and memory functioning was assessed by using the California Verbal Learning Test (CVLT) and portions of the Rey-Osterreith (RO) Test. Manual dexterity was measured with the Grooved Pegboard Test. Verbal abilities were assessed by using the Word List Generation Test and the information subset of the Wechsler Adult Intelligence Scale-Revised (WAIS-R). Visual perceptual motor functioning was assessed by using the WAIS-R Block Design subset and the Copy component of the RO Test. Mental control and attention were assessed by using the Paced Auditory Serial Addition Test (PASAT). For all neuropsychological tests, scores were standardized (mean = 0, standard deviation = 1) to the two cohorts combined. For the current GT test scores, the expected value of a standardized score was -1 or above. For all other neuropsychological tests, if the difference between a veteran's standardized GT score and his standardized test score was >1, the score was lower than expected (Delis *et al.*, 1987; Lezak, 1983).

2.7 COLLECTION OF REPRODUCTIVE OUTCOME AND CHILD HEALTH DATA

During the telephone interview veterans were asked questions about their children. These questions covered pregnancies that ended early, stillbirths, birth defects, major health problems or impairments in the first 5 years of the child's life, leukemia or other cancers, and infant and child mortality. Pregnancies occurring before the veteran was assigned to Vietnam or other duty locations are not included in the analyses presented here. An analysis of preliminary interview data showed an excess in reports from Vietnam veterans of total birth defects and of cerebrospinal malformations (CSMs). These findings prompted the initiation of two substudies.

The main substudy was designed to compare the rates of total birth defects recorded on hospital birth records of children of Vietnam veterans with the corresponding rates for non-Vietnam veterans in order to verify the cohort differences found in the telephone interview data. All veterans undergoing medical examinations from January through September of 1986 (the last 2,282 of the veterans examined) were asked for permission to retrieve copies of hospital birth records for each of their children. These men reported 3,683 eligible births, for which 3,366 birth records were retrieved.

The second substudy was designed to identify possible CSM cases from telephone interview responses and then to verify them by using corresponding birth records. Infants "at risk" for a CSM were selected from the entire interview population and included those reported by their father as having cerebrospinal malformations, those whose fathers described a similar condition without using its actual name, and those who were stillborn. For the 294 such infants reported in the interview, 221 birth records were retrieved.

A "birth defect" was defined as a condition coded within the range of 740.0-759.9 of the *International Classification of Diseases, Ninth Revision* (World Health Organization, 1977). In addition, we classified the birth defects documented in hospital records as major or minor, using the general method of Erickson *et al.* (Centers for Disease Control, 1988d; Erickson *et al.*, 1984).

3.0 METHODS OF ANALYSIS

3.1 APPROACH TO ANALYSIS

The goal of the analyses was to obtain valid estimates of the association between service in Vietnam and particular adverse health conditions. These estimates were derived primarily from comparing events in the Vietnam group as a whole with those events in the non-Vietnam group as a whole. Because of the large number and diversity of interview items and of the health measurements performed and the large number of possible factors in the "Vietnam experience," an almost limitless number of associations could have been evaluated. To provide focus, we specified certain conditions as being of primary interest. These were conditions that have been suggested as being related to dioxin or herbicide exposure or to other aspects of military service in Vietnam, such as combat or stress.

3.2 COVARIATES

While investigating possible associations between place of service and various health outcomes, we evaluated the influence of other variables that were potential confounders or effect modifiers (variables that might distort or influence an outcome or association). Some of these variables were obtained from military records, but those relating to the period after service were obtained during the telephone interview. Continuous variables (*e.g.*, age) were broken into categories in order to reduce the number of assumptions for the logistic model used in the multivariate analyses described below (Rothman, 1986).

Before we began analyses, we specified six characteristics as being of general interest as potential confounders or effect modifiers (primary covariates). These characteristics are race, age at entry into the Army, year of entry into the Army, primary military occupational specialty (MOS), enlistment status, and score on the general technical (GT) test taken upon entry into the Army. Table 1 shows how these variables were defined and categorized. By including both year of entry and age at entry, the results of all adjusted analyses would also be adjusted for age at interview (or examination). We selected these six primary covariates for the following reasons:

1. They may influence health status (race, age, GT score) or they may be associated with different military experiences or reactions to those experiences (race, age at entry, year of entry, MOS, enlistment status).

2. They may be associated with different probabilities of being assigned to Vietnam (year of entry, MOS, enlistment status).

3. They could not have been influenced by the type of military experience, since they were set before or shortly after the men entered the Army.

4. They are not subject to differential recall or reporting, since most were abstracted from military records completed while the men were on active duty (except for race, which was obtained during the telephone interview and which should not have caused differential recall by place of service).

For each health condition being analyzed, we considered additional covariates as potential confounders, depending on the condition being analyzed.

Table 1. Definition and Categorization of Entry Characteristics

Characteristic	Categories Used in Analysis	Percent of Veterans In Category[a]	
		Vietnam	Non-Vietnam
Age at entry into Army (years)	<20 (referent)	51.6	45.0
	20+	48.4	54.0
Race	White (referent)	83.2	82.1
	Black	11.0	11.1
	Hispanic & other	5.8	6.8
Score on GT test[a]	40-89	24.7	21.4
	90-109 (referent)	33.5	31.6
	110-129	31.9	33.5
	130-160	9.9	13.5
Enlistment status	Drafted (referent)	64.4	57.2
	Volunteered	35.6	42.8
Primary MOS	Tactical operations[b]	34.2	26.8
	Other (referent)	65.8	73.2
Year of entry into Army	1965-66 (referent)	33.5	36.0
	1967-69	56.8	39.8
	1970-71	9.7	24.2

