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POSTSERVICE MORTALITY AMONG VIETNAM VETERANS

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SUMMARY

This report presents results of the mortality component of the Vietnam Experience Study (VES). The VES is a historical cohort study in which the health of 9,324 Vietnam veterans is compared with that of 8,989 Vietnam-era veterans who served in Korea, Germany, or the United States. Eligibility for the study was limited to male U.S. Army veterans who first entered military service between 1965 and 1971, served a single term of enlistment, and were discharged in the enlisted pay grades E-1 to E-5. Participants were randomly selected from computerized lists of accession numbers of military personnel files of Army veterans discharged during the relevant time period. Ascertainment of deaths occurring after discharge from active duty and before January 1, 1984 was done using several methods, ranging from computer linkages to personal contact with next-of-kin, resulting in practically complete death ascertainment for both cohorts. In addition to an analysis based on death-certificate cause of death, a medical review panel independently assigned an underlying cause of death using information from supplemental sources, including hospital records, autopsy reports, personal physician contacts, and coroner and law enforcement files.

Veterans of service in Vietnam were found to experience a 17% higher rate of postservice mortality than veterans who served in Korea, Germany, or the United States. As expected in such a study of young men, the majority of deaths in both cohorts were due to external causes. The most noteworthy pattern of overall mortality was the changing difference between Vietnam and non-Vietnam veterans over time. During the first 5 years postdischarge, mortality among Vietnam veterans was 1.45 times the death rate of non-Vietnam veterans (95% CI=1.08-1.95). During the succeeding years, there was virtually no difference between the two groups (RR=1.01, 95% CI=0.79-1.28). This pattern was generally consistent across most demographic and military subgroups of veterans. However, there was some indication that Vietnam veterans with some physical impairment at entry into service, those who were drafted into service, and those discharged before 1970 were at an especially high risk of dying during the first 5 years after discharge compared with their non-Vietnam counterparts. When the data were stratified by type of military unit and military occupational specialty, the relative risks of mortality were similar for those more or less likely to have engaged in combat. Unlike the finding of especially high excess mortality among Australian Vietnam veterans who served in the Engineer Corps, no excess was found among engineers in this study.

External causes accounted for most of the increased mortality in the early postservice period. Deaths due to motor vehicle accidents (MVA) were significantly increased during this time (RR=1.93, 95% CI=1.16-3.22). A more detailed examination of MVA deaths did not indicate any particular factor that could explain the overall excess in Vietnam veterans. The increased risk did not appear to be related to elevated blood alcohol levels at the time of death, and the risk was evident regardless of the type of MVA. Drug use information on MVA victims was limited, and the medical review panel identified only one drug-related MVA death from available supplementary records. Suicide and homicide showed similar increases (RRs=1.72, 95% CI=0.76-3.88 and 1.52, 95% CI=0.59-3.91, respectively) in the early follow-up period but the rate ratios were not statistically different from 1.0. Mortality from accidental poisoning was elevated throughout the follow-up period, although the number of such deaths was small. Most of these involved

the use of illicit drugs. When all drug-related deaths identified by the medical review panel were analyzed together, there appeared to be an increasing relative risk with number of years since discharge. The only natural cause of death category for which the mortality rate among Vietnam veterans differed from that among non-Vietnam veterans was circulatory system diseases. Vietnam veterans had a surprising deficit in such deaths relative to non-Vietnam veterans (RR=0.49, 95% CI=0.25-0.99). Statistical adjustment for potential confounders had little effect on the results, except for suicide where adjustment increased the RR in the early postservice period to 2.54 (death certificate data).

These results are similar to previous observations of increased mortality from external causes among World War II and Korean War combat veterans. In contrast, broader cross sections of World War II veterans, including combat and noncombat groups, showed no difference, or even a deficit, in postdischarge traumatic deaths, as did non-Vietnam veterans in this study. Although the influence of factors specific to the Vietnam experience cannot be completely ruled out, our findings and those of prior studies suggest that the postservice excess of traumatic deaths among Vietnam veterans is probably related to unusual stresses the veterans endured while stationed in a war zone.

The pattern of drug-related mortality among Vietnam veterans seems to differ from that of external causes of death. The drug-related excess is most pronounced among draftees, among those whose jobs involved combat operations, and among those who served in Vietnam during 1968 and 1969, the years of heaviest combat activity. Thus, the increased death rate from drug-related causes among Vietnam veterans may be linked to intensity of combat exposure rather than to a general effect of the Vietnam experience.

This mortality assessment of Vietnam veterans is an incomplete evaluation of their health experience. Additional data on the present and past health status of living Vietnam veterans will be forthcoming from the health interview and the medical, psychological, and laboratory evaluation components of the VES. Furthermore, since this group of veterans has not yet reached the age-span where chronic diseases have an important impact on mortality, continued monitoring of mortality among VES participants may provide additional insights.

1. INTRODUCTION

In response to Vietnam veterans' concerns about their health, the Centers for Disease Control (CDC) has proposed three distinct, but related, epidemiologic studies:

- a) The Vietnam Experience Study (VES) is a historical cohort study to ascertain whether adverse health effects are associated with service in Vietnam.
- b) The Agent Orange Study is a historical cohort study to ascertain whether men with possible exposure to the phenoxy herbicide code-named Agent Orange while in Vietnam, have experienced any health problems related to that exposure.
- c) The Selected Cancers Study is a concurrent, population-based case-control study to ascertain whether Vietnam veterans are at increased risk of particular types of cancer that occur too infrequently to be evaluated adequately in the two cohort studies.

The first two studies include three methods of health assessment: a mortality assessment, health interviews of living veterans, and a clinical, psychological, and laboratory assessment of a random sample of those who complete the health interview. This report presents results of the mortality component of the VES.

1.1. GENERAL BACKGROUND OF THE STUDY

Many Vietnam veterans believe that their service in Vietnam and, more specifically, their exposure to Agent Orange have increased their risks for a wide variety of illnesses. Health concerns include dermatologic conditions, cancer, and congenital anomalies among their offspring. Unfortunately, little objective evidence about the physical health of Vietnam veterans is available.

In response to these concerns and the lack of objective data, the United States Congress passed two laws mandating that the Veterans Administration (VA) conduct epidemiologic studies of the health of veterans of the Vietnam conflict. Public Law 96-151 (1979) specifies the conduct of an epidemiological study of U.S. veterans to assess the possible health effects of exposure to herbicides and associated dioxins during the Vietnam conflict.¹ Public Law 97-72 (1981) expands this mandate to include the study of other environmental exposures that may have occurred in Vietnam.² In January 1983, the responsibility for the design, conduct, and analysis of studies responsive to these laws, first assigned to the VA, was transferred by an Interagency Agreement to CDC. In May 1983, CDC prepared a draft protocol that underwent extensive peer review,* and in November 1983, issued a revised protocol.³

* This included formal reviews by the Office of Technology Assessment Agent Orange Advisory Panel, the DHHS Advisory Committee on Special Studies Relating to Possible Long-Term Health Effects of Phenoxy Herbicides and Contaminants ("Ranch Hand Panel"), the Agent Orange Working Group Science Panel, and a Centers for Disease Control Ad Hoc Review Panel.⁴

1.2. PREVIOUS MORTALITY STUDIES OF VIETNAM VETERANS

When the present study was designed, little was known about the long-term physical health consequences, including death, of military service in Vietnam. Since that time, six mortality studies of Vietnam veterans have been reported. Five were conducted in the United States, and the sixth dealt with Australian military personnel who served in Vietnam.

The first of the five mortality studies of U.S. servicemen was conducted by the U.S. Air Force.⁵ It was a retrospective cohort study of Air Force personnel involved in the aerial herbicide spraying operation in Vietnam designated "Operation Ranch Hand." Although the differences were not statistically significant, Ranch Hand flight crews had slightly lower death rates than other Air Force personnel of similar military rank and occupation, and Ranch Hand ground personnel had slightly higher death rates than the comparison group. However, since the principal concern of the Ranch Hand Study was the adverse health effects of herbicide exposure in this unique group of veterans, the relevance of the Ranch Hand results to our study is questionable.

Four other mortality studies of U.S. Vietnam male veterans were conducted by the State health departments of Massachusetts, New York, Wisconsin, and West Virginia.⁶⁻⁹ All were death certificate-based proportionate mortality studies, which are useful in detecting unusual patterns in cause-specific deaths. However, without actual mortality rates it is difficult to determine whether an increased frequency for one cause of death reflects a true rise in risk for that cause or a deficit in other causes of death. In addition, the Massachusetts and West Virginia studies are based on nonrandom samples of deaths, and it is unclear whether some selectivity in identifying deaths occurred.

The Massachusetts study compared causes of death among Vietnam veterans with those among Vietnam-era veterans who did not serve in Vietnam and among nonveteran males from Massachusetts.⁶ Vietnam service was determined from a computer-based list of veterans who had applied for a military service bonus awarded by the Massachusetts Office of Veterans Services. The most striking finding of the study was a markedly increased number of connective tissue cancers in Vietnam veterans (9 observed versus 1 expected, based on the mortality pattern of non-Vietnam veterans). No other causes of death were significantly elevated in Vietnam veterans.

The study by the New York State Department of Health compared cause-specific mortality patterns of New York State Vietnam veterans with those for non-Vietnam veterans.⁷ Vietnam service status was determined by matching the computer-based record systems of the Defense Manpower Data Center (Department of Defense) and the VA Beneficiary Identification and Record Locator Subsystem (BIRLS). The strongest association with Vietnam service involved deaths from nonmotor-vehicle injuries of transport.

The Wisconsin study examined mortality among Vietnam veterans, other Vietnam-era veterans, veterans not of the Vietnam era, and nonveterans within the State of Wisconsin.⁸ Deaths among Vietnam era veterans were identified from a Wisconsin Department of Veteran Affairs Graves Registration File, and Vietnam status was determined from military personnel files. Relative to other Vietnam-era veterans, those who served in Vietnam had excess mortality from cancer of the pancreas, diseases of the genitourinary system, and pneumonia. An excess of connective tissue cancer was noted when Vietnam veterans were compared with veterans not of the Vietnam era (5 deaths observed

versus 0.3 expected). No significant excess was noted, however, when Vietnam veterans were compared with other Vietnam era veterans or with nonveterans (5 deaths observed versus 3 expected).

The West Virginia study examined causes of death among deceased Vietnam-era veterans who had been given a military service bonus by the State Department of Veterans Affairs.⁹ Among 615 such veterans who had served in Vietnam there was a slightly larger proportional mortality ratio (PMR=1.11) for suicide and for motor-vehicle accidents (PMR=1.07), using for comparison the general male population of the same age. Non-Vietnam veterans exhibited about the same results for motor-vehicle accidents, but their suicide experience was not unusual. Both Vietnam and non-Vietnam veterans experienced increased mortality from cancer of the respiratory tract, but increases in relative frequency of death from cancer of connective tissues (3 observed versus 0.7 expected) and Hodgkin's disease (5 observed versus 2.4 expected) were confined to Vietnam veterans. When Vietnam veterans were compared directly with non-Vietnam veterans, these excesses persisted, and, in addition, there were more deaths among Vietnam veterans from testicular cancer (3 observed versus 0.6 expected).

The study of Australian Vietnam veterans was a retrospective follow-up of mortality from 1965 to 1981 among 19,205 Vietnam veterans and 25,677 veterans who did not serve in Vietnam.¹⁰ Both groups had a lower overall mortality rate than the general population of Australian men of similar age, but Vietnam veterans had a 29% higher overall death rate than those who did not serve in Vietnam. Interestingly, the excess was due mainly to an increased rate among Vietnam veterans in the Engineer Corps (rate ratio=2.5). In addition to an overall elevated death rate, Vietnam veterans had increased death rates for digestive system diseases, diseases of the circulatory system and external causes. The death rates from neoplasms (all types combined) were similar in the two groups.¹⁰

1.3. RATIONALE AND RESEARCH QUESTIONS

Aside from the obvious importance of studying premature deaths because of the human tragedy they represent, there are several methodologic reasons why a detailed study of mortality is essential in a comprehensive evaluation of the health consequences of military service in Vietnam. First, death is an objective health outcome, not subject to some of the potential biases of self-reported health information. Second, the prevalence of certain health outcomes can be assessed accurately only if deaths due to them are included in the analysis. For example, a sizeable proportion of people with cardiovascular diseases and certain cancers die within a short time after the onset of the disease, as do those with very serious intentional or unintentional injuries, thus becoming unavailable for interview or examination in a subsequent study. This would lead to a serious underestimation of rates for such conditions in a retrospective study, unless mortality is included. Finally, a study of mortality may be the only feasible mechanism for continued surveillance of the study cohort after the current VES ends. This is critical for serious health effects which may first become manifest more than 15 years after service in Vietnam.

