Table 16. Risk Factors Associated With Current "Poor Psychological Status"[a]

Factor	Prevalence of "Poor Psychological Status"		OR[b]	95% CI
	%	N		
Vietnam Service				
Year of Entry 1965-67				
Non-Vietnam	5.6	51	1.0	referent
Vietnam	13.0	163	2.3	1.6-3.2
Year of Entry 1968-71				
Non-Vietnam	8.8	93	1.0	referent
Vietnam	10.9	134	1.3	0.8-2.0
Other Risk Factors				
Race				
White	8.8	322	1.0	referent
Other than white[c]	14.7	119	1.4	1.1-1.8
Age at Enlistment				
<19	16.3	105	1.9	1.5-2.4
19-24	8.7	326	1.0	referent
>24	12.7	10	1.4	0.7-2.8
Enlistment GT Score				
<88	16.0	142	1.9	1.6-2.2
88-101	12.4	110	1.3	1.2-1.4
102-113	9.5	88	1.0	referent
114-124	8.1	70	0.8	0.7-0.8
>124	3.4	29	0.6	0.5-0.7

[a] "Poor psychological status" defined as meeting full DIS criteria for generalized anxiety, depression, or substance abuse in the past month *and* elevations on at least two of eight MMPI clinical scales (1-4, 6-9).
[b] Adjusted for all other risk factors in table.
[c] Other than white includes blacks, Hispanics, American Indians, Asians, and Pacific Island Americans.

more prevalent among those who were other than white, had entered the Army when they were under age 19, or who had lower GT scores upon enlistment.

Current "poor psychological status" associated with service in Vietnam was found to be elevated for each subgroup examined (year of entry, age at entry, ethnicity, GT score at entry) (Figure 2). The same relative excess prevalence among Vietnam veterans is found in all of these subgroups; however, the absolute difference decreases as the risk moves downward from the higher differences in young blacks and Hispanics with low GT scores to older whites with high GT scores.

4.5 REPRODUCTIVE OUTCOMES AND CHILD HEALTH

Birth Defects

Data on the number of veterans, eligible pregnancies and births, and hospital birth records received for this study component are summarized in Table 17. During the telephone interview, Vietnam veterans reported birth defects among their children at rates of 64.6 per 1,000 total births, whereas non-Vietnam veterans reported them at a rate of 49.3 per 1,000 total births. The adjusted odds ratio is 1.3 (95% CI = 1.2-1.4) (Table 18). The excess is present for virtually every major organ system and does not appear to be explained by a single type (or category) of defect. The odds ratios for anomalies of the nervous system, hydrocephalus, anomalies of the integument, and deformities of the musculoskeletal system are significantly greater than 1.0. There was a positive association between Vietnam service

Figure 2. Predicted Probability of Poor Psychological Status

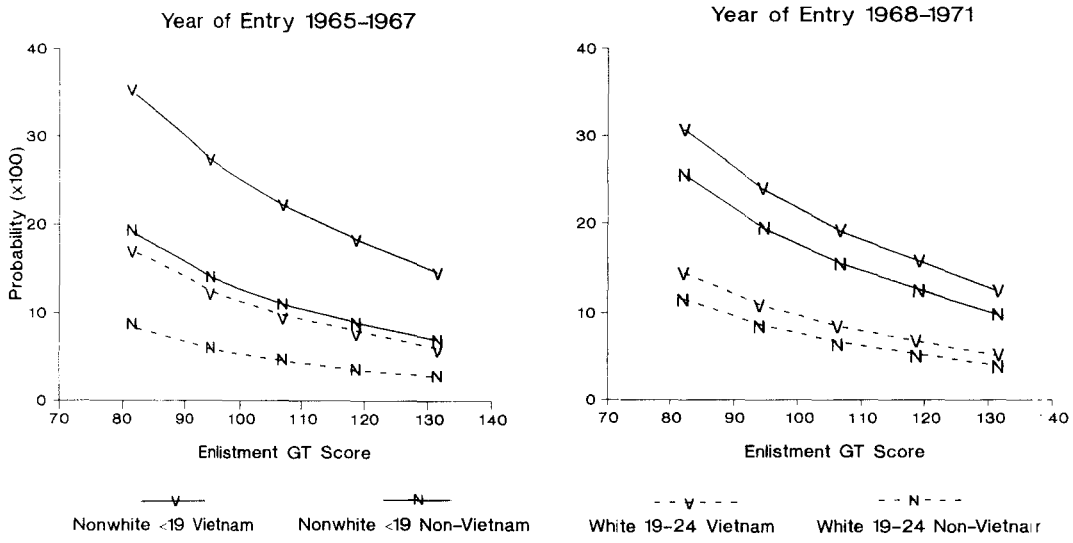

Table 17. Number of Veterans, Eligible Pregnancies and Births, and Birth Records Received, in the Interview Study and the Hospital Birth Record Substudies, by Place of Service

	Vietnam	Non-Vietnam	Total
		Interview Study	
Veterans	7924	7364	15288
Eligible pregnancies	15009	13715	28724
Eligible births	12788	11910	24698
Eligible live births	12659	11777	24436
		Birth Defects Substudy	
Veterans	1237	1045	2282
Eligible births	1945	1738	3683
Birth records received	1791	1575	3366
		Cerebrospinal Malformations Substudy	
Eligible births	154	140	294
Birth records received	127	94	221

and reported birth defects among children of both white and black veterans (adjusted ORs of 1.3 and 1.2, respectively), but the reverse was true for children of veterans of Hispanic and other races (OR=0.7).