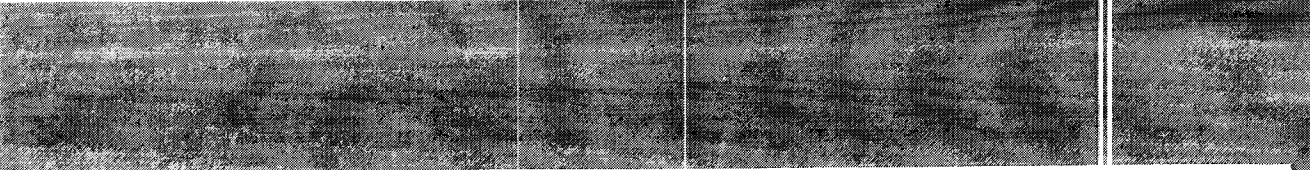[a] Excludes 169 men with missing or out-of-range GT scores.
[b] Tactical operations includes jobs such as infantryman, artillery crewman, armored vehicle crewman, and combat engineer.

3.3 STATISTICAL METHODS

Because of the large number of health conditions being evaluated, we developed a statistical strategy that could be uniformly applied. As a measure of association for dichotomous outcomes, we used the odds ratio (OR), and for continuous data we compared mean values. For some dichotomous outcomes, multiple logistic regression was used for statistical modeling (Kleinbaum et al., 1982). Crude ORs and their 95% confidence intervals (CIs) were computed with standard SAS software (SAS Institute, Inc., 1985) when the number of "cases" of a health condition among all veterans in the study was 10 or more. As a general approximation, if a 95% CI excludes 1.0, the OR estimate can be considered to be statistically significant (i.e., $p < 0.05$).

Multiple logistic regression was used to account for potential confounding and effect modification associated with selected covariates. Two basic statistical models were used in the regression analyses. Model 1, used when the total number of "cases" was 25 or more, consisted of a variable defining the exposure groups (Vietnam, non-Vietnam), the 6 primary covariates, and, if there were ≥100 total "cases," all significant interaction terms between the exposure variable and each primary covariate. Model 2 was added when the total number of "cases" was at least 50. It consisted of all variables in Model 1, other covariates selected as potential confounders or effect modifiers for particular outcomes, and, if there were ≥150 total "cases," all significant interaction terms between the exposure variable and each covariate.

The results of logistic regression are presented as odds ratios and 95% CIs. When significant interaction terms were present in the final model ($p < 0.01$), ORs and CIs were standardized across strata defined by the covariate involved in the interaction (Flanders and Rhodes, 1987; Wilcosky and Chambless, 1985).

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For continuous outcomes, multiple linear regression was used for statistical modeling (Draper and Smith, 1981). Log-normal data were transformed before analysis and were presented as the percent difference between the ratio of adjusted geometric means. Normally distributed data are presented as the difference between adjusted arithmetic means.

For laboratory and clinical data that were continuously distributed, we compared the two cohorts on the basis of the proportion of laboratory (test) values in the upper (or lower) tail of the distribution. In these dichotomous comparisons, we do not imply that the cut point is necessarily of clinical significance, but that multiple logistic regression analysis was applied to test the odds of having a value in the upper (or lower) tail of the distribution. The cut points used were the upper (95th) or lower (5th) percentile of the measure in the total study population of the two cohorts combined. Methods for standardizing neuropsychological test scores are described in Section 2.6.

These approaches to analysis were used for the vast majority of health outcomes evaluated. When other methods were used, they are described in the methods section of the corresponding volume of this monograph.

For analyses of reproductive outcomes, the primary measure used to assess the association of Vietnam experience was also the odds ratio, but the characteristics of the veteran used for multiple logistic adjustment were somewhat different: age of the veteran at the time of the birth or adverse pregnancy outcome, race, year of entry into the Army, enlistment status, GT score, primary MOS, and number of years between entry into the Army and the birth or adverse pregnancy outcome. Two additional covariates were included in analyses of records-based outcomes: maternal age and gravidity.

Since many veterans reported multiple pregnancies or children, we evaluated the possible impact of correlation among offspring within a family by comparing the results of the standard logistic regression method with results of a modified logistic method that accounted for intrafamilial correlation (Centers for Disease Control, 1988d; Liang and Zeger, 1986).

4. RESULTS

4.1 PERSONAL CHARACTERISTICS OF VIETNAM AND NON-VIETNAM GROUPS

Characteristics taken from military records (Table 2) show considerable similarity between the two groups, including age, race, enlistment status, and confinement time while in the Army. The non-Vietnam group had higher GT test scores on entry into the Army, and proportionally more Vietnam veterans entered the Army before 1969, reflecting the buildup of U.S. forces in Vietnam to their peak in the summer of 1969 (Summers, 1985). Further, Vietnam veterans were more likely to be assigned a tactical MOS and to units directly associated with combat activities. They also tended to leave the Army at higher ranks and with fewer nonhonorable discharges. This difference in status on exit from the Army may reflect either the personal characteristics of those who were sent to Vietnam or a different Army personnel policy related to Vietnam service.