At the time the VES was conceived, the research objective was simply to examine the relationship between Vietnam service and deaths from all causes combined as well as specific causes of death. This objective stemmed from the rationale that the "Vietnam Experience" was a generic term for a wide range of

health-influencing exposures operating among those who served in the military in Vietnam. Included in the "experience" are known exposures, such as the psychological stresses of war, possible exposure to various infectious diseases prevalent in Vietnam, possible misuse of drugs and alcohol, and possible exposure to the defoliant Agent Orange, as well as many unknown exposures. These factors are unmeasured in this study; therefore, it is not possible to examine directly their relation to mortality. However, based on the observed patterns of mortality, speculation on the possible influence of one component relative to the others may be possible.

As a result of the recently reported findings from the mortality studies of Vietnam-era veterans reviewed above, special attention will be focused on the relationship of Vietnam service to deaths from external causes, specifically, motor vehicle accidents, suicide and other external causes of death. Moreover, the risk of death associated with Vietnam service will be examined in various subgroups, particularly type of unit and military occupational specialty. Although previous studies suggest a relationship between service in Vietnam and several natural causes of death, for example, soft-tissue cancers, the numbers of these deaths expected in our cohort are too few to address these questions adequately.

2. STUDY GROUP DEFINITION, DATA COLLECTION, AND FOLLOW-UP

The present study employs a historical cohort design to evaluate the risk of death among U.S. Army veterans who served in Vietnam relative to a comparison cohort of Army veterans who served during the same time period but not in Vietnam. This type of study involved identifying a cohort of Vietnam-era veterans, determining those veterans who died after discharge from active duty, and collecting detailed information on the nature and circumstances of each death.

2.1. CRITERIA FOR INCLUSION

The primary objective in defining the study and reference groups was to obtain two cohorts that were as similar as possible with regard to major health-influencing factors other than Vietnam service. Achieving this objective does not result in a representative sample of all military personnel who served in Vietnam. Comparability, however, was considered of paramount importance to increase the likelihood that any differences between the cohorts in mortality or morbidity after discharge was the result of service in Vietnam rather than the result of differences in preexisting health-related factors. To achieve this objective, only veterans meeting the following criteria were included in the study:

- a) U.S. Army veterans. The majority of military personnel who served in Vietnam were in the Army. Air Force and Navy personnel involved in the conflict were often stationed in various other parts of Southeast Asia near Vietnam. Marine Corps personnel were deployed in ways very similar to Army troops but in smaller numbers, and a very high proportion of all Marine Corps personnel of the Vietnam era spent time in Vietnam, thus making it difficult to find an adequately large comparison group of Marines without experience in Vietnam.
- b) Male veterans. On the basis of the sample size and selection process described below, too few women would be included for any meaningful conclusions to be drawn regarding the health of female Vietnam veterans.
- c) Military occupational specialty (MOS) other than "duty soldier" and "trainee." During the early stages of the study, we found that men with behavior or conduct problems were given the military occupational specialty of "duty soldier" (MOS 57A10). The probability of assignment to Vietnam for someone with this MOS may have been based more on the personal characteristics of the individual than on his specific training. A military occupational speciality of trainee (09B00) indicates that the individual never left basic or advanced training in the United States.
- d) Single term of enlistment in the Army. Veterans who reenlisted may be very different in background characteristics from those not choosing to do so. Further, reenlistment carried with it more opportunity to serve in the country of one's choice. Again, these characteristics may be associated with subsequent health. It should be noted that because of the method of sample selection, men who subsequently entered another branch of the military could be included in the cohort.
- e) Minimum of 16 weeks of active service time. Army regulations stated that servicemen could not be sent to duty stations such as Vietnam until they had completed at least 16 weeks of active service time.¹¹

- f) Pay grade E-1 to E-5 at discharge. In many combat specialties the vast majority of career soldiers had at least one tour of duty in Vietnam, making it difficult to identify a comparison group of their peers who did not have Vietnam service.
- g) Entered military service for the first time between January 1, 1965, and December 31, 1971. This corresponds to the period when a substantial number of single-term volunteer or drafted soldiers were assigned to duty in Vietnam. Before and after this period, the majority of servicemen in Vietnam were advisors (career enlisted men and officers), who were few in number and who are disqualified for one or more of the reasons given above.
- h) Duty stations for men in the comparison group limited to the United States, Germany, and Korea. On the basis of a pretest conducted by CDC in May of 1983, the vast majority of draftees and single-term volunteers who did not serve in Vietnam were assigned to these locations. More importantly, it was felt that the assignment process for other foreign countries worked differently than for the U.S., Germany, and Korea. Therefore, those who served elsewhere may be quite different in their background characteristics from those who served in Vietnam, Germany, Korea, and the United States.

2.2. SAMPLE SIZE AND POWER

The VES was designed principally to assess morbidity associated with service in Vietnam; mortality is being examined for the reasons described in Section 1.3. Power computations for the health interview phase suggested that a sample size of 6000 for each cohort was necessary to detect a relative risk of 2.0 for conditions that occur with a prevalence of 5/1000 or greater in the unexposed population (assuming the probabilities of Type I and Type II errors are 0.05).³ To obtain 6,000 completed interviews in both the Vietnam and non-Vietnam groups, the starting sample size had to account for the possibility of an estimated 15 percent non-location rate and a 15 percent interview refusal rate. Thus, the minimum number of veterans to be selected for each cohort was estimated to be 8300 (i.e., $8,300 \times 0.85 \times 0.85$).

Given about 8,500 servicemen in each of the two cohorts, the minimum detectable relative risks for overall mortality and selected causes of death are presented in Table 1. Adequate power exists to detect as statistically significant moderate increases in overall mortality and certain common causes of death. For example, the study has 95 percent power to detect a relative risk of 1.3 for overall mortality and 1.5 for deaths due to accidents. The study has good power to detect moderate increases in risk of suicide, circulatory disease, and malignant neoplasms. The study's power to detect relative increases for less frequent causes of death is limited unless a large risk is associated with Vietnam service. Additionally, the study has reasonable power to detect differences in risk for total mortality in certain subgroups of veterans. For example, if only 10% of veterans are in a subgroup of interest, a minimum relative risk of 2.0 can be detected for all causes.

2.3. SELECTION OF VETERANS

Vietnam-era veterans were randomly selected from a set of computer tapes containing "accession numbers," each of which refers to a unique military personnel record on file at the National Personnel Records Center (NPRC) in St. Louis, Missouri. NPRC supplied CDC with a restricted range of

approximately five million accession numbers for U.S. Army veterans whose service records were received by NPRC between September 1964 and June 1977. NPRC estimated that the vast majority of discharged U.S. Army Vietnam-era veterans would be included in this set.

From a pilot test conducted in September 1983, it was estimated that approximately 40% of Army veterans randomly selected from the NPRC files would meet the eligibility criteria outlined above and that approximately half of these would have served in Vietnam. Thus, to identify 16,000 to 17,000 qualified veterans, the required starting sample size was approximately 43,000 veterans.

A random number generating program was used to select the sample of approximately 43,000 accession numbers from this universe. The sample was split into 12 equal random samples for ease of processing. The decision to disqualify short-term men (less than 16 weeks of active service time), trainees, and "duty soldiers" was made after the original sample had been drawn. In order to make up for these losses, we added two additional random samples of approximately 3,500 each to the list originally drawn. Personnel records corresponding to these numbers were pulled and reviewed for the inclusion criteria listed above.

As outlined in Figure 1, 99% (N=48,513) of the random numbers generated corresponded to a unique accession number on the NPRC computer tapes. Of these, 1,355 referred to records that could not be located after several attempts. Apparently, many of these were missing because of a subsequent reenlistment after an earlier discharge. Of the 47,158 veterans whose records were located and reviewed, 61% were excluded because they failed to meet one or more of the inclusion criteria outlined above, but less than 1% were excluded because information necessary to determine study eligibility or to categorize them with respect to critical factors, such as duty station, was missing. Thus, 18,581 men qualified for the study (9,558 Vietnam and 9,023 non-Vietnam veterans).

2.4. COLLECTION OF DATA FROM MILITARY PERSONNEL FILES

Each month for 14 consecutive months, lists containing 3,500 accession numbers were sent to NPRC. NPRC located the corresponding military records (201 files) and sent them to the Army Reserve Personnel Center, formerly known as the Reserve Component Personnel and Administration Center (RCPAC), also located in St. Louis, Missouri. Each file was reviewed there for certain eligibility criteria, and a data abstraction form was initiated. Data abstraction forms and files of veterans who appeared to meet the criteria for the study were forwarded to the U.S. Army and Joint Services Environmental Support Group (ESG) in Washington, D.C., where a second qualification process was completed. Detailed information was then abstracted from the files of those veterans found to be qualified for the study. A majority of the data for the study were taken from the Department of Defense Form 214 and Department of the Army Form 20. All data abstraction forms were then sent to CDC for keying and editing.

Information abstracted from the personnel files can be grouped into two types. The first type consists of data collected at time of entry into the Army. Variables include demographics, such as date of birth, race, and birthplace, and preservice characteristics, such as physical and mental health as determined by the entrance physical examination, and measures of general intelligence and aptitude.

The second type of characteristics abstracted from the military personnel records describes the veteran's military experience. These include the date of entry, location and dates of each tour of duty, types of units, military occupational specialty during each tour, total length of active military service, indications of misconduct, date of separation from active duty, and type of discharge (character of service). A more detailed description of entry and military history characteristics is presented in Appendix A. Finally, names and addresses of next-of-kin were abstracted for use in locating living veterans for the health interview and examination phases of the study.

Military records of veterans ascertained to have died after discharge were independently rereviewed to verify that duty stations had been accurately recorded. All of them were found to have been correctly classified as "Vietnam" or "non-Vietnam" in the initial abstraction process.

2.5. VITAL STATUS ASCERTAINMENT

Although men were identified by date of entry into the Army, this report examines mortality after separation from active duty. Follow-up began the day the veteran was separated from active service and terminated on the date of his death or December 31, 1983, whichever came first. Follow-up was terminated at the end of 1983 because identification of deaths from the various tracing sources after that date was not complete. Veterans who died on active duty are excluded from the study but some data on them are given here for completeness.

2.5.1. Inservice Deaths

Inservice deaths were identified during the review of military personnel files to determine study eligibility. Any veteran who died during active military service, regardless of the manner or circumstances of his death, has a "casualty report" (Form 1300) placed in his military personnel file. This process was necessary to remove the decedent from the active military rolls as well as to activate payment of benefits to his survivors.

Table 2 presents the numbers of inservice deaths by the manner of death. Overall, 234 (2.4%) of Vietnam veterans were found to have died during active service, but only 34 (0.4%) of the comparison group had died in service. The possible effect of this disproportionate depletion of the cohorts on the postservice mortality experience is examined later.

The narrative summary from the casualty report, which described the manner and circumstances of death, was used to place inservice deaths in respective categories. A "hostility-related" death is defined as one resulting from direct or indirect contact with hostile enemy action. The "implements of war-related" death category includes deaths not directly or indirectly related to enemy action, but from the operations or implements of war, such as "killed by friendly fire." Finally, an "other" category includes deaths not related to war operations or to enemy action, such as those from motor vehicle accidents, drownings, and natural causes.

The majority of inservice deaths among Vietnam veterans was due to hostility-related causes. The rates of inservice deaths not due to war-related activities are identical in the two cohorts (i.e., 3.7 deaths per 1,000).

Although not shown, only 3 of the 68 deaths assigned to the "other" cause of death category were due to natural causes. All three are among Vietnam

veterans and their causes are malaria (ICD-9,084.0), malignant neoplasm of connective or soft tissue (ICD-9,171.9), and unknown or unspecified cause (ICD-9,799.9). The remaining deaths in the "other" category were due to external causes, with a majority of these attributed to motor-vehicle accidents (11 Vietnam and 19 non-Vietnam).