Vietnam veterans reported more children with multiple defects than did non-Vietnam veterans, with an adjusted OR of 1.6 (95% CI=1.1-2.5) compared with an OR of 1.3 (95% CI=1.1-1.4) for children with only one defect. Vietnam veterans were also more likely to report two or more children with birth defects, with an adjusted OR of 1.5 (95% CI=1.0-2.1). For veterans reporting only one child with a birth defect, the adjusted OR was 1.2 (95% CI=1.1-1.4).

Table 18. Number of Children with Birth Defects Reported in the Interview, Crude Rates Per 1,000 Total Births Among Vietnam and Non-Vietnam Veterans, and Adjusted Odds Ratios, by Organ System

Organ System (ICD-9 Codes[b])	Vietnam (N=12788) Rate	Vietnam (N=12788) No.	Non-Vietnam (N=11910) Rate	Non-Vietnam (N=11910) No.	OR[a]	95% CI
Total Anomalies (740-759)	64.6	826	49.5	590	1.3	1.2-1.4
Nervous (740-742)	2.6	33	1.1	13	2.3	1.2-4.5
Anencephaly (740.0)	0.2	3	0.0	0	–	–
Spina bifida (741.0-741.9)	0.7	9	0.4	5	1.7[c]	0.6-5.0
Hydrocephalus (742.3)	0.9	11	0.2	2	5.1[c]	1.1-23.1
Eye (743)	1.6	20	1.1	13	1.3	0.7-2.8
Ear, Face, Neck (744)	2.9	37	1.8	22	1.6	0.9-2.8
Circulatory (745-747)	6.7	86	6.1	73	1.1	0.8-1.6
Respiratory (748)	1.2	15	0.8	10	1.5	0.6-3.5
Digestive (749-751)	8.4	108	6.8	81	1.2	0.9-1.6
Genital (752)	2.7	35	2.3	27	1.3	0.8-2.2
Urinary (753)	3.6	46	2.4	28	1.4	0.9-2.3
Musculoskeletal (754-756)	33.3	426	25.9	309	1.2	1.1-1.5
Integument (757)	3.2	41	1.4	17	2.2	1.2-4.0
Chromosomal (758)	0.8	10	1.0	12	0.8[c]	0.3-1.8
Other Unspecified (759)	1.6	20	0.8	10	1.7	0.8-3.9

[a] Adjusted for veteran's age at birth, race, year of entry into Army, enlistment status, general technical test score, primary military occupational specialty, and years between entry and birth.
[b] The range of codes includes all the fourth digit codes contained within that range.
[c] Crude OR presented because the number of cases is not sufficient for multivariate modeling.

In the substudy of birth records retrieved for all reported birth defects, the crude rates of defects per 1,000 total births recorded in hospital birth records were similar for the two cohorts (72.6 for the Vietnam and 71.1 for the non-Vietnam group), with an adjusted odds ratio of 1.0 (95% CI=0.8-1.4) (Table 19). The odds ratios for subclassifications of major, minor, or suspected birth defects range from 0.9-1.1.

Analysis of total, major, minor, and suspected defects stratified by race shows that adjusted odds ratios vary considerably (Centers for Disease Control, 1988). For total defects, the odds ratio for children of black veterans is 3.3 (95% CI=1.5-7.5), but for children

Table 19. **Number of Children with Birth Defects Noted on Hospital Birth Records, Crude Rates Per 1,000 Total Births Among Vietnam and Non-Vietnam Veterans, and Adjusted Odds Ratios, by Type of Defect**

Type of Defect	Vietnam (N=1791)		Non-Vietnam (N=1575)			
	Rate	No.	Rate	No.	OR[a]	95% CI
Total Defects	72.6	130	71.1	112	1.0	0.8-1.4
Major	28.5	51	23.5	37	1.1	0.7-1.8
Minor	32.4	58	34.3	54	1.0	0.7-1.5
Suspected	11.7	21	13.3	21	0.9	0.5-1.7

[a] Adjusted for veteran's age at birth, race, year of entry into Army, enlistment status, general technical test score, primary military occupational specialty, years between entry and birth, maternal age, and gravidity.

of white veterans, it is 0.9, and for children of veterans of other races, it is 0.4. The odds ratios also vary for major and minor defects. The odds ratio is statistically significant both for total defects and for minor defects among children of black veterans.