Table 2. Comparison of Selected Demographic and Military Characteristics Among Vietnam and Non-Vietnam Veterans Who Were Interviewed and Who Were Examined

	Interviewed		Examined	
Characteristic [a]	Vietnam (N = 7924)	Non-Vietnam (N = 7364)	Vietnam (N = 2490)	Non-Vietnam (N = 1972)
Mean Age at Interview (Years)	37.5	37.4	37.4	37.4
Race % White (Not Hispanic)	83.2	82.0	82.5	81.1
Mean Age at Enlistment (Years)	19.8	20.1	19.8	20.1
Year of Enlistment % Before 1969	72.0	60.6	70.5	60.5
Enlistment Status % Volunteer	35.6	32.8	38.3	35.1
Mean Score on Enlistment GT Test	103.9	106.6	104.6	107.6
Primary MOS[b] % Tactical operations	34.2	26.9	34.0	25.3
Type of Unit[c] % Combat unit	57.0	44.8	55.9	45.0
AWOL or Confinement Time % With some	10.0	10.5	9.4	10.8
Type of Discharge[d] % Nonhonorable	1.8	6.2	1.9	6.5
Pay Grade at Discharge[e] % E1-E3	9.3	15.9	9.4	16.4

[a] Unknown values are excluded from the results shown here.
[b] Primary military occupational specialty—the job for which the man was trained in the Army. Tactical operations includes jobs such as infantryman, armored vehicle crewman, artillery crewman, and combat engineer.
[c] This refers to the principal unit recorded in the military record for the man's foreign assignment or U.S. assignment if no foreign service was performed. Combat units include Infantry, Artillery, Armor, Cavalry, and Engineer.
[d] Also called "character of service." Nonhonorable includes underhonorable, other than honorable, undesirable, general-underhonorable, bad conduct, and dishonorable.
[e] Grades E1-E3 correspond to the various ranks of "private."

The characteristics of the subsample of veterans who were examined are nearly identical with the characteristics of those who were interviewed, except that for both examined cohorts there were slight increases in mean GT scores and in the proportion who volunteered for military service (Table 2). Additional information available only for the examination participants indicates that preservice behavioral problems did not differ for Vietnam and non-Vietnam groups. In both groups, 28% reported that they had been expelled or suspended from school, about 10% had run away from home, and 16% had been arrested as juveniles.

The socioeconomic characteristics at the time of the study were generally similar for the two groups, both among the telephone interview participants and among those who were examined (Table 3). There were no differences in marital status and only small differences in most other characteristics. Non-Vietnam veterans tended to have higher educational levels, and more of them were in the highest income category. These educational and income differences almost disappeared, however, when results were adjusted for the six primary covariates and other covariates. Over 90% of both groups were currently employed. Types of occupations were similar, except that more non-Vietnam veterans were in executive, managerial, and professional occupations. Information from those examined indicates that over 90% in both groups were satisfied with their current personal relationships.

Table 3. Comparison of Selected Socioeconomic Characteristics Among Vietnam and Non-Vietnam Veterans Who Were Interviewed and Who Were Examined

| | Interviewed | | Examined | |
| | Vietnam (N=7924) % | Non-Vietnam (N=7364) % | Vietnam (N=2490) % | Non-Vietnam (N=1972) % |
Characteristic[a]				
Marital Status at Interview				
Married	74.2	74.5	73.2	73.8
Divorced, separated, widowed	17.1	16.6	18.1	17.7
Never married	8.7	8.9	8.7	8.5
Education[b]				
Less than high school	14.1	11.6	13.7	10.1
High school graduate	39.6	37.9	37.2	35.8
Some college	28.5	28.9	30.3	29.1
College graduate	17.8	21.7	18.9	25.0
Usual Occupation				
Executive, managerial	18.5	20.5	19.6	21.8
Professional specialties	11.0	14.0	11.3	15.0
Office, clerical, sales, etc.	7.8	7.7	8.0	6.8
Service, transportation	13.5	12.4	15.3	13.7
Precision work, craft, repair	25.7	24.5	24.0	24.4
Operators, laborers	20.6	18.1	18.9	16.3
Farmers, foresters, fishermen	2.9	2.8	2.8	2.4
Unemployed at Interview	9.5	8.5	9.6	9.1
Income[c]				
<$10,000	9.7	9.4	10.0	10.0
$10,000-$29,999	46.6	45.0	47.1	45.1
$30,000-$49,999	33.4	33.3	32.9	32.5
≥$50,000	10.3	12.4	10.0	12.4

[a] Men with unknown values for a particular variable were excluded from the analysis of that variable.
[b] Highest grade or year of regular schooling attained as of interview.
[c] Combined family (gross) income for the calendar year immediately preceding the year of interview.

4.2 HEALTH PROBLEMS REPORTED BY TELEPHONE INTERVIEW

During the telephone interview, veterans were asked about use of alcohol and illicit drugs and about therapy for drug, alcohol, or emotional problems (Table 4). The proportion of Vietnam and non-Vietnam veterans who reported current alcohol use was about the same, although Vietnam veterans showed a 2% excess of heavy alcohol use (90 or more drinks per month) compared with non-Vietnam veterans (11.6% versus 9.7%). The vast majority of veterans in both groups denied regular use of illicit drugs (at least once a week) during the year before the interview, and marijuana alone was the principal drug reported (9.8% for Vietnam veterans and 7.8% for non-Vietnam veterans). The proportions reporting the use of hard drugs were much lower than for marijuana, with an excess among Vietnam examinees (2.5% compared with 1.8%). About 13% of Vietnam veterans and 9% of non-Vietnam veterans reported having received counseling during the previous year for alcohol, drug, or emotional problems.

Although over 80% of Vietnam and non-Vietnam veterans considered their current health status to be "good" or "excellent," Vietnam veterans were almost twice as likely as non-Vietnam veterans to report their current health to be "fair" or "poor" (19.6% versus 11.1%) (Table 5). Current limitations in activities were reported more often by Vietnam veterans (26.6% versus 21.5%), as was use of prescribed medications (19.1% versus 16.8%). A higher proportion of Vietnam veterans reported having various somatic symptoms, such as headache, dizziness, fatigue, and gastrointestinal ailments (9.5% versus 5.7%). Vietnam veterans also reported having been hospitalized more frequently since discharge from active duty (50.7% versus 46.7%). When asked about the past occurrence of a list of physician-diagnosed conditions, Vietnam veterans reported a higher rate than non-Vietnam veterans for every condition except cancer (all sites combined). Odds ratios were greatest for chloracne and other types of skin conditions. Within each cohort, the prevalence of medical