2.5.2. Postservice Deaths

Deaths occurring after separation from active duty were identified with the assistance of several Federal agencies. Computer tapes containing the names, social security numbers, and dates of birth of all veterans not known to have died in service were submitted simultaneously to the following agencies:

- o Veterans Administration - Beneficiary Identification and Record Locator Subsystem (BIRLS)
- o Social Security Administration
- o Internal Revenue Service (through special arrangement with the National Institute for Occupational Safety and Health)
- o National Center for Health Statistics (NCHS) - National Death Index

Each of these agencies receives notifications (in different degrees of completeness) of deaths and maintains this information in computer-based files. In addition to these, two other sources were used to identify postservice deaths. The first is the "casualty report" described previously, which is also filed for any veteran who dies while in reserve status, a period of up to 4 years following date of separation from active duty for draftees and up to 3 years for volunteers. It is also filed for those veterans who are currently receiving military benefits at the time of death.

The second additional source of postservice deaths was the locating and contacting procedures used for the health interview component of the VES. Names of next-of-kin and address information obtained from military personnel files and the various Federal agencies were used to locate veterans not identified as deceased by other sources. Several mechanisms were used to ascertain their present address and telephone number, including Directory Assistance telephone tracing, credit bureau checks, local directories, and contacts with relatives and neighbors. All tracing and follow-up activities were done by persons who had no knowledge of the veterans' military background, including countries of service. Four percent of all postservice deaths were identified solely through these means.

As shown in Table 3, confirmation of vital status was finally established for 93.6% of the Vietnam cohort and 91.9% of the non-Vietnam cohort. Since the proportion of veterans with uncertain vital status was small and similar for the two cohorts, these men were considered alive at the end of follow-up for analytic purposes.

2.6. DETERMINATION OF CAUSE OF DEATH

For veterans who died during the follow-up period, a copy of their death certificate was obtained from the appropriate state or local vital statistics office. Successful retrieval of death certificates was achieved for all but nine deaths. Underlying cause and contributing causes of death were determined from the death certificate by an experienced nosologist and, independently, by a panel of physicians using all available supplemental medical and law enforcement information.

2.6.1 Death Certificates

Underlying causes of death were determined and coded by an experienced nosologist at the National Center for Health Statistics. Causes of death were coded to both the Eighth and Ninth revisions of the International Classification of Diseases.^{12,13} The Eighth Revision was used when the mortality experience of Vietnam and non-Vietnam veterans was compared with that of the U.S. general male population, and the Ninth Revision was used when the mortality of Vietnam veterans was compared directly to that of non-Vietnam veterans. The nosologist had no knowledge of whether the decedent had served in Vietnam.

The reproducibility of the cause-of-death coding was examined through a blind resubmission to the nosologist of a 10% random sample of deaths due to external causes and a 10% sample coded to nonexternal causes. There was 98% agreement between initial and repeat cause-of-death codes.

2.6.2. Medical Review Panel - Supplementary Records

To provide an assessment of the cause of death independent of the one given on the death certificate, a special review was undertaken by a medical panel consisting of two physicians and a registered nurse. The nurse used the death certificate information to obtain pertinent medical and legal documentation describing the nature and circumstances of each death. Sources for record retrieval included hospitals, law enforcement agencies, coroners or medical examiners, and private physicians. For each death, any source that was deemed important for determining the nature and circumstance of the death, with the exception of interviews with next-of-kin, was pursued. Next-of-kin were contacted only when their permission was required for release of medical records. Only deaths for which all available records were successfully retrieved were reviewed. The nurse synthesized the available information into a summary statement which also indicated the sources and availability of pertinent records.

Before meetings of the medical review panel, the case summaries were reviewed by the two physicians, and each independently assigned an underlying cause of death. The physicians were not aware of the place of military service and the death certificate cause of death. Significant diseases known to be present at the time of death were listed as "other significant conditions." For external causes of death they judged the intentionality and manner of death (accident, suicide, homicide, undetermined).

One physician was assigned as "primary reviewer" for each death and reported his determination of the underlying cause of death, other significant conditions, and manner of death as well his rationale. If the other panelist disagreed, the evidence and reasoning in support of each point of view was presented. Additional information could be requested from the nurse, and final resolution of the disagreement was occasionally deferred until a subsequent medical panel meeting, held after the case had been reviewed by outside experts in the fields of forensic pathology and nosology. A cause of death was assigned only after a consensus was reached. All causes of death and other significant conditions were coded according to the Ninth Revision of the International Classification of Diseases.

3. METHODS OF ANALYSIS

3.1. DEFINITION OF CRITICAL VARIABLES

3.1.1. Place of Service

To be included in the subgroup of Vietnam veterans, an individual had to have served in Vietnam any time during his term of enlistment. Although the normal maximum tour in Vietnam was designated by the Army as 12 months¹¹, no minimum time was placed on the actual number of months a veteran had to have served in Vietnam to be included in the study. For example, if a veteran was wounded in Vietnam, having served only 4 months of his 12-month tour, he was still included in the Vietnam cohort. A small number of men managed to serve two terms of duty in Vietnam within their term of enlistment. A non-Vietnam veteran had to have served at least one tour of duty in Germany, Korea, or the United States and to have never served in the Army in Vietnam.

Most comparisons presented here are between veterans who served in Vietnam and those who served elsewhere. Analyses using veterans who served only in the United States or in Germany or Korea as the comparison group are not presented unless they help elucidate a particular finding observed with all non-Vietnam veterans.

3.1.2. Covariates

Table 4 presents a list of all covariates considered and their categorizations used in the analysis. All were obtained from veterans' military personnel files. Several of the variables need an explanation:

- PULHES. The term PULHES is an acronym for six categories that describe the physical and mental health of the veteran at entry into the service. The categories are physical capacity or stamina, upper extremities, lower extremities, hearing and ears, eyes and visual acuity, and psychiatric functioning. Each category was rated on a four-point scale, ranging from a score of one, indicating no impairment, to a score of four, indicating maximum impairment, which was below Army retention standards.¹⁴
- Composite Measure of Physical/Psychological Functioning. This represents a summary measure of the PULHES results. The veteran was given an overall rating of physical and psychological health based on his separate ratings in the six categories of the PULHES. Any impairment on one or more of the individual components would result in a rating of some impairment on the summary measure. For analytic purposes, the composite measure was dichotomized into "no impairment" and anything other than no impairment. This composite rating was used to determine eligibility for military service as well as eligibility for specific military occupational specialties. In controlling for preservice health, the composite index, rather than the components of the PULHES, was used.
- Army Classification Battery. This is a series of aptitude tests given at entry into the service to aid in assigning a military occupational specialty. The battery consisted of five separate tests, each measuring a different area of aptitude. The areas are verbal ability, arithmetic reasoning, general information, general technical, and pattern analysis. The tests were scored numerically, and the possible range of scores was from 0 to 200. Scores on the

various components were highly correlated. Of the five tests, the general technical (GT) test was considered to be the best single test for indicating aptitude.

- Armed Forces Qualification Test (AFQT). This is an aptitude test that served two functions: 1) to determine whether the individual met the minimum qualification criteria for military service, and 2) if qualification criteria were met, to aid in the placing of individuals in military occupational specialties. This test was numerically scored with a possible range of scores from 0 to 100.
- Military Occupational Specialty (MOS). This describes the job or jobs for which the veteran was trained or the one(s) he actually held while in the Army. Assignment of "primary" MOS was based on an individual's civilian education and other training and work experience, as well as on his performance on Army aptitude tests.¹⁵ For the purpose of this analysis all MOSs were divided into two broad categories, "tactical" and "all others." Tactical includes infantrymen, armored vehicle crewmen, combat engineers, and artillery crewmen.¹⁶ (A more detailed distribution of MOS is provided in Appendix A, Table 4.) When considering the possible confounding effects of MOS, we used the MOS for which the veteran was trained (Primary MOS). When the potential modifying effect of MOS was examined, the job the veteran actually held (Duty MOS) was used.

Potential confounders in this study are primarily variables measured before service (entry characteristics). Characteristics measured during service or at discharge have the potential of being part of the "Vietnam experience", and controlling for them may alter the effect of Vietnam service. However, certain military service characteristics examined in this study (pay grade at discharge, type of discharge, and absence without official leave (AWOL) or confinement time) could also be associated with background characteristics. Since the role of these factors is unclear and prior studies suggest that at least one of them (pay grade) is an important predictor of mortality¹⁷, both their possible modifying and confounding potential were examined.

3.1.3. Cause-of-Death Categorization

Each of the 15 major subgroups of the International Classification of Diseases, Ninth Revision was examined, with the exception of the groups pertaining to complications of pregnancy and childbirth and to conditions originating in the perinatal period. Neither was applicable to the study population.

Because we anticipated that the majority of deaths would be attributed to external causes, a more detailed breakdown of external causes of death (shown in Table 5), was examined. The categorization includes deaths due to motor-vehicle accident, accidental poisonings, suicides, homicide, injury of undetermined intentionality, and a category of all other external causes.

Because of the expected underascertainment of suicide on the basis of death certificates and the potential for the underascertainment to be different for Vietnam than for non-Vietnam veterans, a broader definition was also examined. This includes accidental poisonings (E850-E869, E929.2), recorded suicides (E950-E959), injuries of undetermined intentionality (E980-E989), and unknown cause of death (799.9).¹⁸

There is no comprehensive classification of alcohol or drug-related deaths in the ICD-9 nomenclature. Rather, alcohol-specific and drug-specific conditions are contained within various ICD-9 categories. For example, alcohol-dependence syndrome is included in the category of mental disorders and alcoholic liver disease, in the digestive system category. For estimating the extent of substance abuse in this study, special categories of alcohol- and drug-related deaths were developed. These are shown in Tables 6 and 7.

Alcohol-related deaths encompass three categories:

- (1) Nontraumatic deaths in which either the underlying cause or a contributing cause is an alcohol-specific medical, neurologic, or psychiatric disease.
- (2) Deaths attributed to accidental poisoning by alcohol and other accidental deaths in which a contributing cause was nondependent abuse of alcohol or excessive blood level of alcohol. Excessive blood level of alcohol is not defined quantitatively in the ICD-9 manual. Although NCHS policy is to code as "excessive blood alcohol" (ICD-9, 790.3) any citation on the death certificate of a blood alcohol concentration greater than zero, the medical review panel definition was a blood alcohol concentration greater than or equal to 100 mg%.
- (3) Deaths due to suicide, homicide, or injury of undetermined intentionality with a contributing cause of nondependent abuse of alcohol or excessive blood level of alcohol.

Drug-related deaths included deaths with an underlying or contributing cause of drug dependence or nondependent abuse of drugs other than alcohol or tobacco, deaths due to accidental poisoning by drugs, suicide where the mode of death was drugs, and deaths with intentionality undetermined but where the mode was drugs.

3.2. INTERNAL COMPARISONS

The analysis was approached in stages. The first stage addresses the hypotheses under study without adjustment or consideration of any covariates. The second stage of the analysis focuses on the concept of effect modification. This is concerned with identifying subgroups of Vietnam veterans that are at unusually high or low risk. Of particular interest here, in light of the finding for Australian Vietnam veterans, is whether the effect of Vietnam service on subsequent mortality is different for men who served in engineering units compared with other units. The final stage in the analysis determines whether any covariates, alone or in combination, could explain or mask any associations between service in Vietnam and the subsequent likelihood of dying.

The analytic approach used in stage one is a simple comparison of the relative frequency of death among Vietnam veterans with the relative frequency among veterans who did not serve in Vietnam. The mortality rates are based on person-years at risk since discharge from active duty. In this study veterans enter follow-up at different points in time, depending on their dates of separation from active duty. This could potentially affect the distribution of follow-up time for the two cohorts under study. The person-year approach takes into account these differing lengths of follow-up. The person-year approach also assumes a constant death rate over time. If the rate changes appreciably during the

follow-up period, rates can be calculated separately for smaller time intervals within which the assumption may be more reasonable. Unadjusted rate ratios (RR) were computed from the crude death rates (Vietnam/non-Vietnam). Ninety-five percent confidence intervals (CI) around the RRs were computed by using the procedures described by Laird and Oliver.¹⁹

In stage two, the exploration of effect modification, we attempted to identify high-risk subgroups that could provide insight into the nature of any Vietnam service-mortality association. All covariates listed in Table 4 were examined for their potential modifying effect by stratifying the data by the various levels of the covariate. Homogeneity of the rate ratios was assessed through chi-square tests for interaction derived from multivariate regression models.¹⁹ The criteria for lack of homogeneity of the rate ratios across the various levels of the modifying factor, which is evidence for possible effect modification, is a chi-square statistic with an associated p-value less than or equal to 0.05.