We therefore examined types of abnormalities among black infants more carefully. No single type of major defect occurred more than once in either cohort. None of the infants with major defects had identical anomalies or any pattern of multiple anomalies suggestive of a syndrome. For black Vietnam veterans, 13 infants had minor defects, including 4 with polydactyly (2 of whom were siblings) and 2 (a sibling pair) with supernumerary nipples; none of the infants of black non-Vietnam veterans had polydactyly or supernumerary nipples. No other minor anomalies occurred more than once.

An analysis of potential cerebrospinal malformations (CSM) cases was done separately in each cohort for stillbirths and for live births (Table 20). Among reported stillbirths, birth records documented five cases of CSM among offspring of Vietnam veterans and six among those of non-Vietnam veterans. Ten of these eleven CSM cases found in stillbirth records had no interview report of a defect. Among live births with a CSM reported or suspected, birth records documented two CSM cases among children of Vietnam veterans and six cases among children of non-Vietnam veterans. Because record retrieval rates were so low for children of non-Vietnam veterans and because negative responses were not verified, we did not calculate rates of CSM cases, since the comparison would be unreliable.

Table 20. **Analysis of Hospital Birth Records for All Reported Stillbirths and Those Live Births With a Reported Probable or Possible Cerebrospinal Malformation**

	All Stillbirths		Live Births With a Reported CSM or Possible CSM		Stillbirths and Live Births	
	Vietnam	Non-Vietnam	Vietnam	Non-Vietnam	Vietnam	Non-Vietnam
Reported in Interview	99	114	55	26	154	140
Birth Records Received	78	74	49	20	127	94
CSM on Record						
Total	5	6	21	6	26	12
Anencephaly	3	4	7	3	10	7
Spina bifida	1	0	8	2	9	2
Hydrocephalus	1	2	6	1	7	3

CSM = Cerebrospinal malformation

Low Birth Weight - Hospital Birth Record Substudy

Rates of low birth weight (<2,500 grams) were similar for offspring of Vietnam (5.6%) and non-Vietnam (5.5%) veterans, with an adjusted OR of 1.1 (95% CI = 0.8-1.4). The mean birth weights of offspring of Vietnam and non-Vietnam veterans were 3,366 and 3,370 grams, respectively.

Other Pregnancy and Child Health Outcomes - Interview Study

Vietnam veterans were more likely to report a pregnancy that ended in a miscarriage than were non-Vietnam veterans, with an adjusted OR of 1.3 (95% CI = 1.2-1.4). This excess appeared regardless of the trimester in which the miscarriage was reported to have occurred (the magnitude of the odds ratios varyed little across trimesters). Vietnam veterans, however, were no more likely to report other reproductive outcomes examined (pregnancies ending in an induced abortion, tubal pregnancies, and stillbirths) (Centers for Disease Control, 1988d).

Cancers were reported among children of Vietnam (25 cases) and non-Vietnam (17 cases) veterans, with an OR of 1.5 (95% CI = 0.8-2.8). When these childhood cancers were examined by type, the predominant type reported for both cohorts was leukemia, with 12 cases among children of the Vietnam veterans and 7 among children of the non-Vietnam veterans, with a crude OR of 1.6 (95% CI = 0.6-4.1).

Over half of the reported childhood health problems were attributed to respiratory diseases (mostly asthma or pneumonia) and diseases of the ear (primarily otitis media). The adjusted OR for all reported disease categories is 1.3 (95% CI = 1.2-1.4). For most disease categories, Vietnam veterans reported more health problems among their children than did non-Vietnam veterans (Centers for Disease Control, 1988d).

An analysis of reported infant mortality (death occurring before the first birthday of a live-born infant) and child mortality (death occurring after the first birthday) showed no appreciable differences between children of Vietnam and non-Vietnam veterans (Centers for Disease Control, 1988d).

5.0 DISCUSSION

5.1 STRENGTHS AND LIMITATIONS

The VES has several principal strengths: (1) the random sampling method used to identify large representative cohorts of Vietnam and non-Vietnam U.S. Army veterans, (2) the measures used to assure good comparability of the two cohorts, (3) the rigorous vital status ascertainment and cause of death classification methods, (4) the high participation rates in the interview component, (5) the comparability of the examined cohorts (in the face of differential participation rates), (6) the attempt at independent validation of certain interview outcomes, and (7) the meticulous data quality control and bias-avoidance methods used in all components of the study. In addition, veterans were rarely misclassified as to cohort status.