Table 4. Reported Alcohol Use, Drug Use, and Therapy for Drug, Alcohol, or Emotional Problems Among Vietnam and Non-Vietnam Veterans Who Were Interviewed and Who Were Examined

	Interviewed		Examined	
	Vietnam (N=7924) %	Non-Vietnam (N=7364) %	Vietnam (N=2490) %	Non-Vietnam (N=1972) %
Characteristic				
Alcohol Use[a]				
Never	16.4	17.4	15.8	17.2
Former	19.8	18.8	20.4	19.0
Current	63.9	63.9	63.9	63.8
<30 drinks/month	30.7	32.3	30.0	32.6
30-89 drinks/month	21.6	21.8	23.0	21.8
≥90 drinks/month	11.6	9.7	11.3	9.4
Current Drug Use[b]				
None	87.8	90.4	86.8	89.7
Marijuana only	9.8	7.8	10.2	8.9
Hard drugs	2.5	1.8	3.0	1.5
Therapy for Drug, Alcohol, Emotion Problems[c]	12.4	8.9	13.4	9.8

[a] Current and former drinkers said they had consumed at least one alcoholic drink per month for a year or more.
[b] Current users said they used drugs at least once a week in the past year. Hard drugs include amphetamines, barbiturates, cocaine, heroin, psychedelics, phencyclidine and methaqualone
[c] Includes counseling or treatment during the previous year.

Table 5. Current Health Status and Postdischarge History of Selected Health Problems Reported During the Telephone Interview Among Vietnam and Non-Vietnam Veterans

	Interviewed			Examined		
	Vietnam (N=7924) %	Non-Vietnam (N=7364) %	OR[a]	Vietnam (N=2490) %	Non-Vietnam (N=1972) %	OR[a]
Current Health Status						
Perceived health status is "fair" or "poor"	19.6	11.1	1.8[b]	20.3	11.5	1.9[b]
Limitations in activities	26.6	21.5	1.3[b]	26.9	24.1	1.
Prescribed medication use	19.1	16.8	1.1[b]	19.5	18.0	1.
Somatic symptoms[c]	9.5	5.7	1.7[b]	10.2	6.4	1.7[b]
Postdischarge Health History						
Hospitalized	50.7	46.7	1.1[b]	51.8	49.5	1.0
Hypertension	25.4	20.3	1.3[b]	25.0	20.5	1.2[b]
Cancer	1.4	1.4	1.0	1.9	1.3	1.4
Benign growths	19.0	17.1	1.2[b]	20.1	18.5	1.
Diabetes	1.9	1.4	1.2	1.7	1.5	1.
Chloracne	1.4	0.3	3.9[b]	1.9	0.3	7.3[b]
Other skin conditions	31.2	19.7	1.9[b]	33.0	21.8	1.[b]
Gastrointestinal ulcers	12.5	9.8	1.2[b]	12.6	10.2	1.
Hepatitis	4.8	3.3	1.5[b]	4.8	4.0	1.3
Cirrhosis	0.7	0.5	1.3	0.7	0.6	1.
Other liver conditions	2.7	1.8	1.4[b]	3.6	2.1	1.[b]
Urinary tract problems	15.7	13.7	1.2[b]	16.8	15.2	1.
Fertility difficulties[d]	20.0	15.5	1.3[b]	21.0	14.5	1.[b]

[a] Odds ratio adjusted for the six entry characteristics.
[b] 95% confidence interval excludes 1.0.
[c] Includes problems such as nervousness, fatigue, gastrointestinal ailments, dizziness, and headaches.
[d] Tried to conceive a child over a period of a year or more without success.

problems was similar among those interviewed and those examined. The odds ratios for the medical history characteristics of the examination participants were also very similar to those of the interview participants (Table 5).

4.3 MEDICAL, NEUROPSYCHOLOGICAL, AND LABORATORY EXAMINATION

Dermatologic Conditions

Although Vietnam veterans reported having had chloracne and other skin conditions more frequently than non-Vietnam veterans, dermatologic findings were similar for both cohorts (Table 6). Chloracne-like skin lesions, hyperpigmentation, hirsutism, and skin cancer were rare and occurred with similar frequency among Vietnam and non-Vietnam veterans. Infection-related conditions and postinflammatory scars were similarly prevalent in the two cohorts.

Cardiorespiratory Conditions

The prevalence of cardiorespiratory conditions among examination participants was similar in both cohorts (Table 7). About one-third of Vietnam and non-Vietnam veterans were

Table 6. Prevalence (%) of Selected Skin Conditions Noted During Dermatologic Examination

Condition	Vietnam (N = 2490) %	Non-Vietnam (N = 1972) %	OR[a]	95% CI
Chloracne-Like Lesions	0.9	0.8	1.4	0.7-2.9
Acneiform Lesions				
Comedones only	4.3	4.6	0.9	0.7-1.2
Any acne	15.6	16.8	0.9	0.8-1.1
Hyperpigmentation	4.0	3.2	1.2	0.9-1.7
Hirsutism	0.2	0.3	–	–
Skin Cancer	0.6	0.7	0.8	0.4-1.7
Infections				
Folliculitis	21.0	21.8	0.9	0.8-1.1
Tinea	37.6	38.0	1.0	0.8-1.1
Any infection	59.1	59.3	1.0	0.8-1.1
Postinflammatory Scars	17.8	18.0	1.0	0.9-1.2

[a] Odds ratio adjusted for the six entry characteristics.