The objective of the third stage of the analysis is to examine confounding. Preservice differences in health-related factors could possibly mask or explain the association between Vietnam and mortality. Since relatively few covariates are measured at entry into the service, all are examined for their potential confounding effects. The influence of a potential confounder was evaluated by fitting a multivariate model that incorporated only that covariate and a term for Vietnam service.

The analytic tool used in stages two and three of the analysis is the Cox regression model, which is often referred to as the proportional hazards model.²⁰ This technique allows for the adjustment of confounders and the examination of the behavior of effect modifiers. It also accounts for differing periods of follow-up by comparing, for every death, the covariates of the deceased individual with those of individuals who have been followed for a similar period of time. The Cox procedure directly models the rate ratio rather than the absolute rate of mortality, thus avoiding the need to estimate an unknown underlying hazard function. The widely used software package PHGLM provided estimates of the parameters, standard errors, and likelihood ratio tests of hypotheses.²¹

The underlying assumption for the proportional hazards model is that the ratio of hazard functions (death rates) for the two groups (Vietnam, and non-Vietnam) is constant over the entire follow-up period. Serious violations of this assumption may result in misleading estimates of the effect of Vietnam service on mortality. For example, if the rate ratio is greater than one at some times and less than one at other times, the estimated parameter would be an average which may falsely indicate no difference in the mortality experience between the two groups. This assumption was checked (Appendix F), and if the effect of Vietnam service on mortality appeared to vary over time, separate models were formed for shorter time periods for which the proportionality assumption appeared more reasonable.

All adjusted rate ratios were obtained from Cox regression models stratified on primary MOS (tactical versus nontactical) and enlistment status and adjusted for other potential confounders.²² Stratification, instead of adjustment for MOS and enlistment status, is based on a priori and empirical knowledge that these factors are important determinants of duty location and mortality. Use of stratification, instead of

adjustment, reduces the number of parameters to be estimated which could be important in the cause-specific analysis where there are relatively few deaths. The rate ratio estimated from the stratified model is a valid summary of relative mortality in the two cohorts only if the rate ratios in the strata are similar. The uniformity of the four stratum-specific RRs was checked and is presented in Appendix F.

In the cause-specific analyses, a modification of the above analytic approach was necessary because of the small number of deaths in many of the disease categories. If a category contained less than 10 deaths (Vietnam and non-Vietnam cohorts combined), rate ratios were not computed, and no formal conclusions were drawn about comparative risks in the two cohorts. In addition, a smaller set of covariates were examined for their potential modifying or confounding effects.

Other analytic techniques used include standard chi-square statistics for 2x2 and Rx2 tables and the t-statistic for the difference between two means. Additionally, the "percent agreement" and kappa statistic are used to quantify and judge the level of agreement between the medical review cause of death and cause of death from the death certificate. The "percent agreement" is the number of deaths assigned to a particular cause-of-death category by both the medical review panel and the death certificate divided by the total number of deaths assigned to that category by the death certificate. The kappa statistic is a measure of inter-rater concordance which corrects for agreement expected by chance alone.²³ We used the following criteria when interpreting the kappa statistic: a kappa greater than 0.75 represents excellent agreement beyond chance, values between 0.40 and 0.75 represent fair to good agreement and values below 0.40 represent poor agreement.²⁴

All references to "statistical significance" imply that a particular ratio or difference is statistically different from the null value at the $\alpha=0.05$ level, assuming a two-sided test of significance.

3.3. EXTERNAL COMPARISONS

The standardized mortality ratio (SMR) adjusted for age, race, and calendar period was used to compare the death rates among Vietnam and non-Vietnam veterans with the rates in the total U.S. male population. The SMR is the ratio of observed deaths among cohort members to the expected number of deaths based on the U.S. mortality experience. The purpose of comparing the two veteran cohorts to the U.S. male general population is to evaluate the anticipated "healthy veteran effect" for natural causes of death.²⁵ Since all cohort members were initially selected into Army service on the basis of a certain level of physical fitness, one would expect their subsequent mortality from natural causes to be less than that of the general population, which includes men who do not meet the minimum physical requirements of the Army. This expected deficit should be most pronounced in the time period closest to separation from active duty and might eventually disappear with the passage of time as the veterans age.

The SMR calculations were done by using a software package containing U.S. death rates updated through 1980.²⁶ Ninety-five percent confidence limits for the SMRs were calculated with the Rothman-Boice programs.²⁷

4. RESULTS

This chapter is divided into four sections. In the first section, the preservice and military service characteristics of the Vietnam and non-Vietnam cohorts are examined. This provides an understanding of differences existing at entry into the service and differences that may have developed as a result of military service. The second section examines the all-cause mortality experience of the Vietnam group relative to veterans who served in Germany, Korea and the United States. Presented in the third section are results of the cause-specific mortality analyses, including analyses based on cause of death determined from death certificates and on medical review cause of death. The last section contains the results of comparisons of each cohort with the mortality of men of the same age and race in the U.S. general population in the same time period.

4.1. DISTRIBUTION OF COVARIATES FOR VIETNAM AND NON-VIETNAM VETERANS

Ideally, to determine the increase in mortality associated with service in Vietnam, one would like to compare two groups of veterans who are similar with respect to all factors that could influence mortality, except for service in Vietnam. Because this ideal can rarely be attained, except in experimental situations, it is important at the outset to understand any differences in possible health-influencing factors that may exist between Vietnam veterans and veterans who served elsewhere. Caution needs to be exercised, however, when interpreting the statistical significance of differences between the two groups. The large sample sizes tend to make even small between-cohort differences in these factors "statistically significant."

The characteristics of the two cohorts as determined at entry into the Army and those determined during military service are summarized in Table 8. Appendix A contains the actual distributions of all of the characteristics by cohort, with results of tests of statistical significance of differences for each characteristic.

There is no difference in the racial distribution between the two cohorts, but there are slightly fewer draftees among Vietnam veterans than among non-Vietnam veterans (63.7% versus 65.6%) and more Vietnam veterans entered service before 1969. Of the five physical health components measured at entry, significant differences are noted for two: Vietnam veterans had slightly fewer visual (25.5% versus 28.7%) and hearing (5.6% versus 6.7%) impairments. No difference is seen for the assessment of psychiatric functioning. On the tests of general aptitude taken at entry, the mean scores of Vietnam veterans were slightly but "significantly" lower for all components of the Army Classification Battery, and Vietnam veterans also scored slightly lower on the Armed Forces Qualification Test.

The second section of Table 8 contains the military service characteristics, where differences between the two cohorts are greater. More Vietnam than non-Vietnam veterans were in tactical operations jobs (34.3% versus 27.4%), and more Vietnam veterans (26.6%) were assigned to infantry units than were non-Vietnam veterans (14.6%).

Veterans in the Vietnam cohort tended to stay on active duty slightly longer than other veterans (mean=26.1 months versus 25.3 months). Vietnam veterans had fewer instances of AWOL or other "bad" time (11.6% versus 13.3%) and fewer nonhonorably discharges (2.7% versus 8.9%); they were also less likely to be discharged at lower grades (E1-E3) (11.5% versus 20.2%). These differences will be considered in subsequent analyses.

4.2. ANALYSIS OF ALL-CAUSE MORTALITY

4.2.1 Crude Results

Table 9 presents the total numbers of deaths, crude mortality rates, and rate ratios comparing Vietnam veterans to veterans who served in Germany, Korea, or the United States. The mean number of years of follow-up was similar for Vietnam (13.7 years) and non-Vietnam veterans (13.5 years). Of the 9,324 Vietnam veterans, 246 died during follow-up, compared with 200 of the 8,989 non-Vietnam veterans. Overall, Vietnam veterans had a 17% excess in postservice all-cause mortality relative to veterans who did not serve in Vietnam. This modest excess is not statistically significant.

Table 10 presents relative mortality by the number of years since discharge from active duty. The excess in the relative death rate appears to be limited to the first 5-year period after discharge, during which Vietnam veterans have a 45% higher mortality rate than non-Vietnam veterans. After the initial 5-year period, there is no difference in the mortality experience between the two cohorts. The test for the time-dependent effect of Vietnam service yields borderline significance ($X^2=3.60$, $p=0.057$), suggesting that the relative mortality of Vietnam veterans in the first 5 years may be different from that seen later.

Figure 2 displays graphically the change over time in the relative mortality rate associated with Vietnam service. The hazard rates among Vietnam veterans remain higher than those for non-Vietnam veterans through year 6 of follow-up. After year 6 the hazard rates are similar.

To determine whether the time-specific increase in mortality among Vietnam veterans is consistent across the two major subgroups of the comparison cohort, separate analyses were done using veterans with other foreign service (Germany or Korea) as one comparison and veterans with service only in the United States as a second comparison. A similar pattern of excess all-cause mortality limited to the first 5 years after discharge was found in both comparisons (Table 11). The excess was somewhat greater (RR=1.57) than with veterans having other foreign service (RR=1.37).

4.2.2. Consideration of Covariates.

Because the increased rate of mortality associated with Vietnam service appears to be limited to the first 5 years of follow-up, all covariates are examined with respect to two time periods, ≤ 5 years and 6+ years. (See Appendix F for an examination of the proportional hazards assumption within these two time periods.) Table 12 presents a summary of the tests for effect modification. (Refer to Appendix B for details.) There is some suggestion that during the first 5 years of follow-up the effect of Vietnam service is modified by general health status at entry ($p=0.08$), enlistment status ($p=0.10$) and year of discharge from active duty ($p=.06$). Among those with a poorer composite index of health at entry, the effect of Vietnam service on mortality is greater (RR=2.12) than among those with better health at entry (RR=1.20). An 80% increase in relative mortality associated with service in Vietnam is apparent among draftees, but only a 10% increase is observed among those who volunteered for the Army. Finally, a twofold increase in mortality was found among Vietnam veterans discharged before 1970 compared with only a 16% increase for those discharged in 1970 or later. In the later follow-up period, pay grade was identified as an effect modifier ($p=.02$). Although there is heterogeneity in the RRs across the various pay grades, no particular

pattern appears to be associated with this heterogeneity. (See Appendix B, Table 13.) For the total follow-up period, only pay grade at discharge was identified as potentially modifying the effect of Vietnam service on the subsequent rate of mortality ($p=.02$). There is some variation in the RRs for Vietnam service across the various levels of the other covariates in Table 12, but the variation does not represent a statistically significant departure from homogeneity.

Statistical adjustment for each covariate separately has little effect on the estimate of the RR in either postservice period (Table 13) or for the total follow-up period with two exceptions: type of discharge and pay grade at discharge. After adjustment for type of discharge and pay grade, the rate ratios are increased by at least 0.10 in the initial follow-up period and for the total follow-up period.

Confounding was further investigated by including all of the covariates listed in Table 13 in models for the separate time periods. Because of the strong correlation between AWOL/confinement time, type of discharge, and pay grade at discharge, only one was included in the model. Pay grade was chosen because it appeared, in Table 13, to have the strongest influence of the three on the Vietnam-mortality association. This model yielded adjusted rate ratios of 1.53 (95% CI=1.12-2.10) for the early follow-up period, 0.99 (95% CI=0.77-1.28) for the remaining years of follow-up, and 1.18 (95% CI=0.97-1.44) for all years of follow-up.

In addition, a reduced model was formed that incorporated a smaller set of covariates that will be used for adjustment in the cause-specific analyses where the numbers of deaths are considerably smaller. This model included the following variables: age at discharge and race (both well-established predictors of mortality), MOS and enlistment status (a priori and possibly empirical predictors of duty location and mortality), GT score and pay grade (empirically the strongest predictors of all-cause mortality of the remaining covariates), and year of discharge. The RRs obtained from the reduced model (Table 14) are roughly of the same magnitude as the unadjusted RRs. Results from the Cox model also indicate that Vietnam service has a greater effect on mortality among those discharged before age 21 compared to those discharged at age 21 or older ($p=0.02$) and among veterans discharged before 1970 compared to those discharged during 1970 or later ($p=0.05$).