The VES has four principal limitations: (1) the long time that has elapsed since the end of the Vietnam conflict, (2) the differential participation rates in the examined cohorts, (3) the lack of any reliable indirect estimate of Agent Orange exposure (the study was not designed to focus on Agent Orange exposure), (4) and the fact that the VES "exposure," the Vietnam experience, represents a large variety of individual experiences (*e.g.*, combat exposure) that are probably not homogeneous. In addition, in the reproductive outcome component, we did not have data on the personal characteristics and exposures of the mothers (although there is no reason to believe that the two groups of wives, like the two closely similar cohorts of men, are not also closely similar). Further, the extremely large number of questions asked in the interview component virtually precluded our validation of the responses through checking corresponding medical records.

Biases in the design or conduct of any study may affect the results. Information (or detection) bias needs to be considered. Certainly, some of the increased prevalence of self-reported conditions among Vietnam veterans could have been due either to their enhanced recall of these conditions compared with the recall of non-Vietnam veterans or to differences in the health care-seeking behavior of the two groups. If the Vietnam veterans tended to seek health care more frequently, they would probably receive more "diagnoses" from physicians, thus making it easier for them to recall these "conditions" upon interview. Such biases, however, should have little effect on the findings based on medical examination. The examiners and technicians did not know the participants' place of service, nor were they allowed to take any "history" from the participants while they were conducting the routine examinations. Staff members who obtained and abstracted birth records were also "blinded" as to the military history of all veterans.

Another concern is the possibility of selection or participation bias. The selection criteria for the study cohorts were designed to identify two groups of veterans whose characteristics at the time of enlistment were as comparable as possible, and there is evidence that this goal was achieved. Participation bias should be minimal for the interview component, since participation rates were high. For the medical examination, however, the participation rates were lower, especially for the non-Vietnam group. Detailed analyses of reasons for nonparticipation and of the characteristics that influenced participation did not, however, show marked differences in demographic or past medical characteristics between the interview participants and the examination participants. The findings are also not likely to be explained on the basis of common important confounding factors such as age, race, and selected personal habits known to affect health, since the two cohorts were similar with

respect to these factors. Furthermore, the results of additional analyses, adjusted for several health-influencing characteristics, did not change the results.

5.2 PSYCHOLOGICAL OUTCOMES

Veterans and others have been concerned about the psychological health of those who participated in the Vietnam conflict (Blank, 1982; Egendorf *et al.*, 1981; Helzer *et al.*, 1979; Laufer *et al.*, 1984; Robins *et al.*, 1974), particularly about how they have adapted to their return to civilian life. In this study, 15 to 20 years after their return, Vietnam veterans appear to have social and economic characteristics similar to those of Army veterans who did not serve in Vietnam. Very few in either group were found to be in jail, institutionalized, or mentally or physically incapacitated. In both groups about three quarters are now married, 55% are married to their first wife, and over 90% expressed satisfaction with their family and other personal relationships. Over 90% in both groups are now employed. After differences present at induction into the Army are accounted for, educational levels, types of occupation, and household incomes of the two groups are similar.

Although outwardly the two groups seem to have made similar adaptations to civilian life, the results of this study also show that the Vietnam group contains more men who still have psychological problems, revolving mainly around alcohol abuse or dependence (14% versus 9%), anxiety (5% versus 3%), and depression (4% versus 2%). About 15% of Vietnam veterans have "ever experienced" combat-related PTSD, and about 2% experienced the disorder during the month before examination.

Current drug abuse or dependence was not more prevalent among Vietnam veterans. Fewer than 1% in each cohort met DIS criteria for current drug abuse or dependence. The mortality component of the VES found an excess of drug-related deaths in the Vietnam cohort which persisted beyond the first 5 years after discharge from the Army, but the number of such deaths in each cohort was two or less per year (Boyle *et al.*, 198?). The VES telephone interview results, however, indicate that current regular use of illicit drugs was similar among Vietnam and non-Vietnam veterans. Drug use, typically, involving only marijuana, was reported by about 10% of Vietnam and 8% of non-Vietnam veterans. Use of illicit drugs other than marijuana was reported by about 2%-3% in each group.

When DIS and MMPI findings were combined to identify men with substantial evidence of being in a "poor psychological status," more such men were found in the Vietnam group, particularly among those veterans who entered the Army before 1968. This excess persisted after the results were adjusted for other risk factors (low GT score, entry into the Army under age 19, nonwhite ethnicity). The increased psychological risk among those sent to Vietnam before 1968, diminishing thereafter, suggests that some change may have occurred around 1968. Although we are not certain exactly what the change may have been, the range of possibilities includes changes in the nature of the Vietnam conflict, changes in societal attitudes about the conflict, changes in Army selection or training methods, and changes in attitudes or expectations of men entering the Army.

The prevalence of psychological problems among Vietnam veterans with a tactical MOS did not differ appreciably from those with other MOS classifications, except that PTSD has been more prevalent among those with a tactical MOS.