Table 7. Prevalence (%) of Cardiorespiratory Conditions Among Examination Participants

Condition	Vietnam (N = 2490) %	Non-Vietnam (N = 1972) %	OR[a]	95% CI
Hypertension[b]	33.5	31.4	1.1	0.9-1.2
Altered Peripheral Arterial Hemodynamics[c]	4.7	3.6	1.2	0.9-1.7
Electrocardiogram Findings				
Ischemia[d]	1.9	1.8	1.1	0.7-1.7
Left ventricular hypertrophy	1.6	1.0	1.8	1.0-3.3
Any finding[e]	14.3	13.9	1.1	0.9-1.3
Chest Roentgenogram Findings				
Pulmonary	16.0	14.1	1.1	1.0-1.4
Cardiac	1.0	0.9	1.3	0.7-2.5
Any finding	22.4	20.5	1.1	1.0-1.3
Pulmonary Function Parameter[f]				
FEV1, ≤80% predicted	10.2	10.9	0.9	0.7-1.1
FVC, ≤80% predicted	7.1	6.8	1.0	0.8-1.3
FEV1/FVC%, <70%	6.1	6.1	1.0	0.8-1.3

[a] Odds ratio adjusted for the six entry characteristics.
[b] Systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or current use of antihypertensive medications.
[c] Resting index (ankle/brachial blood pressure) <1.0, an absent posterior tibial pulse waveform or a femoral bruit.
[d] ECG changes of ischemia or infarction.
[e] Includes bradycardia, tachycardia, extrasystoles, nonspecific ST and T wave changes, and others.
[f] FEV1 = forced expiratory volume in 1 sec; FVC = forced vital capacity.

hypertensive. Overall, the prevalence of any electrocardiogram (ECG) findings was similar for the two groups, as were patterns of ischemia and prior infarction. Results of the ECG examination showed, however, that more Vietnam veterans had left ventricular hypertrophy (1.6% versus 1.0%; OR=1.8), but the 95% CI included 1.0. Altered peripheral arterial hemodynamics were also rare and were found at a similar prevalence in the two groups.

The two groups were also similar with regard to pulmonary conditions. The proportion of veterans with chest roentgenogram findings was comparable in the two groups, as were the types of findings. Benign calcified nodules were the most common specific pulmonary

finding in both groups. The proportion of veterans with diminished pulmonary function was the same in both groups, and these results were unchanged after current smoking status was taken into account.

Neurologic Conditions

Only a small proportion of veterans in either cohort had any evidence of peripheral neuropathy (Table 8). The largest relative difference between groups was for those veterans who had primarily subjective criteria (symptoms) of neuropathy, with the Vietnam group reporting more problems. Among those who met criteria for objective signs, the prevalence of peripheral neuropathy was greater in both groups, but relative cohort differences were lessened.

Vietnam veterans were 40% more likely to have high-frequency hearing loss than non-Vietnam veterans (Table 8). Differences between these two groups were greatest among men with a tactical MOS (infantrymen, armored vehicle crewmen, and artillerymen), for whom the odds ratio (adjusted for preservice auditory acuity) was 2.5 (95% CI = 1.5-4.0), whereas for other men it was 1.2 (95% CI = 0.9-1.6).

Neuropsychological Tests

The current mean GT scores were significantly (2.5 points) lower for the Vietnam veterans (Table 9), a finding consistent with the difference observed when they took the same test upon entry into the Army. Adjustment of the current GT score for the six entry characteristics, including the induction GT score, decreased the current GT score difference between the two groups. More importantly, the amount of change in GT scores since entry into the service was similar for Vietnam and non-Vietnam veterans (about a 9-point gain in each group). There were small but statistically significant differences between cohorts in mean scores adjusted for the six entry characteristics for three subtests (see Table 9), but the proportions of veterans with test scores below expected values were similar in both groups.

Immune Function Assays

The mean values for none of the immune function tests differed between cohorts (Table 10). The proportions of veterans in each cohort with values above or below the reference range for all test measurements were similar; all odds ratios were less than 1.5, and their confidence intervals included 1.0. The percentage of subjects who were anergic, defined as a <2-mm response to all seven recall antigens in the CMI test, was 3.5% for Vietnam and 3.9% for non-Vietnam veterans (OR = 1.0).

Table 8. Prevalence (%) of Neurologic Conditions Among Examination Participants

Condition	Vietnam (N = 2490) %	Non-Vietnam (N = 1972) %	OR[a]	95% CI
Peripheral Neuropathy				
Symptoms only[b]	3.0	1.9	1.5	1.0-2.2
Signs only[c]	8.2	6.5	1.2	1.0-1.6
Symptoms and signs	1.0	0.8	1.2	0.6-2.3
High-Frequency Hearing Loss[d]				
Right ear	14.4	9.9	1.4	1.2-1.7
Left ear	18.4	12.9	1.4	1.2-1.6
Both ears	9.4	6.2	1.4	1.1-1.8

[a] Odds ratio adjusted for the six entry characteristics.
[b] Numbness, tingling, burning sensation, or weakness of arms or legs.
[c] Findings from neurologic physical examination or out-of-reference-range values for: nerve conduction velocity or amplitude tests, or vibration and thermal thresholds.
[d] Average hearing threshold ≥ 51 decibels at three combined frequencies: 3,000, 4,000, and 6,000 H_z.