4.2.3. Influence of Inservice Deaths.

As shown in Figure 1, the rate of inservice deaths among Vietnam veterans was more than 6 times the rate among non-Vietnam veterans. The majority of deaths among Vietnam veterans (83%) were a result of war-related activities (Table 2). This unusual inservice mortality experience among Vietnam veterans may have been selective, that is, it may have eliminated either the healthiest or the least healthy members from the cohort. Such an event might bias our estimate of the effect of Vietnam service on postservice mortality. To examine this possibility, we compared the entry characteristics of Vietnam veterans who died in service as a result of hostile enemy action with characteristics of Vietnam veterans who were alive at discharge from active service (Table 15). There are few differences of note. The two groups are similar in terms of race, enlistment status, the ratings on the individual components of the PULHES profile (with the exception of visual acuity and the composite measure of physical health), and scores on all the Army aptitude tests. For visual acuity and the composite physical health measure, those

killed by hostile enemy action were less likely to have any impairment on either measure compared with those discharged alive. (See Appendix C for detailed tables.)

To examine this further, we performed a worst case analysis by assuming that those killed by enemy action had survived and that their postservice mortality experience was worse than that of the remaining Vietnam group. For example, if those killed in action had experienced twice the overall postservice death rate of the actual Vietnam study group, the result would be 10 additional deaths in the Vietnam group, and none among non-Vietnam veterans. However, the "new" RR would be essentially the same as the original one (RR=1.19).

4.2.4. Influence of Incomplete Follow-up

As described in Section 2.5, the proportion of veterans with uncertain vital status was small and similar between the two cohorts (less than 9% in both cohorts). Because of this, we assumed that all those with uncertain vital status were alive at close of follow-up. Our assumption would lead to biased rate ratios if the probability of dying among Vietnam veterans with uncertain vital status was different from that of veterans who served elsewhere. By examining the entry and military service characteristics of men with known and uncertain vital status (Table 16), it can be seen that although men with uncertain vital status are very different from those with known vital status in the same cohort, the characteristics of the "uncertain status" groups are similar between cohorts. The characteristics associated with uncertain vital status may be linked to a more unstable lifestyle. In particular, men with uncertain vital status are more likely to be non-white, have lower GT scores, and have a nonhonorably discharge and lower pay grade at discharge. Thus, regardless of cohort status, these men may live a more transient existence with few ties to institutions and relatives, making them more difficult to trace. Since several of these characteristics are also strongly related to mortality (see Appendix B), death rates may indeed be higher among these men but, given the similarity in their characteristics between cohorts, it seems unlikely that there would be a different effect of Vietnam service in this group. In any case, we can estimate the possible effect of a differential rate of mortality. For example, if Vietnam veterans with uncertain vital status had twice the death rate of Vietnam veterans with known status and if the two status groups among non-Vietnam veterans had similar rates, the RR would only increase from 1.17 to 1.22. On the other hand, if Vietnam veterans with uncertain status had a much better survival rate (i.e., approximately one-half the death rate of other men), the revised RR would be 1.12. Thus, two extreme situations produce results that are not very different from the original finding.

4.3. ANALYSIS OF CAUSE-SPECIFIC MORTALITY

4.3.1. Cause of Death Based on Death Certificates

Of the 446 veterans identified as deceased in the time period from date of discharge from active duty to December 31, 1983, death certificates were obtained for 437 (98%). For five of the nine deaths for which death certificates were not obtained, casualty reports were available indicating the death occurred while the veteran was on reserve status or receiving veterans benefits. For the remaining four deaths, the location and date of death were available and confirmed through other sources.

Displayed in Table 17 are the numbers of deaths, crude death rates and unadjusted rate ratios comparing Vietnam veterans with non-Vietnam veterans for 11 major ICD-9 cause-of-death groupings. The four major groupings not shown had no deaths assigned to them (diseases of the blood and blood-forming organs; endocrine, metabolic, and nutritional diseases; diseases of the skin; and diseases of the musculoskeletal system). Of the categories shown, only four contained sufficient numbers for formal analysis. For two of these cause-of-death categories, Vietnam veterans appear to be dying at different rates than non-Vietnam veterans: diseases of the circulatory system (51% decrease) and external causes of death (25% increase). In one additional category mortality appears to be different between the two groups, that is, deaths due to genitourinary conditions. However, it is based on only four deaths, too few for formal analysis. Two of these deaths were attributed to urinary tract infection, one to renal disease (unspecified), and one to renal failure, and all were among Vietnam veterans.

Neoplasms: Table 18 shows mortality from neoplasms (all types) among Vietnam veterans relative to non-Vietnam veterans by time since discharge. A nonsignificant decrease in the relative rate of death is seen in both follow-up periods. We also divided the latter time period into smaller units, (6-10 years and 11+ years) to assess risks in the more recent years that would correspond to a longer latent period for these diseases. Only 7 deaths from neoplasms occurred in the 11+ year follow-up period, 2 among Vietnam veterans and 5 among non-Vietnam veterans, suggesting a deficit among Vietnam veterans. In examining the specific types of neoplasms (Table 19), there does not appear to be any site-specific associations with service in Vietnam. The three deaths among Vietnam veterans from neoplasms of uncertain behavior were all due to brain tumors, but the one among non-Vietnam veterans was a bronchial adenoma.

Circulatory system diseases: Table 20 shows that regardless of the time since discharge, there is a deficit of circulatory disease deaths among Vietnam servicemen relative to those not serving in Vietnam. In Table 21, results for specific types of circulatory disease deaths are presented. The deficit among Vietnam veterans does not appear to be limited to any one type of circulatory disease but extends to all major types.

Mental disorders: Although there were too few deaths in each follow-up interval for formal analysis, Vietnam service did not appear to be associated with the likelihood of dying from mental disorders in either time period. All deaths except one in this category were related to abuse of drugs or alcohol. Drug and alcohol-related mortality will be discussed in more detail later in this Section and also in Section 4.3.2.

External causes of death: Table 22 presents mortality from specific types of external causes. Vietnam veterans were more likely than non-Vietnam veterans to die in motor vehicle accidents (MVA), from accidental poisonings, and from injuries that were undetermined whether accidentally or purposely inflicted. Vietnam service does not appear to be associated with deaths from other accidental causes, suicide, or homicide.

There are 13 accidental poisoning deaths among Vietnam veterans and 5 in the non-Vietnam group. Nine Vietnam veterans died from drug intoxication compared with four non-Vietnam veterans. Of the remaining four accidental poisoning deaths among Vietnam veterans, three were due to carbon monoxide poisoning and one to a work-related toxic gas exposure; the other non-Vietnam veteran death was due to poisoning by an unspecified substance.

Deaths undetermined whether accidentally or purposely inflicted among Vietnam veterans include four poisonings, three deaths by shotgun wound to the head (not stated as self-inflicted), and one in a fire. In this same category, there is one death by drowning and another due to narcotic poisoning among non-Vietnam veterans.

Deaths from MVAs, other accidents, suicide, and homicide contain adequate numbers for further exploration (Table 23). Deaths due to MVAs are significantly elevated among Vietnam veterans in the first five years after discharge (RR=1.93). After 5 years, the excess is considerably less, although still somewhat elevated (RR=1.16). No association is seen in either time period for accidental deaths other than those from motor vehicles or poisonings.

For deaths due to suicide, a 72% nonsignificant increase is seen among Vietnam veterans in the initial 5 years of follow-up, but a deficit is seen thereafter. Because of possible inaccuracy in the recording of suicide on death certificates, we broadened the definition to include all accidental poisonings (E850-E869), reported suicides (E950-E959), injuries undetermined whether accidentally or purposely inflicted (E980-E989), and ill-defined and unknown causes of death (799.9). The main difference between the results for this new category and the previous one is the slight, non-significant elevation in risk now seen in the later follow-up period. (RR=1.12). Finally, an early postservice excess is seen for deaths due to homicide but the relative risk drops below 1.0 thereafter. There were no postservice deaths due to war-related injuries.

In Appendix D, the consistency of the association between Vietnam service and deaths due to MVAs and suicide is examined with respect to age at separation, race, duty MOS, enlistment status, GT score, pay grade at discharge, and year of discharge. In general, the RRs are increased in the first 5 years postservice and are close to 1.0 thereafter. There is some nonsignificant variation among the various subgroups, but the overall patterns are similar to what is observed for total mortality.

Drug- and alcohol-related deaths: Twenty-one deaths meet the criteria outlined in Section 3.1.3 for an alcohol-related death (Table 24). Over the entire follow-up period, there is a 27% increase (nonsignificant) in alcohol-related deaths among Vietnam veterans relative to non-Vietnam veterans. When the rate ratios are examined by time since discharge, a 73% nonsignificant increase is seen in the later period of follow-up. Because information on alcohol use may not be consistently reported on death certificates for external causes, deaths from alcohol-related diseases are examined separately. Alcohol-related diseases include alcoholic psychoses (291.0-291.9), alcohol dependence syndrome (303), nondependent abuse of alcohol (305.0), alcoholic polyneuropathy, (357.5), alcoholic cardiomyopathy (425.5), alcoholic gastritis (535.3), alcoholic liver disease (571.0-571.3), and excessive blood level of alcohol (790.3). Nine of the 21 alcohol-related deaths are due to these causes; 3 occurred among Vietnam veterans and 6 in the non-Vietnam group.

Table 24 also shows that Vietnam service appears to be strongly associated with the likelihood of dying from a drug-related death. Overall, the rate of drug-related deaths among Vietnam veterans is 2.1 times that for non-Vietnam veterans. Furthermore, increased mortality among Vietnam veterans is seen not only in the first 5 years after discharge, but also in the subsequent time period.

4.3.2. Cause of Death Based on Medical Review

This section presents a re-analysis of selected ICD-9 cause-of-death categories based on review, by a panel of physicians, of available information relevant to the cause of death beyond the death certificate. It also includes a detailed examination of deaths associated with the use of alcohol and drugs as determined by the panel. First, a brief examination of differences between underlying causes of death derived from death certificates and those determined by the medical review panel is presented. Further detail is provided in Appendix E.

To arrive at the best judgment of underlying cause of death, we sought all pertinent documentation that might help to determine the nature and circumstances of the death. Information was obtained for 426 of the 446 total deaths: 95% (n=233) of Vietnam veteran deaths and 97% (n=193) of deaths among non-Vietnam veterans. Law enforcement records, autopsy reports, medical examiners' reports, and hospital records were the most common sources of information used by the medical review panel (Table 25). More supplemental records were available for non-Vietnam veterans than for Vietnam veterans from every source except hospitals and physicians. Significant differences in the availability of records between the cohorts are noted for law enforcement records, medical examiner's reports, and histopathology reports. The total number of available records also differed somewhat by cohort (Table 26). Four or more different types of records were obtained for 50% of non-Vietnam veteran deaths versus 45% of Vietnam veteran deaths.

The percent agreement and kappa statistic, quantifying agreement between the medical-review-panel cause of death and that from the death certificate, are presented in Table 27 for major cause-of-death categories. A more detailed examination of the agreement between medical-review-panel assignment of causes of death and death-certificate underlying causes is presented in Appendix E. Overall, there is good agreement (82%, kappa=0.79) between death-certificate and medical-review cause of death. Exceptionally good agreement is found for deaths due to neoplasms, MVAs, suicide, and homicide; for both Vietnam and non-Vietnam veterans, the kappa statistics for these causes are greater than 0.90. Poorer agreement is apparent for other causes of death, but most kappa values are based on small numbers and, therefore, are subject to considerable variation. All kappa values, however, are statistically significant at the 0.01 level, indicating that although agreement is poor in some categories, it is better than expected by chance alone.

Table 28 presents cause-specific mortality rates by cohort as determined by the medical review panel. For categories where formal analysis was possible, an elevated rate ratio for Vietnam veterans is seen for deaths due to neoplasms, mental disorders, and external causes. Additionally, a lower death rate for Vietnam veterans is noted for circulatory diseases. None of the differences are statistically significant.