This current small excess (a few percentage points) of psychological problems among the Vietnam veterans could be due to study biases, but this is not likely. The excess does not appear to have been due to characteristics of the Vietnam veterans, since the characteristics

of the two groups, as described in military records, are very similar. The only difference in entry characteristics was that those with higher entry GT scores were less likely to have been sent to Vietnam. This difference was small, however, and did not account for the different psychological findings for the two groups. The self-reported prevalence of childhood behavioral problems was also nearly identical for the two groups as were prevalences of preservice psychological symptoms of anxiety, depression and substance abuse.

Physical health status is also not likely to have distorted the psychological results. Few differences were found between the two groups in neuropsychological performance, neurological findings, or other objective measures of physical health (Centers for Disease Control, 1988b). This fact may also be interpreted as indicating that although the psychological differences observed between the two groups may account for at least some of the excess of somatic symptoms reported by the Vietnam group, the psychological problems were not severe enough to have produced many signs of current functional impairment.

Military service in Vietnam was, undoubtedly, an emotionally and psychologically difficult experience for many U.S. servicemen. The increased prevalence of certain psychological and emotional problems among Vietnam veterans is probably a residual of the stresses caused by service in Vietnam, extended perhaps, by additional stresses of returning to an unsupporting and sometimes hostile climate in the United States.

5.3 PHYSICAL OUTCOMES

Our finding of many differences between the two groups in health history but very few differences in current objective signs has several possible explanations. One could be that some aspects of the Vietnam experience caused a wide range of illnesses soon after the men returned to civilian life, but that these illnesses have now subsided to the point that objective signs are no longer detectable. Another possible explanation is that the increased anxiety and depression observed in the Vietnam cohort resulted in a variety of somatic symptoms, which increased the number of visits to a doctor, the possibilities for receiving a "diagnosis," and the likelihood of a positive response to questions about health problems during the interview. This is a well-recognized pattern in reactions to stress (Kellner, 1987).

Although we analyzed numerous objective measures of health, we found very few differences between the two cohorts. Stool occult blood was more prevalent among Vietnam veterans—a finding that is difficult to explain in terms of military service in Vietnam. The fact that we included so many health measures in the screening examinations increased the probability that we would find some spurious (chance) differences. In any event, this abnormality was rare, affecting less than 2% in either group, and the absolute difference between the two cohorts was less than 1%.

Two other conditions found in excess among Vietnam veterans—hearing loss and past hepatitis B infections—can be explained on the basis of assignment to Vietnam. Increased hearing loss, particularly among those with a tactical MOS, is consistent with results of several studies showing that exposure to military noise leads to irreversible hearing impairment (Brown, 1985; Man *et al.*, 1975; Walden *et al.*, 1975). Similarly, the higher prevalence of evidence of past hepatitis B infection among Vietnam veterans is consistent with prior service in a country where this viral infection is endemic in the local population (Snitbhan *et al.*, 1975).

Although the VES design did not focus exclusively on conditions thought to be related to exposure to dioxin-contaminated herbicides, such conditions were included in the screening

examinations. We found no differences between the two cohorts in any such outcome (Centers for Disease Control, 1988b), including chloracne and other skin conditions, peripheral neuropathy, hepatic dysfunction, porphyria, serum lipid abnormalities, and impaired cell-mediated immune function. This lack of differences may be related to the time that has elapsed since exposure in Vietnam. Most of the conditions of interest, such as chloracne or peripheral neuropathy, may have resolved during the last 15-20 years. Alternatively, the two groups may not have differed in their exposure, or perhaps so few in the Vietnam group were heavily exposed that such men were seldom included, if at all, in our Vietnam sample. When the VES was begun, an objective measure of herbicide exposure was not available. In a recent study of Vietnam-era veterans, however, a new technique for directly measuring dioxin in blood serum was used to demonstrate that very few in a sample of over 600 U.S. Army Vietnam veterans had significant exposure to dioxin-contaminated herbicides (Centers for Disease Control, in press).

In these two groups of fairly young men, we expected to find only a few cancer cases. The numbers of cancer cases observed so far are, in fact, too small for analysis, and no trends suggestive of any differences between cohorts have been identified as yet. A continuing mortality follow-up is planned, and a case-control cancer study is ongoing, with an expected 1990 publication date (Centers for Disease Control, 1983).

At first, semen analysis was not part of the examination schedule, but because more Vietnam veterans were reporting difficulties in conceiving children, it was added toward the end of the study. Analysis of the results for the 571 who participated in the semen study showed that Vietnam veterans had lower sperm concentrations and a lower average proportion of spermatozoa with a "normal" head size and shape. These findings are difficult to interpret, because the association between such deficiencies and fertility potential is not well established. Researchers generally agree, however, that major reductions in sperm quantity or quality are associated with reduced fertility (Meistrich and Brown, 1983; Smith *et al.*, 1977; Wickings *et al.*, 1983; Zukerman *et al.*, 1977). Low values for sperm concentration, for normal sperm head shape, and for percent of motile sperm have traditionally been used as indicators of reduced fertility potential (Alexander, 1982; Belsey *et al.*, 1980; MacLeod and Gold, 1951a; MacLeod and Gold, 1951b; Wyrobek *et al.*, 1983). In the VES, veterans in the Vietnam group were twice as likely to have low sperm concentrations (<20 million per milliliter) and 60% more likely to have low levels (<40%) of "normal" sperm heads than veterans in the non-Vietnam group. Although the latter finding was not statistically significant, it was in accord with the significantly lower mean proportions of "normal" spermatozoa among Vietnam veterans. The two groups had about the same proportion of men whose semen samples were judged as being low (<40% motile cells) for motile sperm.