Table 9. Selected Results of Neuropsychological Tests

| Measure[b] | Arithmetic Mean | | Below Expected Value[a] | | | |
	Vietnam (N=2490)	Non-Vietnam (N=1972)	Vietnam %	Non-Vietnam %	OR[c]	95% CI
ACB General Technical (GT) Score at Examination	109.4	111.9[d]	17.4	15.8	1.	0.9-1.3
CVLT Total Correct						
Trials 1-5	45.7	47.0	17.2	16.4	1.	1.0-1.4
Short-delay free recall	9.5	9.7	18.7	19.0	1.|	0.9-1.3
Long-delay free recall	9.7	10.1	17.7	18.8	1.0	0.9-1.2
Grooved Pegboard (Seconds)						
Dominant hand	73.7	73.0	24.1	21.9	1.)	0.9-1.2
Nondominant hand	78.2	77.0	23.7	21.0	1.)	0.9-1.2
PASAT Total Correct Trial 1	38.8	39.1	12.0	12.9	0.)	0.8-1.1
RO Complex Figure						
Copy	32.6	32.9[d]	14.6	15.1	1.)	0.8-1.2
Short-delay recall	19.9	20.4	17.4	18.0	1.)	0.9-1.2
Long-delay recall	20.1	20.5	16.9	17.6	1.)	0.9-1.2
WAIS-R						
Information subtest	9.9	10.3	8.0	7.2	1.1	0.9-1.3
Block design subtest	10.4	10.7[d]	14.8	15.8	0.)	0.8-1.1
Wisconsin Card Sorting Test						
Average Number of Cards Per Sort	21.4	20.2[d]	24.4	21.5	1.1	1.0-1.41
Word List Generation						
F, A, S total	34.7	35.7	16.8	18.3	1.:	0.8-1.2

[a] See text, Section 4.3.
[b] ACB = Army Classification Battery; CVLT = California Verbal Learning Test; PASAT = Paced Auditory Serial Addition Test; RO = Rey-Osterreith Test; WAIS-R = Wechsler Adult Intelligence Scale-Revised.
[c] Odds ratio adjusted for the six entry characteristics.
[d] $p < 0.05$ (after adjustment for the six entry characteristics).

Other Laboratory Assays

Results of most laboratory tests were similar for both cohorts (Table 11). For γ-glutamyl transferase (GGT), however, there were differences, both in unadjusted geometric means and in the proportion of veterans with elevated values. After the results were adjusted for current smoking status, alcohol consumption, illicit drug use, and body mass index, these cohort differences virtually disappeared.

Total urinary porphyrin levels were practically the same for the two cohorts. One Vietnam veteran had a urinary porphyrin pattern consistent with porphyria cutanea tarda. Nine other veterans, five Vietnam and four non-Vietnam, had porphyrin patterns consistent with chronic hepatic porphyria.

With few exceptions, results of tests of endocrine function were similar for the two cohorts. There was a 1% difference in mean glucose, which persisted after the results were adjusted for entry characteristics and other covariates (current smoking status, alcohol use, body mass index, medication use), but the proportion with values above 140 mg/dL was the same in both cohorts. After the results were adjusted for entry characteristics, the mean level of thyroid-stimulating hormone (TSH) was about 4% higher among Vietnam veterans, a statistically significant difference. In addition, the Vietnam veterans were twice as likely to have a TSH value above 10 mIU/L. When hypothyroidism was defined either as a TSH >10 mIU/L or as self-reported use of thyroid replacement medication, the odds ratio was 1.3 (95% CI = 0.7-2.4).

Table 10. Results of Hematologic and Immune Tests

Parameter	Mean[a]		Below Reference Range[b]			Above Reference Range[b]		
	Vietnam (N=2490)	Non-Vietnam (N=1972)	Vietnam %	Non-Vietnam %	OR[c]	Vietnam %	Non-Vietnam %	OR[c]
Hemoglobin, g/dL	16.2	16.1	2.4	2.3	1.1	4.5	4.2	1.0
Total WBC Count, cells/cu mm	6705	6546	6.7	7.6	1.0	3.3	2.6	1.2
Total Lymphocyte Count, cells/cu mm	1973	1936	4.8	5.3	1.0	5.2	4.6	1.2
Lymphocyte Subset Populations								
B-cell count, cells/cu mm	240	230	4.4	4.2	1.1	5.2	4.1	1.2
T-cell count, cells/cu mm	1480	1460	4.8	5.1	1.0	5.2	4.7	1.1
T-cell Subset Populations								
T4, cells/cu mm	1020	990	4.5	5.0	1.0	5.5	3.9	1.4
T8, cells/cu mm	560	550	4.2	4.4	1.0	4.5	5.3	0.9
T4/T8 ratio	1.8	1.8	4.7	5.3	0.9	5.1	4.7	1.1
Serum Immunoglobulins, mg/dL								
IgG	1078	1077	5.0	5.0	1.0	4.8	5.1	1.0
IgM	121	121	4.7	4.7	1.0	4.6	5.1	0.9
IgA	207	203	4.4	5.6	0.8	5.0	4.8	1.0

a Means are arithmetic for hemoglobin, total WBC count, and total lymphocyte count; all other means are geometric.
b Reference ranges were defined as values between the 5th and 95th percentiles for both cohorts combined, except for hemoglobin: 14-18 g/dL.
c Odds ratio adjusted for the six entry characteristics.

Table 11. Results of Selected Laboratory Tests

	Geometric Mean		Out of Range[a]			
	Vietnam (N = 2490)	Non-Vietnam (N = 1972)	Vietnam %	Non-Vietnam %	OR[b]	95% CI
Serum Analytes						
Alanine aminotransferase, IU/L	26.4	25.8	5.3	4.4	1.2	0.9-1.5
Aspartate aminotransferase, IU/L	26.0	26.0	5.4	4.4	1.2	0.9-1.8
γ-glutamyl transferase, IU/L	43.2	41.1[c]	5.5	4.4	1.3	1.0-1.8
Total bilirubin, mg/dL	0.8	0.8	5.1	4.9	1.0	0.7-1.4
Triglycerides, mg/dL	94.1	92.6	4.7	5.3	0.9	0.7-1.2
Total cholesterol, mg/dL	209.8	207.2	5.1	4.7	1.1	0.8-1.5
HDL cholesterol, mg/dL	42.9	43.3	5.3	4.3	1.2	0.9-1.5
Fasting glucose, mg/dL	93.4	92.4[c]	0.6	0.6	1.0	0.4-2.2
Thyroid-stimulating hormone, mIU/L	1.6	1.6[c]	1.0	0.6	2.0	0.9-4.3
Free thyroxine index	2.2	2.2	5.4	4.6	1.2	0.9-1.5
Testosterone, ng/dL	636.6	643.7	5.0	5.0	1.0	0.8-1.3
Follicle-stimulating hormone, IU/L	6.6	6.5	4.7	5.2	0.9	0.7-1.2
Luteinizing hormone, IU/L	13.3	13.1	5.2	5.2	1.0	0.8-1.3
Urine Analytes						
D-Glucaric acid, mg/g of creatinine	10.6	10.2	5.1	4.9	1.0	0.8-1.4
Total porphyrins, ug/g of creatinine	43.0	42.2	5.2	4.5	1.2	0.8-1.8