When rate ratios based on medical review were compared with those based on death certificates, two differences are apparent for causes with substantial numbers of deaths. The first category is neoplasms, with the rate ratio derived from medical review of 1.21, and a rate ratio of 0.82 from death certificates. This difference is primarily the result of two neoplasm deaths among non-Vietnam veterans being reclassified elsewhere and the opposite situation occurring among Vietnam veterans. (Details are available in Appendix E.)

When examining neoplastic deaths by time since discharge (Table 29), the rate ratio is similar in both periods of follow-up. Furthermore, among those followed for 11 or more years, there is no suggestion of differential mortality (three deaths among Vietnam veterans versus five among non-Vietnam veterans). Examination of specific types of cancer (Table 30) shows more deaths among Vietnam veterans from brain cancer, leukemia, and non-Hodgkin's lymphomas, all in very small numbers. The increase in the total number of malignant neoplasm deaths through medical review is primarily the result of confirming the malignancy of three brain tumors, all among Vietnam veterans. The nature of the tumor was not specified on the death certificate for any of the three. Finally, the three non-Hodgkin's lymphoma deaths among Vietnam veterans are the result of reclassifying two deaths among Vietnam veterans to lymphosarcoma (ICD-9, 200). These deaths were classified by the death certificate to cardiac arrest (ICD-9, 427.5) and acute lymphoid leukemia (ICD-9, 204.0). Further details are given in Appendix E.

Mental disorders is the second cause-of-death category for which there is a difference between the rate ratios obtained from medical review and death certificates. With the medical-review cause of death, a threefold risk is evident among Vietnam veterans, but the rate ratio is close to unity according to death-certificate causes of death. All "mental disorder" deaths, by either classification, involved alcohol or drugs. Differences in classification of these deaths is the result, in most cases, of a greater specificity in terminology used by the medical review panel. For example, in two cases the review panel cited alcoholic liver damage, unspecified (ICD-9, 571.3) as the underlying cause, whereas the death certificate wording limited the classification to alcohol dependence syndrome (ICD-9, 303). Alcohol- and drug-related deaths determined from medical review are examined in more detail below in this section.

Table 31 examines relative mortality for specific external causes of death as determined from medical review. These results are identical to those found from the death certificate analysis. Vietnam veterans are more likely than non-Vietnam veterans to die in motor vehicle accidents, from accidental poisonings and from injuries undetermined whether accidentally or purposely inflicted. The overall rate ratios are not significantly elevated for deaths due to suicide, homicide, and all other external causes. However, further exploration of external causes of death by time since discharge indicates the same pattern for MVAs, suicide, and homicide as seen in the death certificate results; the rate ratios are elevated in the first 5 years after discharge and are close to 1.0 for the remainder of follow-up.

Supplemental information collected for the medical review panel allowed further exploration of MVA deaths. Daytime and nighttime motor-vehicle-crash deaths as well as single and multiple vehicle events all occurred more frequently among Vietnam veterans during the early postdischarge period (Table 32).

We also examined the role of alcohol and drug use in motor vehicle accident deaths. Drug use information on MVA deaths was limited; the medical review panel identified only one drug-related MVA death. Blood alcohol level information or the suspected involvement of alcohol was available for 82 (62%) of the 132 medically reviewed MVA deaths. Table 33 shows that in the initial follow-up period, there is a weak relationship between Vietnam service and alcohol-related MVAs (RR=1.35) in contrast to a stronger relationship for MVAs that are not alcohol-related (RR=2.25). The pattern of risk for MVAs with

"unknown alcohol involvement" is similar to that for "no alcohol involvement."

The agreement between the death certificate and medical review panel for alcohol- and drug-related deaths is presented in Table 34. Twenty-one deaths are defined as "alcohol-related" from death certificates and 133 from medical review. This lack of agreement is evident regardless of the specific type of alcohol-related death; the κ statistic ranges from 0.11 for accidental causes to 0.44 for alcohol-related natural causes of death. The overall agreement for drug-related deaths is much better than that for alcohol-related deaths, but for specific categories the agreement is poor.

Overall there is a slight excess of alcohol-related deaths among Vietnam veterans (Table 35), due mainly to accidents. Deaths from alcohol-related natural causes and deaths due to alcohol-related suicide, homicide and injuries of undetermined intentionality are not associated with service in Vietnam.

The distribution of drug-related deaths by cohort is presented in Table 36. Overall, Vietnam veterans are 1.6 times as likely to die from drug-related deaths as non-Vietnam veterans. Suicide by drugs is a very minor component of this excess. Moreover, as shown in Table 37, when the follow-up interval is subdivided into three time periods, the RRs appear to increase over time, with a substantial excess of drug-related deaths in the most recent years of observation.

Although based on a small number of deaths, the drug-related mortality excess appears to be limited to Vietnam veterans who were drafted into service and those whose jobs involved tactical or combat operations (see Appendix D, Table D-3). Additionally, there is some suggestion that those discharged during 1970 or after had a greater excess of drug-related deaths. However, when we examine the year in which the veteran served in Vietnam as opposed to his date of discharge, it appears that the drug-related excess is especially high among Vietnam veterans who were stationed in Vietnam during 1968 or 1969 (RR=4.93, 95% CI=1.14-21.34). The rate of drug-related deaths is similar between Vietnam and non-Vietnam veterans serving before (RR=1.20) and after (RR=0.71) that time period.

4.3.3. Consideration of Covariates

Table 38 presents adjusted rate ratios based on a Cox regression model for cause-specific death categories with sufficient numbers of deaths for formal analysis. Adjusted values are based on a model stratified on MOS and enlistment status, and including age, race, GT score, pay grade at discharge and year of discharge. Rate ratios based on death-certificate cause of death and medical-review cause of death are both presented. In the early follow-up period, adjustment increases the RR for suicide based on death-certificate cause of death from 1.72 to 2.54 and, based on the medical review data, from 1.64 to 2.47. Pay grade at discharge and GT score are the covariates that have the greatest effect on the adjusted suicide estimate. Adjustment also had some effect on the RR for alcohol- and drug-related deaths based on the death-certificate data. For alcohol-related deaths, the RR increased from 1.73 to 2.23 in the later follow-up period while the RR for drug-related deaths in the initial follow-up period increased from 1.93 to 2.86.

4.4. COMPARISON OF VETERAN AND U.S. DEATH RATES

Presented in Table 39 are the observed and expected numbers of deaths from all causes for the two veteran cohorts stratified by the number of years since

discharge from active military service. Over the total follow-up period, both groups of veterans have a significantly lower mortality rate for "natural causes" than the general U.S. male population. However, during the first 5 years after discharge, Vietnam veterans have a higher death rate from external causes whereas non-Vietnam veterans have a lower rate relative to the general population. In the later time period both groups of veterans show a similar deficit in external cause mortality.

Standardized mortality ratios for major natural cause-of-death categories are given in Table 40. Among Vietnam veterans the SMRs for most natural causes of death are below 1.0, with the exception of deaths due to diseases of the genitourinary system (SMR=2.53, 95% CI=0.82-5.89). For diseases of the circulatory system, the deficit of deaths in Vietnam veterans is much greater (52%) than for non-Vietnam veterans (13%). Both cohorts experienced lower-than-expected mortality for diseases of the digestive system and neoplasms.

The SMRs for specific external causes (Table 41) show an excess of deaths among Vietnam veterans due to accidental causes, mainly from motor vehicle accidents. Suicide mortality is at the same level as that in the general population in the Vietnam cohort. Among non-Vietnam veterans, the SMRs for specific external causes are all at or below 1.00, indicating no excess of deaths relative to the general population experience.

5. DISCUSSION

The findings described here raise a number of issues related to the interpretation of and conclusions about the postservice mortality experience of Vietnam veterans. Among these are the strengths and limitations of the study, findings from previous studies of Vietnam veterans, and prior investigations of veterans of other wars. These topics are reviewed here, and a number of summary comments are made regarding mortality risks of Vietnam veterans. Some of the concluding remarks are speculative, since available data do not allow further inferences. Other comments represent our best judgment about relationships between mortality and the Vietnam experience, given the totality of data examined.

5.1. STRENGTHS AND LIMITATIONS

This study began with a carefully defined cohort of Vietnam-era soldiers, and various methods were used to ascertain deaths occurring after separation from active duty. Vietnam and non-Vietnam veterans were chosen according to a stringent set of criteria to ensure maximum comparability. A comparison of entry and military-service characteristics for the two groups of veterans has confirmed their general similarity. Adjustment for residual differences in background characteristics between the two groups did not appreciably alter most relative mortality estimates. This indicates that differences in known background characteristics do not account for the observed pattern of relative mortality among Vietnam veterans. However, the possibility exists that other, unmeasured differences between the two cohorts could affect the estimate of the effect of Vietnam service on mortality.

Through the multiple overlapping sources of death ascertainment, virtually all deaths that occurred in the U.S.A. should have been identified, but some that occurred elsewhere may have been missed. Confirmation of death was obtained from copies of official death certificates, which were recovered for all but 2% of the deaths. A distinct advantage of this study is the special attempt to locate all presumably living men for the purpose of conducting health interviews; in most cohort mortality studies these persons are not individually traced. This component of the study provided verification of vital status on 94% of Vietnam veterans and 92% of those serving elsewhere. Furthermore, background and military-service characteristics of those with unconfirmed vital status are similar between the two cohorts, suggesting that mortality rates in these subgroups are not likely to be very different.

We attempted to keep misclassification of cohort status and cause of death to a minimum. After death certificates were coded, the correspondence between the ICD codes and the actual medical statements on the certificates was verified independently by two CDC staff persons. Any discrepancies were resolved with the nosologist. An evaluation of the reproducibility of cause of death coding by the nosologist indicated excellent agreement between the original codes and a sample of blind repeats. To minimize misclassification of cohort status, we verified duty location for all postservice deaths.

A special feature of this study is the special independent medical review of causes of deaths by reference to supplemental medical and legal documents recovered for 97% of deaths for which death certificates were obtained. This process clarified general or vague terms on death certificates, assured that as much information as possible was considered in cause-of-death determinations, and permitted use of similar criteria to determine underlying cause of death for the two cohorts. This was especially valuable for

identifying deaths that were alcohol or drug-related. Through the medical review effort many more alcohol-related deaths were found than were derived from death certificates alone and half again as many drug-related deaths. These larger numbers of "cases" produced more reliable risk estimates and the standardization of criteria produced more valid results. Interestingly, the number of suicide deaths derived from death certificates (n=29) was about the same as from the medical review (n=32) and the adjusted rate ratios based on the two sources are similar in both follow-up periods (RRs=2.54 and 2.47 in the early interval and RRs=0.57 and 0.74 in the later interval).

Any observational study has limitations. Perhaps the most important one here is the restricted sample size and limited number of deaths in this young population for most major cause of death categories, and especially for specific diseases or conditions. With the exception of the relatively common external causes of death, this study could detect, as statistically significant, only substantial elevations in cause-specific death rates. Nevertheless, numbers of deaths from some causes are significant to identify patterns of risk that are informative. This is important in interpreting the findings for drug-related deaths, suicide, and homicide.

The extent of underreporting in our data, in particular for deaths which are alcohol- or drug-related, may be substantial. If alcohol- or drug-related deaths were more or less likely to be reported among Vietnam veterans than non-Vietnam veterans, the resulting rate ratios would reflect this reporting bias. In our data, however, only drug-related deaths appeared in excess among Vietnam veterans; if reporting was differential, we might expect both alcohol and drug deaths to be in excess.

A methodologic issue of concern in the analysis of these data was the choice of relevant covariates as possible confounders. In particular, some of the military service variables such as "pay grade at discharge" and "AWOL/confinement time" are measured during or after the military experience and could be affected differentially by it in the two cohorts. If this was the case, adjustment for that covariate could introduce a bias in the RR estimate. Pay grade was retained in the reduced model (e.g., Table 38) since it is a strong determinant of mortality in these data and in prior studies of Army veterans.^{17,28} The biggest shift in the relative mortality estimate caused by including a military service covariate in the Cox model, namely pay grade, occurred for suicide.