The implications of these differences in semen characteristics for pregnancy outcomes are less clear. Results of some investigations in animals, mainly mice, suggest a relationship between induced sperm changes and heritable genetic damage, but no studies among humans have clearly shown that sperm head changes are related to adverse reproductive outcomes (Wyrobek *et al.*, 1982) or that they are associated with birth defects. Case reports and results of early studies suggested that poor semen quality was associated with ill-fated pregnancies (Joel, 1966; MacLeod and Gold, 1957), but results of a more recent study showed no evidence that diminished semen quality is associated with spontaneous abortions (Homonnai *et al.*, 1980).

Within each cohort, the fertility histories of all interview participants were generally similar to those whose semen characteristics were evaluated (Centers for Disease Control, 1988b). Of the veterans in each cohort who reported past difficulties in begetting children after trying for one or more years with one partner, three-quarters have eventually fathered children. Even among those who have been told by a physician that they had a particular condition that would impair their fertility, about 60% have fathered children. Furthermore, in each cohort the average number of children fathered per veteran after assignment to primary tour of duty is identical (1.6 children), as is the proportion who have not fathered any children (23%). This finding is consistent with that of another study in which fertility was evaluated over a 20-year period among men with low sperm counts (Bostofte *et al.*, 1982). Those investigators found that lower sperm counts correlated with an increasing time interval needed to achieve pregnancy, but that pregnancy rates were not affected unless the sperm count was below 5 million cells per milliliter.

We cannot determine the reasons for the differences in sperm characteristics between Vietnam and non-Vietnam veterans. We evaluated several factors that are known to affect or are suspected of affecting sperm characteristics, including race, age, and reported use of alcohol, marijuana, other drugs, cigarettes, and certain medications. None of these factors accounted for the differences in sperm characteristics observed in these two groups. We also found that the more prevalent psychological problems in Vietnam veterans (anxiety, depression, PTSD) did not account for the sperm differences (Centers for Disease Control, 1988b). Neither were past self-reported sexually transmitted diseases related to the differences, nor were technical factors, such as the time between last ejaculation and sperm collection or time between specimen collection and analysis.

The differences in sperm characteristics between the two groups did not appear to be specific to particular subgroups of veterans. In the two cohorts, the semen findings did not vary consistently with Army entry and service characteristics, including year of entry, tactical MOS, reported use of heroin or other drugs while in the Army, level of combat experienced, nor any of the three different self-reported levels of exposure to herbicides.

5.4 REPRODUCTIVE OUTCOMES

Vietnam veterans were more likely to report not only more health problems for themselves, but also more of most types of adverse reproductive events and health problems in their children. The only exceptions to this pattern were induced abortions, tubal pregnancies, stillbirths, and child mortality. Except for reports of birth defects, we found that it was not feasible to verify such reports by using objective data sources, because the sample of births was so large and the possible reproductive and child health outcomes so numerous. Consequently, the possibility of differential recall or reporting, or both, must be considered when the interview results are being interpreted.

For birth defects, a second source of information not subject to differential reporting was available for a subgroup of children included in the main birth records substudy. This substudy had an 80% power to detect a relative risk of 1.4 for total birth defects in the two subgroups of children for whom birth records were received. The number of subjects in the substudy, however, was not large enough for us to assess cohort differences for specific birth defects. For all races combined, we found no differences between children of Vietnam and non-Vietnam veterans in the prevalence of total, major, minor, or suspected birth defects documented in hospital birth records. This finding supports the explanation of differential

reporting in the interview and the conclusion that (at least for birth defects evident at birth) children of Vietnam veterans were not at increased risk.

The reasons for the apparent racial variation in the association between Vietnam service and total birth defects found in the hospital records substudy are unclear. The findings for black offspring may be explained, in part, by the occurrence of polydactyly and supernumerary nipples in several members of two families; furthermore, some investigators have suggested that both of these conditions have a strong genetic component, most likely autosomal dominant inheritance (McKusick, 1986). In addition, the results are based on small numbers of offspring among black and Hispanic veterans, so the racial variation may be due to sampling variability (Centers for Disease Control, 1988d).

