearce N, Pesatori AC, Saracci R, Steenland K, Kogevinas M. 1998. Exposure to dioxin and nonneoplastic mortality in the expanded IARC international cohort study of phenoxy herbicide and chlorophenol production workers and sprayers. *Environ Health Perspect* 106 Suppl 2:645-653.
  28. Ware J. 1993. Appendix C: Script for personal interview SF-36 administration. In: *SF-36 Health Survey Manuals and Interpretation Guide*. Boston, MA: Nimrod Press.
  29. Zober A, Ott M, Messerer P. 1994. Morbidity follow-up study of BASF employees exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) after a 1953 chemical reactor incident. *Occup Environ Med* 51:479-86.

**TABLE I. Selected characteristics of the U.S. Army Chemical Corps veterans who completed the telephone interview by Vietnam service status<sup>a</sup>**

Characteristic	Vietnam (n=1,499)		Non-Vietnam (n=1,428)	
	Number	%	Number	%
Rank				
Officer	105	7.0	203	14.2
Enlisted	1394	93.0	1225	85.8
Race				
White	1217	81.2	1235	86.5
Non-White	282	18.8	193	13.5
Age at interview (years)				
<46	0	--	36	2.5
46 – 50	249	16.6	559	39.2
51 – 55	793	52.9	658	46.1
>55	457	30.5	175	12.3
Median Age at Interview	53 years		51 years	
Regular Smoker				
Yes	1071	71.4	858	60.1
No	428	28.6	570	39.9
Body Mass Index				
<25.0	341	22.8	390	27.3
25.0 – 29.9	710	47.4	695	48.7
≥30.0	448	29.9	343	24.0
Herbicide Spraying				
Yes	662	44.2	146	10.2
No	811	54.1	1234	86.4
Unknown	26	1.7	48	3.4

<sup>a</sup> Distribution of military and demographic characteristics were significantly different,  $p < 0.05$  by the Mantel-Haenszel chi-square test.

**TABLE II. Prevalence and adjusted odds ratios for selected health conditions among U.S. Army Chemical Corps veterans associated with Vietnam service**

Conditions	Vietnam (n=1,499)		Non-Vietnam (n=1,428)		Adj Odds Ratio ( 95%C.I.) <sup>a</sup>	
	Number	%	Number	%		
Diabetes	226	15.08	136	9.52	1.16	(0.91-1.49)
Hepatitis	101	6.74	65	4.55	1.85	(1.30-2.64)
Heart Conditions	243	16.21	158	11.06	1.09	(0.87-1.38)
All Cancer <sup>b</sup>	108	7.20	53	3.71	1.46	(1.02-2.10)
All Respiratory Problems <sup>c</sup>	267	17.81	174	12.18	1.41	(1.13-1.76)
Hypertension with Medication	496	33.09	355	24.86	1.06	(0.89-1.27)
Current health is poor	189	12.61	91	6.37	1.68	(1.27-2.22)
Health limits kind & amount of work	245	16.34	135	9.45	1.53	(1.21-1.95)

<sup>a</sup> Adjusted odds ratio and 95% confidence interval for each disease condition associated with Vietnam service was derived from a logistic regression model with adjustment for age, race, body mass index, rank and regular smoking.

<sup>b</sup> The condition category "All Cancer" excludes non-melanoma skin cancers.

<sup>c</sup> The condition category "All Respiratory Problems" includes all non-malignant respiratory conditions.

**Table III. Mean serum 2, 3, 7, 8 – TCDD concentration (range)<sup>a</sup> by service in Vietnam and history of herbicide spraying.**

Vietnam Service	Self-Reported Herbicide Spraying		P-Values <sup>c</sup>
	Yes	No	
Yes	4.3 (0.5-85.8) n <sub>1</sub> = 357 <sup>b</sup>	2.70 (0.6-27.7) n <sub>2</sub> =413	p<0.001
No	3.1 (0.8-9.6) n <sub>3</sub> =9	2.1 (0.4-12.5) n <sub>4</sub> =87	p<0.15

<sup>a</sup> Measured in parts per trillion (ppt), lipid corrected (ng/g serum lipid).

<sup>b</sup> The number of serum samples analyzed for 2,3,7,8-TCDD.

Veterans who did not report on the history of herbicide spraying (n=17) or who provided inadequate blood samples were not included in the table.

<sup>c</sup> Student's t-test was used to compare the geometric means of two exposure groups.