Another potential limitation of this study is the relatively short time that has elapsed since the Vietnam conflict. If the "Vietnam experience" does place veterans at an increased risk for certain fatal chronic diseases, the time interval between exposure and death may be longer than our current 10-15 years of follow-up. Continued monitoring of mortality in VES participants, therefore, may provide additional insights.

5.2. COMPARISON WITH PREVIOUS MORTALITY STUDIES OF VIETNAM VETERANS

The present findings can be viewed against the results of five previous mortality studies of Vietnam veterans. Four are proportional mortality studies⁶⁻⁹, which may not be directly comparable to this study because of incompleteness of data and inherent limitations of the analytic method.²⁹ The fifth, a cohort study of Australian Vietnam veterans, is very similar in design to our study and, thus, is a more appropriate comparison.¹⁰ The U.S. Air Force's "Ranch Hand Study" is not discussed here, since its principal concern is the adverse health effects of herbicide exposure in a unique group of veterans.⁵

Two of the proportional mortality studies were conducted using fairly well-defined populations.^{7,8} The results of one included nonsignificant increases in suicide, homicide, accidental poisonings and nonmotor vehicle accidents of transport among Vietnam veterans relative to other Vietnam-era veterans. However, deaths due to MVAs were not elevated.⁷ Time since discharge was not considered in that study and this was critical in elucidating the pattern of external cause mortality in our study. In the other study, only deaths from suicide and motor-vehicle accidents were examined, and neither occurred more frequently among Vietnam veterans.⁸

The two other proportional mortality studies were conducted by using deaths occurring among veterans registered for a military service bonus in their respective states^{6,9}, and it is unclear what bias may have been introduced through this selection process. In one of the studies, a nonsignificant increase in deaths from MVAs among Vietnam veterans was found.⁶

The excess in overall mortality among Australian Vietnam veterans was mainly confined to men who had served in the Engineer Corps, a finding the investigators could not entirely explain.¹⁰ A similar variation in risk is not seen in the present study, although the number of men assigned to Engineer units is relatively small.

The 30% excess of external-cause mortality among Australian Vietnam veterans relative to non-Vietnam veterans is similar to what is seen in our study. Although the Australian investigators do not examine external cause mortality by time since discharge, there is a suggestion of a decline in relative mortality from all causes with increasing time since discharge. Deaths from suicide, homicide, and accidental poisoning also occur more frequently among Australian Vietnam veterans. MVA mortality is not elevated overall, but an excess in the youngest age group is suggested. The authors conclude that although modest, the consistency of the results across several external cause-specific categories may indicate that the association is, in fact, real.

The results of our study are in agreement with those of the Australian study, that is, no association was found between service in Vietnam and mortality due to neoplasms (all types combined). In several of the proportional mortality studies, however, investigators found an increased frequency of deaths from connective-tissue and other soft-tissue cancers among Vietnam veterans.^{6,8,9} There are no such deaths in the present study, and only two among Australian Vietnam veterans, but small sample sizes in both studies preclude the detection of increased risks for these rare malignancies. For this reason, these tumors and others are being examined in CDC's Selected Cancers Study.³

One surprising finding is the lower mortality rate from cardiovascular disease (CVD) among Vietnam veterans. This result is evident regardless of time since discharge and applies to several major types of circulatory disease. The lower rate might be explained as a by-product of some kind of selection process taking place in the final assignments to Vietnam, which might correlate with cardiovascular fitness established during basic or advanced training. In fact, the SMR results suggest that the CVD deficit may be the result of an unusually high rate in the comparison group. CVD mortality in the non-Vietnam cohort is only slightly below that of the general population, whereas we expected it to be much lower.²⁵ Various indices of CVD morbidity measured in the other components of the VES may help in

elucidating the mortality findings. Contrary to our findings for CVD, Australian Vietnam veterans experienced a significant 90% increase in deaths from such causes.¹⁰ The investigators speculate that this increase may have resulted from health-influencing behaviors, such as cigarette smoking and excess alcohol intake, which Vietnam veterans may have acquired more easily than non-Vietnam veterans because of the stressful environment of the war zone and/or the availability of these substances.

Australian Vietnam veterans have an excess of deaths from alcohol-related natural causes, but no increases in deaths from alcohol-related external causes or any type of drug-related mortality. These findings are contrary to ours and may reflect differences in use of drugs and alcohol by American and Australian troops. In contrast to the reportedly heavy use of illicit drugs by American troops in Vietnam,^{30,31} drug use among Australian soldiers was reported to be uncommon, while alcohol use was heavy.¹⁰

Another point that can be raised here is the relationship between the present findings for drug-related deaths and two factors: (1) the reported heavy use of drugs (especially narcotics) among servicemen in Vietnam in the latter part of the conflict (1969-1971)^{30,31} and (2) surveys of postservice drug use by veterans in which no association with service in Vietnam or combat exposure was found.^{31,32} With respect to the first point, our results do not show a relationship between total mortality or any specific cause of death and discharge from the Army in 1970 or later, a time period that would include men who were in Vietnam in the early 1970s. On the contrary, the overall mortality excess is greatest among Vietnam veterans discharged in the late 1960s, and drug-related deaths are most excessive among Vietnam veterans who were in Vietnam in the late 1960s. Regarding the second point, it would appear that the drug-related findings are at variance with findings in two surveys of drug use among living Vietnam veterans.^{31,32} One possibility for the discordant results is response bias on the part of interviewed Vietnam veterans whereby actual drug use is concealed. Admittedly, this would have had to operate in two independent surveys. Another consideration is the time frame for the studies. Since the greatest part of our excess occurs 11 or more years after discharge, it could be a delayed response that affects a susceptible subgroup of Vietnam veterans and is completely masked when use habits are studied in living veterans at earlier points in time. Also, one of the surveys was conducted with veterans returning from Vietnam in late 1971³¹, while the drug-related excess in our study was found among those serving in Vietnam during the late 1960's.

5.3. POSSIBLE INTERPRETATIONS AND CONCLUSIONS

The increase in early postdischarge mortality from external causes (i.e., MVA, suicide and homicide) among Vietnam veterans seen in this study has at least three possible explanations:

- 1) It reflects a peculiarity of the process of selecting men for assignment, whereby those sent to Vietnam tended to have characteristics that placed them at increased risk of dying from external causes shortly after discharge from active duty.
- 2) It is a result of the psychological and physical stresses associated with military duty in a combat zone, a set of circumstances not unique to the Vietnam conflict.
- 3) It is a consequence of the uniqueness of the Vietnam conflict, some combination of environment and experience that exerted special effects

while men were serving there and/or after their return to an unsupportive and sometimes hostile social climate in the U.S.A.

The first of these possibilities appears doubtful for several reasons. In our data, no important differences were apparent in background characteristics between Vietnam and non-Vietnam veterans (e.g., race, age, aptitude test scores) at the time of entry into the Army. On the other hand, the non-Vietnam group had a higher prevalence of nonhonorably discharges, lower pay grades at discharge, and more AWOL or confinement time while in the Army, characteristics that might be associated with risk-taking behavior. Furthermore, if Vietnam veterans tended to have a greater predisposition (by selection) toward traumatic events than non-Vietnam veterans, it might be expected to manifest itself in increased relative mortality from such causes throughout the entire period of observation, rather than being confined to the first few years after discharge, as was observed here. Further doubt about such selective factors is raised by a survey of high-school boys which showed that those who subsequently served in Vietnam were similar to those who served elsewhere in the military with respect to family background, early academic abilities and achievements, and adolescent personality traits.³³

The second possible explanation has some basis in the light of previous studies of postservice mortality among U.S. veterans who served in other war zones. Increased postdischarge mortality from external causes was observed in two groups of World War II combat veterans and one group of Korean War combat veterans, when compared with the general U.S. male population, even though older men and officers were included.³⁴ In contrast, broader cross sections of World War II veterans, including both combat and noncombat groups, showed no difference, or even a slight deficit, in postdischarge traumatic deaths, 25,³⁴ as did non-Vietnam veterans in our study.

The third possible explanation for the present findings, the unique elements of the Vietnam conflict, seems plausible on the surface, since the Vietnam conflict was characterized by a number of special features. Among these were: (1) entry to, and exit from, the war zone in a very compressed time period, with little or no time for adjustment (the "jet-age war" phenomenon); (2) individual replacement after predetermined 12-month tours of duty (associated with reduced morale and cohesiveness within units); (3) fighting an enemy that was hard to distinguish from one's allies; and (4) fighting for "body counts" rather than for territory. On top of this, returning Vietnam veterans encountered an indifferent and sometimes hostile reception at home. This is in direct contrast to the experience of most World War II and Korean War veterans who were sent overseas "for the duration" as members of pre-formed units that trained and stayed together. Warfare was more "conventional", and objectives could be more easily understood. Furthermore, the World War II and Korean veterans returned to a generally more supportive homeland. In spite of these contrasts in military experience, however, the same pattern of excess postservice mortality due to external causes seen in Vietnam veterans is also found among men returning from combat areas in the two previous wars. Thus, increased external cause mortality seen here among Vietnam veterans may be one of the unfortunate sequelae of unusual stresses endured while stationed in a hostile fire zone.

Although this explanation is very suggestive, it should be noted that certain features of our data do not support this conclusion. Namely, Vietnam veterans who were likely to have engaged in combat did not have a higher rate of mortality than Vietnam veterans who were less likely to have done so. We

might expect just the opposite if the excess mortality observed here is the result of the psychological and physical stresses associated with military duty in a combat zone. Also, the findings for the World War II and Korean War Army veterans are not particularly enlightening for deaths due to suicide and homicide, because of small number of such deaths and the lack of data on suicide and homicide risks according to time period after discharge. In addition, the influence of factors specific to the Vietnam experience in explaining this early postservice external mortality excess cannot be completely ruled out. Indeed, cross sectional surveys 32,33,35-37 have uncovered a variety of psychosocial and economic problems among Vietnam veterans that may be the precursors for certain types of traumatic deaths, such as suicide.

If the MVA excess among Vietnam veterans is causally related to their experience in a combat zone, it may be consistent with one or more theories of young driver risk-taking behavior.³⁸ According to these theories, unusual risk-taking on the part of young drivers may be:

- (1) an outlet for stress, aggression, hostility, or frustration. Could service in Vietnam have created these feelings?
- (2) a physiological need for increased arousal that makes some people seek ways of increasing their stimulation. Could service in Vietnam have produced a desire for sensation- or thrill-seeking?
- (3) an attempt by some persons to increase the level of perceived driving risk to some higher target level that they find acceptable. Could service in Vietnam have produced an acceptance of increased risk in everyday life?

Whatever the explanation is, factors responsible for the MVA results were operable only in the first few years after discharge. Thus, this may have been the critical period in which those most affected by the Vietnam experience succumbed.

The pattern of drug-related mortality among Vietnam veterans in this study appears different from the pattern of external causes (i.e., MVAs, suicide, homicide). Excess drug-related deaths increase with time since discharge, and certain subgroups of Vietnam veterans seem to be at especially high risk, namely, draftees and those whose job was in tactical operations (i.e., combat-related activities). Examination of risks in relation to the calendar year men were in Vietnam shows the largest excess associated with 1968 and 1969, the years of heaviest combat. Thus, the increased death rates from drug-related causes among Vietnam veterans may be linked to intensity of combat exposure rather than to a general, across-the-board effect of the Vietnam experience.

The mortality assessment of Vietnam veterans presented here is an incomplete evaluation of the health experience of this group. Additional data on the present and past health status of living Vietnam veterans will be forthcoming from the health interview and medical, psychological, and laboratory evaluation components of the VES. Because this group of veterans has not yet reached the age span where chronic diseases have an important impact on mortality, continued monitoring of mortality among VES participants may provide additional insights.

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FIGURE 1. Selection of Study Group.

* Excluded from study.

+ Eighty-three percent (N = 194) of active duty deaths among Vietnam veterans were due to war-related activities.

**FIGURE 2. Mortality Rates* of Vietnam
and Non-Vietnam Cohorts
by Years Since Discharge**

* Mortality rates are three-year moving averages.