[a] Reference ranges were defined as ≤95th percentile for both cohorts combined, except for the following: HDL cholesterol, free thyoxine index, testosterone, follicle-stimulating hormone, luteinizing hormone, ≥5th percentile for the combined cohorts; glucose, <140 mg/dL; and thyroid-stimulating hormone, ≤10 IU/L.

[b] Odds ratio adjusted for the six entry characteristics.

[c] p<0.05 (after adjustment for the six entry characteristics).

The Vietnam and non-Vietnam groups differed with respect to two other laboratory items, stool occult blood and hepatitis B serology. Occult blood was found in the stools of more Vietnam (1.3%) than non-Vietnam (0.5%) veterans (OR = 2.8, 95% CI = 1.3-6.0). The tests of few Vietnam (0.5%) or non-Vietnam (0.9%) veterans were positive for hepatitis B surface antigen (HBsAg). However, the prevalence of past hepatitis B infection (defined as having antibody to either surface or core antigens while negative for HBsAg) was higher among Vietnam (14.1%) than non-Vietnam (11.1%) veterans (OR = 1.4, 95% CI = 1.1-1.8).

Semen Analysis

The 571 men who participated in the semen analysis substudy had characteristics that were nearly identical to the characteristics of all the medical examination participants (Centers for Disease Control, 1988b), suggesting that these veterans were representative of the entire examination sample. Some differences were found in semen characteristics (Table 12), with Vietnam veterans having significantly lower mean sperm concentrations than non-Vietnam veterans and twice the proportion with values below the clinical reference range of >20 million cells per milliliter. Five Vietnam and three non-Vietnam veterans had sperm concentrations below 5 million cells per milliliter. The mean percentage of cells with "normal" head morphology was also significantly lower for Vietnam veterans. These differences persisted even after the results were adjusted for the six entry characteristics and six additional covariates relating to this examination (current smoking status, alcohol use, illicit drug use, medication use, time since previous ejaculation, and time between sample collection and video recording). Measurements of sperm head dimensions indicated that the Vietnam veterans' lower proportion of "normal" sperm cells was due to larger and more

Table 12. Selected Results of Semen Analysis

Sperm Characteristic	Mean[a] Vietnam (N=324)	Mean[a] Non-Vietnam (N=247)	Men Below Reference Range[b] Vietnam %	Men Below Reference Range[b] Non-Vietnam %	OR[c]	95% CI
Concentration	64.8[d]	79.8[d,e]	15.9	8.1	2.3	1.2-4.3
Motile cells	56.9%	60.4%	28.0	23.4	1.2	0.8-1.3
"Normal" cell morphology	57.9%	60.8%[e]	15.9	11.4	1.6	0.9-2.3

[a] The mean for sperm concentration is geometric; all other means are arithmetic.
[b] Reference ranges were defined as concentration, >20 million cells/ml; proportion motile, $\geq$40%; and proportion normal cells, $\geq$40%.
[c] Odds ratio adjusted for the six entry characteristics.
[d] Million cells per milliliter.
[e] $p < 0.05$ (after adjustment for the six entry characteristics).

tapered sperm heads. The percentage of motile cells was similar for the two cohorts, as were other measures of sperm movement, such as velocity, lateral head motion, and linearity of motion.

Other Examination Results

Several hundred conditions were evaluated during the medical examinations, particularly during the dermatologic, neurologic, and general physical examinations. For the most part, these other conditions were found with similar frequency in the two cohorts. Differences, when detected, tended to be minor and did not follow any pattern that would suggest that one group was at higher risk for a particular type of health outcome.

4.4 PSYCHOLOGICAL EVALUATION

Among examination participants, alcohol- and drug-use behaviors, as well as psychiatric conditions, were evaluated in greater detail as part of the Diagnostic Interview Schedule (DIS) (Table 13). Vietnam veterans were more likely than non-Vietnam veterans to meet DIS criteria for alcohol abuse or dependence, for generalized anxiety, or for depression. Few men in either group met DIS criteria for drug abuse or dependence. Overall, more than 80%

Table 13. Percent of Vietnam and Non-Vietnam Veterans Who, in the Month Before Examination, Met DIS Criteria for Selected Psychiatric Conditions

Condition	Vietnam (N=2490) %	Non-Vietnam (N=1972) %	OR[a]	95% CI
Alcohol Abuse or Dependence	13.7	9.2	1.5	1.2-1.8
Drug Abuse or Dependence	0.4	0.5	0.9[b]	0.4-2.0
Generalized Anxiety[c] (With or without depression)	4.9	3.2	1.5	1.1-2.1
Depression (With or without generalized anxiety)	4.5	2.3	2.0	1.4-2.9
Total No. of Above Conditions				
One or more	19.2	13.1	1.5	1.3-1.8
Two or more	3.5	1.8	1.9	1.2-2.8

[a] Adjusted for the six entry characteristics.
[b] Crude OR presented because the number of cases is not sufficient for an adjusted estimate.
[c] For clinical purposes, depression is considered the primary diagnosis for individuals with both depression and anxiety. The percents with generalized anxiety alone are 2.8% for Vietnam veterans and 2.2% for non-Vietnam veterans; the percents with generalized anxiety and depression are 2.1% for Vietnam and 1.0% for non-Vietnam veterans.

of the men in each group did not meet DIS criteria for any of these four conditions: alcohol abuse or dependence, generalized anxiety, depression, and drug abuse or dependence. However, 19% of Vietnam veterans met criteria for at least one—significantly more than the 13% found among the non-Vietnam veterans. Further, more Vietnam veterans met criteria for two or more of these conditions (3.5% versus 1.8%).