The veterans in the main substudy of total birth defects were selected from those veterans who completed the medical examination. Detailed analyses of the results for the examination participants compared with those of the telephone interview participants did not show differences in characteristics or health histories (Centers for Disease Control, 1988b). In addition, the proportion of veterans in each cohort who participated in this substudy was very high, and, moreover, the two cohorts were similar with respect to various demographic and military covariates (Centers for Disease Control, 1988d). Thus, in this substudy, there is no evidence of selection bias or participation bias. In addition, the participants were selected independently of the interview reports, and, consequently, the selection was not likely to be biased by potential differential reporting between the two veteran cohorts.

One limitation of these studies is the lack of data about the mothers of the children studied. Only limited maternal information (age and gravidity) was uniformly recorded in the hospital birth records. Other maternal behaviors and exposures, such as to tobacco, alcohol, and drugs, may be important for a more complete assessment of the outcomes studied. Given the similarity of sociodemographic and behavioral characteristics between the fathers in the two cohorts, however, it seems unlikely that maternal characteristics would differ greatly. In this study, we have extensive information on paternal characteristics, but very little is known about the association of paternal behaviors or exposures and birth defects in children.

The CSM substudy was designed to identify possible CSM cases, on the basis of interview reports, and to verify them by using birth records. No attempt was made to verify negative responses (*i.e.*, children with no reported CSM), because these defects are very rare, occurring at a rate of only 1.4 to 2.5 per 1,000 total births (Birth Defects and Genetic Diseases Branch, CDC, 1987a; 1987b). The total number of verified CSMs in the Vietnam cohort is similar to the number that would be expected in the interview population on the basis of rates for these defects in two U.S. birth defect surveillance systems (Birth Defects and Genetic Diseases Branch, CDC, 1987a; 1987b) (Table 21). In contrast, the number of records-based CSM cases among children of non-Vietnam veterans is much lower than would be expected (Table 21). This suggests a deficit of ascertained CSMs among children of non-Vietnam veterans, rather than an excess among children of Vietnam veterans. These data may reflect true differences between the cohorts, or they may reflect differences in the opportunity to identify and verify probable CSM cases. There is evidence to suggest the latter explanation, since participants were selected for this substudy on the basis of the fathers' interview reports and, hence, the selection was subject to differential reporting in the two cohorts. Further, participation rates differed appreciably; Vietnam veterans were much more likely to participate in this substudy than non-Vietnam veterans (Centers for Disease Control, 1988d).

Table 21. Observed Numbers of Cerebrospinal Malformations and Expected Numbers Based on Two U.S. Surveillance Systems

Cerebrospinal Malformation	Vietnam		Non-Vietnam	
	Observed	Expected[a]	Observed	Expected[a]
Anencephaly	10	5.0-9.0	7	4.6-8.4
Spina bifida	9	7.2-12.2	2	6.7-11.4
Hydrocephalus	7	6.1-11.2	3	5.7-10.5
Total	26	18.3-32.4	12	17.0-30.3

[a] Expected numbers are based on total rates from the nationwide Birth Defects Monitoring Program (lower estimates) (Centers for Disease Control, 1987 data) and race-specific rates from the Metropolitan Atlanta Congenital Defects Program (upper estimates) (Centers for Disease Control, 1985 data).

Our results for total birth defects can be compared with the results of three previous epidemiologic studies of Vietnam service and reproductive outcomes of male veterans. The first two, conducted by the Australian government and CDC, were large case-control studies of children born with congenital malformations. In the first study (Donovan *et al.*, 1983), defects were identified through hospital and cytogenetic laboratories, and, in the second (Erickson *et al.*, 1984), through a population-based registry. The third study was a cohort follow-up study of Air Force personnel who conducted the defoliation missions in Vietnam and a comparison cohort of cargo-mission personnel who flew to Vietnam but were not involved in spraying operations (Lathrop *et al.*, 1984). In this study, information about reproductive outcomes was obtained mainly through interviews with spouses. Results of both the Australian study and the CDC study showed no difference in the odds of Vietnam service among case and control fathers for all types of defects combined (ORs = 1.02 and 0.97, respectively). Even these large-scale studies, however, could not adequately address whether Vietnam veterans, or a subgroup of Vietnam veterans, were at increased risk of fathering babies with specific rare malformations. Results of the Air Force cohort follow-up study showed a significant excess of total reported birth defects among children of personnel conducting the defoliation missions. This reported excess prompted them to collect birth and medical records for all children—an effort that is currently ongoing.

In summary, Vietnam veterans reported more adverse reproductive and child health outcomes in the telephone interview than did non-Vietnam veterans. Results of a substudy of birth defects documented on hospital birth records showed, however, that Vietnam veterans were not at increased risk of fathering children with birth defects evident at birth. These results are consistent with the findings of three epidemiologic studies conducted since 1981 on the relationship of Vietnam service and birth defects among children of male veterans.