**TABLE IV. Prevalence and adjusted odds ratios for selected health conditions among U.S. Army Chemical Corps Vietnam veterans associated with spraying herbicides**

Conditions	Vietnam Sprayers (n=662)		Vietnam Non-Sprayers (n=811)		Adj	Odds Ratio (95%C.I.) <sup>a</sup>
	Number	%	Number	%		
Diabetes	123	18.58	99	12.21	1.49	(1.10-2.02)
Hepatitis	49	7.40	50	6.17	1.40	(0.92-2.12)
Heart Disease	129	19.49	110	13.56	1.41	(1.06-1.89)
All Cancer <sup>b</sup>	57	8.61	50	6.17	1.36	(0.91-2.04)
All Respiratory Problems <sup>c</sup>	140	21.15	119	14.67	1.57	(1.20-2.07)
Hypertension with Medication	247	37.31	242	29.84	1.26	(1.00-1.58)
Current health is poor	99	14.95	85	10.48	1.57	(1.14 -2.15)
Health limits kind and amount of work	119	17.98	121	14.92	1.17	(0.88-1.55)

<sup>a</sup> Adjusted odds ratio and 95% confidence interval for each disease condition associated with spraying herbicide in Vietnam was derived from a logistic regression model with adjustment for age, race, body mass index, rank and regular smoking.

<sup>b</sup> The condition category "All Cancer" excludes non-melanoma skin cancers.

<sup>c</sup> The condition category "All Respiratory Problems" includes all non-malignant respiratory conditions.

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**TABLE V. Adjusted odds ratios and 95% confidence intervals derived from a logistic regression model, all veterans**

Covariates	Health Conditions			
	Diabetes	Heart Disease	Hypertension	Respiratory Disease
Vietnam Service	1.04(0.80-1.37)	0.96(0.75-1.24)	0.96(0.80-1.17)	1.22(0.95-1.55)
Race, Non-White	2.17(1.66-2.85)	0.94(0.70-1.26)	2.22(1.79-2.75)	0.84(0.63-1.13)
BMI	2.27(1.91-2.70)	1.27(1.09-1.48)	1.66(1.47-1.87)	1.02(0.88-1.18)
Rank, Officer	0.60(0.37-0.95)	0.63(0.41-0.96)	0.72(0.53-0.98)	0.64(0.42-0.96)
Regular Smoker	1.02(0.79-1.32)	1.78(1.37-2.31)	1.13(0.94-1.36)	1.28(1.01-1.62)
Age in Years	1.07(1.05-1.09)	1.07(1.05-1.09)	1.07(1.05-1.09)	1.02(0.99-1.04)
Herbicide Sprayer	1.50(1.15-1.95)	1.52(1.18-1.94)	1.32(1.08-1.61)	1.62(1.28-2.05)

TABLE V. (continued). Adjusted odds ratios and 95% confidence intervals derived from a logistic regression model, all veterans

Covariates	Health Conditions			
	All Cancer <sup>a</sup>	Hepatitis	Poor Health	Functional Limits
Vietnam Service	1.32(0.89-1.95)	1.70(1.17-2.46)	1.48(1.09-2.00)	1.46(1.13-1.89)
Race, Non-White	0.93(0.60-1.45)	1.84(1.27-2.66)	1.64(1.21-2.21)	1.13(0.85-1.51)
BMI	0.80(0.64-1.01)	0.85(0.68-1.07)	0.97(0.81-1.16)	1.09(0.94-1.28)
Rank, Officer	0.81(0.46-1.41)	0.79(0.37-1.67)	0.23(0.10-0.53)	0.72(0.47-1.10)
Regular Smoker	0.83(0.58-1.19)	2.04(1.36-3.07)	1.87(1.36-2.58)	1.21(0.94-1.55)
Age in Years	1.11(1.08-1.13)	0.91(0.87-0.95)	1.03(1.00-1.05)	1.04(1.02-1.06)
Herbicide Sprayer	1.28(0.89-1.85)	1.29(0.90-1.85)	1.68(1.27-2.22)	1.30(1.01-1.66)

<sup>a</sup> The condition category "All Cancer" excludes non-melanoma skin cancers.

**TABLE VI. Prevalence (%) of self-reported health conditions among 357 Vietnam herbicide sprayers stratified by two levels of serum TCDD concentration<sup>a</sup>**

Conditions	Serum TCDD Concentration <sup>b</sup>			
	High (TCDD $\geq$ 2.5ppt)		Low (TCDD $<$ 2.5ppt)	
	Number (n=179)	%	Number (n=178)	%
Diabetes	39	21.8	21	11.8
Heart Conditions	41	22.9	28	15.7
Hypertension with Medication	78	43.6	60	33.7
Respiratory Problems	33	18.4	32	18.0
Current health is poor	30	16.8	21	11.8
Health limits amount and kind of work	34	19.0	30	16.9

<sup>a</sup> Significance probability for Wilcoxon Signed Test was  $p < .05$  (2-tailed)

<sup>b</sup> Veterans with the serum TCDD levels equal to or above the median value (2.5ppt) were grouped into the "High" group; those who were below the median value were grouped into the "Low" group.