Analyses of combat-related post-traumatic stress disorder (PTSD) were restricted to Vietnam veterans, since non-Vietnam veterans had little opportunity to experience combat. About half of the Vietnam veterans reported never experiencing any combat-related symptoms, about one-third reported one or more such symptoms, and 15% reported experiencing a set of symptoms which would meet DIS diagnostic criteria for combat-related PTSD (Table 14). Among the more common symptoms were jumpiness, "trouble sleeping," and recurrent thoughts or dreams. Among those who had "ever" met diagnostic criteria, 79% indicated that their symptoms began within 6 months after the traumatic event, and 82% indicated that at least some of their symptoms had lasted 6 months or longer. During the month before examination, 82% of Vietnam veterans had no symptoms, 18% had one or more symptoms, and 2% met full criteria for combat-related PTSD.

Table 14. Percent of Vietnam Veterans Who Ever Met DIS Criteria For Combat-Related Post-Traumatic Stress Disorder (PTSD) and Who Met Full Criteria in the Month Before Examination

	Vietnam Veterans (N = 2490)	
	Ever %	Month Before Examination %
Combat-Related Post-Traumatic Stress Disorder[a]	14.7	2.2
Type of Symptoms		
Criterion B		
Recurrent thoughts or dreams	32.4	7.3
Felt as if event recurring	9.4	1.3
Criterion C		
Lost ability to care about others or lost interest in usual activities	17.1	5.1
Criterion D		
Jumpy or easily startled	45.1	10.6
Trouble sleeping	34.6	9.4
Ashamed of being alive	8.1	1.9
Forgetful or trouble concentrating	13.6	0.4
Avoid situations that remind	28.8	7.9
Symptoms get worse in situations that remind	17.3	5.9
No Symptoms	49.9	79.2

[a] To meet DIS criteria for combat-related PTSD, a veteran had to report a combat-related traumatic event (Criterion A), at least one reexperiencing symptom (Criterion B), a numbing symptom (Criterion C), and at least two symptoms of autonomic arousal (Criterion D). All symptoms were related specifically to the traumatic event.

Veterans who met criteria for PTSD during the month before examination were also more likely to meet criteria for other psychiatric conditions. For example, of the men meeting PTSD criteria, 66% also met DIS criteria for anxiety or depression, and 39% met criteria for alcohol abuse or dependence.

The MMPI provided further information on the status of veterans' current psychological health. A larger proportion of Vietnam than non-Vietnam veterans had MMPI measures of psychological problems (Table 15). Scales 1, 2, 3, and 7 provide the best MMPI indication of anxiety or depression. Elevations on these scales were from 1.5 to 1.7 times more prevalent among Vietnam veterans, with between-group prevalence differences of 3% to 8%. Elevations on Scale 8, indicating unusual thoughts and behaviors relating to distress or psychopathology, were found for about 16% of Vietnam veterans compared with about 9% of non-Vietnam veterans.

Scores for other clinical scales (0 and 5, which are of little clinical relevance, and 4 and 9, which relate to addictive or antisocial personality) were not substantially different for the two groups. Overall, for about half of the participants in each group no clinical scale was elevated. For 28.2% of Vietnam and 20.8% of non-Vietnam veterans two or more clinically relevant scales (1-4, 6-9) were elevated (a finding that in a clinical setting would usually lead to further evaluation and, possibly, to treatment).

DIS and MMPI data were combined for each participant in order to identify men with current "poor psychological status" (see definition in Table 16). The proportion of such men was higher in the Vietnam group, particularly among those who had entered the Army before 1968. For the Vietnam veterans, there was very little difference in the prevalence of "poor psychological status" among those with a tactical MOS (13%) and those without (12%). Regardless of whether a man had served in Vietnam or not, "poor psychological status" was

Table 15. Percent and Number of Vietnam and Non-Vietnam Veterans With MMPI Clinical Scales Elevated (T≥70)[a]

MMPI Scale	Vietnam (N=2221)[b] %	Non-Vietnam (N=1754)[b] %	OR[c]	95% CI
Scale 1	15.6	9.1	1.7	1.4-2.1
Scale 2	25.1	17.3	1.6	1.3-1.8
Scale 3	8.9	5.9	1.5	1.2-2.0
Scale 4	15.7	14.7	1.0	0.9-1.2
Scale 5	12.7	12.9	1.1	0.9-1.3
Scale 6	9.1	7.2	1.3	1.0-1.7
Scale 7	16.5	10.9	1.6	1.3-1.9
Scale 8	16.3	9.2	2.0	1.6-2.4
Scale 9	13.7	13.5	1.1	0.9-1.3
Scale 0	11.0	8.3	1.3	1.0-1.6
No scales elevated[d]	51.5	59.6	0.7	0.7-0.8
1 or more scales elevated[d]	48.5	40.4	1.3	1.2-1.5
2 or more scales elevated[d]	28.2	20.8	1.5	1.2-1.7

[a] T-scores ≥70 represent 2 standard deviations above the standardization sample mean.
[b] Veterans with questionable profiles are not included in this analysis.
[c] Adjusted for the six entry characteristics.
[d] Excluding Scales 5 and 0.