5.5 SELF-REPORTED HERBICIDE EXPOSURE

The Vietnam Experience Study was not designed to evaluate the association between herbicide exposure and adverse health outcomes. However, during the telephone interview component of the study, Vietnam veterans were asked a series of questions about possible exposure to herbicides in Vietnam. This information was used to look at the association between self-reported herbicide exposure and health outcome data obtained from the telephone interviews and the medical and psychological examinations.

These data show that Vietnam veterans who reported exposure to herbicides while in Vietnam also reported (during the telephone interview) more postservice diseases and

symptoms and more adverse reproductive and child health outcomes than did veterans without reported herbicide exposure. In addition, there is a positive association between self-reported herbicide exposure and selected medical symptoms and psychological problems identified during the medical and psychological examinations. On the other hand, Vietnam veterans who denied exposure to herbicides tended to report diseases and symptoms at rates similar to rates for non-Vietnam veterans.

To further evaluate this issue, we examined the relationship between self-reported herbicide exposure and four conditions from the medical examination—peripheral neuropathy, pulmonary dysfunction, cardiac ischemia, and peripheral vascular disease—for which we had both objective information (signs) and subjective information (symptoms). For each of the four conditions, the proportion of veterans with symptoms was greater among those who reported herbicide exposure compared with those who reported no exposure (Table 22). In contrast, the proportions of veterans with only subclinical signs of disease (abnormal test results without symptoms) were the same for those reporting exposure compared with those reporting no exposure. In addition to these data, results of a companion CDC study of dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) levels in blood showed no association between self-reported herbicide exposure in Vietnam and current serum dioxin levels. Furthermore, the results of that study suggested that few Army combat troops had been heavily exposed to dioxin-containing herbicides in Vietnam.

The findings presented above indicate that the associations between reported health outcomes and self-reported herbicide exposure are probably due to an increased perception of herbicide exposure among those who are symptomatic. We do not know the reasons for this, but a possible explanation is that those with symptoms may need to attribute them to an external cause. Continued media attention and lawsuits concerning the Agent Orange issue may have focused some Vietnam veterans on the possible health effects of herbicide exposure, making them more aware of various symptoms and providing them with an explanation for these health problems.

More detailed information on this issue of self-reported herbicide exposure is contained in Volumes II-V of this monograph.

Table 22. Percent of Vietnam Veterans With Physical Health Findings and Symptoms by Self-Reported Herbicide Exposure Index

	Herbicide Exposure Index			
Findings and Symptoms[a]	None (N=1051) %	Low (N=762) %	Moderate (N=561) %	High (N=109) %
Peripheral Neuropathy				
Signs without symptoms	8.4	7.6	8.6	6.4
Symptoms regardless of signs	2.0	5.6	11.8	11.9
Pulmonary				
Abnormal PFT without symptoms	10.7	9.2	11.8	7.3
Any symptoms regardless of PFT results	14.9	26.6	30.8	45.9
Cardiac Ischemia				
ECG signs without symptoms	1.7	1.2	0.5	0.9
Any symptoms regardless of ECG signs	14.1	21.0	28.0	34.9
Peripheral Vascular Disease				
APAH without symptoms	3.8	5.0	4.6	4.6
Claudication regardless of APAH findings	1.2	2.9	4.3	9.2

[a] See Volume III, Chapter 14, for definitions of signs and symptoms. PFT = pulmonary function test; ECG = electrocardiogram; APAH = altered peripheral arterial hemodynamics.

6. CONCLUSIONS

Indicators of current socioeconomic status show that U.S. Army Vietnam veterans in this study were almost on a par with other Vietnam-era veterans, yet the two groups responded differently to questions about their health history and psychological status. As a group, the Vietnam veterans report 15-20 years after Vietnam, that they and their children have more health problems than do their non-Vietnam peers. The overall increase of reported health problems among Vietnam veterans covered a wide range of conditions. The differences varied among the conditions, but tended to be only a few percentage points.

Although Vietnam veterans reported more health problems during the telephone interviews, physical and laboratory examinations found few current differences between the two groups. The most noteworthy differences included hearing loss, stool occult blood, evidence of past hepatitis B, lower sperm concentrations, and lower average proportions of morphologically "normal" sperm cells. Despite these last two findings, the average number of children fathered per veteran in each cohort after assignment to primary tour of duty was identical (1.6). Additionally, based on the results of a substudy of birth defects documented on hospital birth records, Vietnam veterans were not at increased risk of fathering children with birth defects evident at birth.

The psychological evaluations showed that 15 to 20 years after the war, Vietnam veterans have more psychological and emotional problems compared with veterans who did not serve in Vietnam. Alcohol abuse or dependence, anxiety, and depression were all more prevalent among Vietnam than non-Vietnam veterans. Also, about 15% of the Vietnam veterans have ever experienced combat-related PTSD, and about 2% experienced the disorder during the month before examination. These psychological problems, however, are not of a magnitude that has resulted in Vietnam veterans having, as a group, lower social and economic attainment.

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