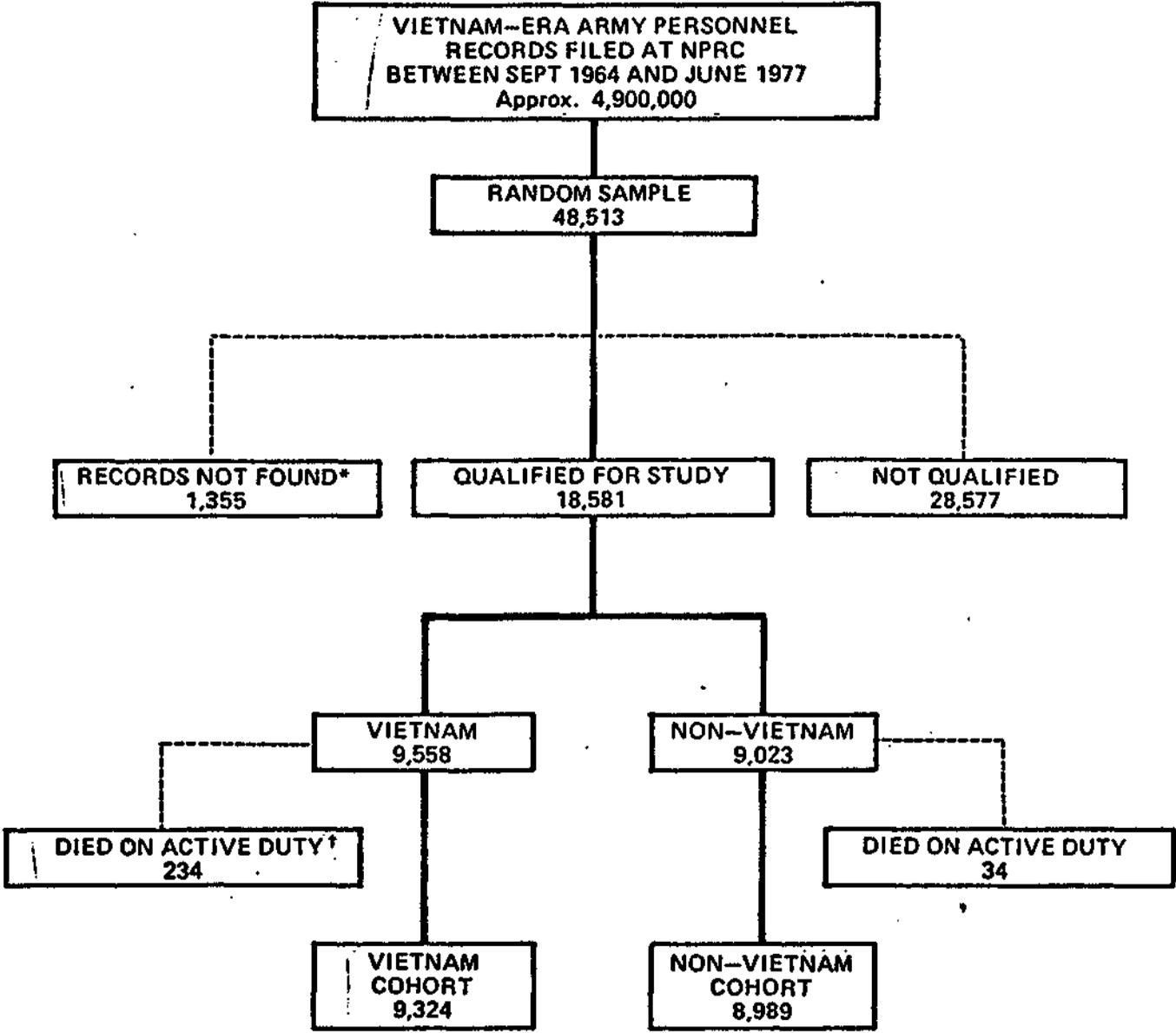


Figure 2

Smoothed Mortality Rates of Vietnam-Era Veterans
by Years Since Discharge

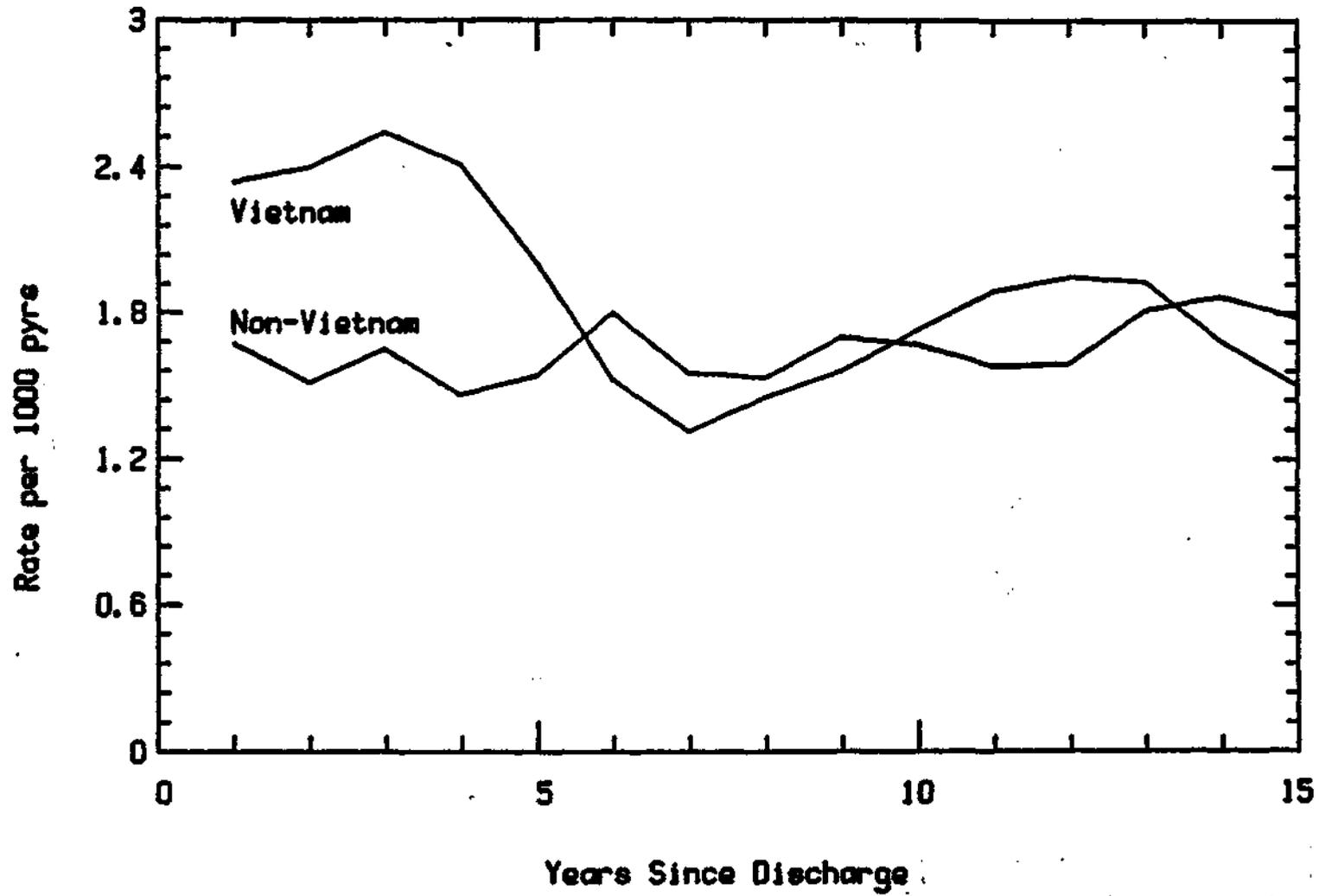


TABLE 1. Smallest Relative Risks Detectable with 95% Power for Selected Causes of Death*

Cause of death	Deaths ⁺ /1000	Rate ratio ⁺⁺
All causes	35.5	1.3
Accidents	13.2	1.5
Homicide	4.6	2.0
Suicide	4.3	2.0
Diseases of heart	3.1	2.3
Malignant neoplasms	2.9	2.3
Cirrhosis of liver	1.1	3.5
Cerebrovascular diseases	0.6	4.9

* Adapted from 1983 CDC Protocol³ (Table 1, p. 43)

+ Expected deaths over 17 years (1968-1984) based on 1978 U.S. age-specific rates for males as applied to a hypothetical cohort of men aged 22 at initiation of follow-up.

++ Vietnam cohort relative to non-Vietnam cohort, with 8500 in each cohort. Calculated by Arc Sin approximation, alpha = 0.05 (two-sided).

TABLE 2. Number of Deaths During Active Military Service Among Vietnam and Non-Vietnam Veterans, by Manner of Death

Manner of death	Vietnam		Non-Vietnam	
	No.	(%)	No.	(%)
Hostility related	181	(77.3)	0	(0.0)
Implements of war related	13	(5.6)	1	(2.9)
Other	35	(15.0)	33	(97.1)
Unknown	5	(2.1)	0	(0.0)
Total	234	(100.0)	34	(100.0)

TABLE 3. Vital Status of Vietnam and Non-Vietnam Veterans at End of Follow-up
(December 31, 1983)

Vital status	Vietnam		Non-Vietnam	
	No.	(%)	No.	(%)
Known dead*	246	(2.6)	200	(2.2)
Known alive	8,488	(91.0)	8,067	(89.7)
Status uncertain	590	(6.3)	722	(8.0)
Total	9,324	(100.0)	8,989	(100.0)

* Includes 9 veterans (7 Vietnam and 2 non-Vietnam) for whom death certificates were not recovered but for whom sufficient information was obtained to be certain that they had died.

TABLE 4. Covariates Considered and Associated Categorizations Employed in the Analysis

Variable	Categories for analysis *
Race	White, Nonwhite
Place of birth	Northeast, Midwest, South, West +
Enlistment status	Volunteer, Draftee
PULHES categories:	
Physical capacity or stamina	No Impairment, Some Impairment
Upper extremities	No Impairment, Some Impairment
Lower extremities	No Impairment, Some Impairment
Hearing acuity and ears	No Impairment, Some Impairment
Eyes and visual acuity	No Impairment, Some Impairment
Psychiatric functioning	No Impairment, Some Impairment
Composite index of physical and psychological health	No Impairment, Some Impairment
Army Classification Battery:	
Verbal ability	Continuous measure; range from 1-200
Arithmetic reasoning	Continuous measure; range from 1-200
Pattern analysis	Continuous measure; range from 1-200
General information	Continuous measure; range from 1-200
General technical (GT)	Continuous measure; range from 1-200
Armed Forces Qualification Test (AFQT)	Continuous measure; range from 1-100
Military occupational specialty (MOS)	Tactical, Other
Type of unit	Infantry, Engineer, Armor, Cavalry, Artillery, Other
Months of active duty	0-11, 12-23, 24+

TABLE 4. (continued)

Variable	Categories for analysis *
AWOL or confinement time	Ever, Never
Type of discharge	Honorable, Nonhonorable
Pay grade at discharge	E1-E3, E4-E5
Age at discharge from active duty	<21, 21+ years ⁺⁺
Year of discharge from active duty	Before 1970, 1970 and later

* Unknown values excluded from analyses.

+ Foreign places of birth included with West category.

++ When rate ratios are adjusted for age at separation, age is treated as a continuous variable.

TABLE 5. External Cause-of-Death Subcategories and Associated ICD-9 Codes Used in Mortality Analyses

Sub-category	ICD-9 codes	Specific causes
1. Motor vehicle accident	E810-825, E929.0	Motor vehicle traffic & nontraffic accidents; Late effects of motor vehicle accidents
2. Accidental poisoning	E850-869, E929.2	Accidental overdose of drugs; poisoning by solids, liquids, gases & vapors; Late effects of accidental poisoning
3. Suicide	E950-959	
4. Homicide	E960-969	
5. Injury of undetermined intentionality	E980-989	Injuries undetermined whether accidentally or purposely inflicted
6. Other external causes	E800-807, E826-849	Railway accidents; Recreational vehicle, water transport and air transport accidents
	E870-879	Surgical and medical misadventures and complications
	E880-888	Accidental falls
	E890-899	Accidental fires and flames
	E900-909	Accidents from natural & environmental factors
	E910-915	Submersion & suffocation
	E916-928	Other accidents
	E929.1,	Late effects of the
	E929.3-929.9	above accidents
	E930-949	Adverse effects of drugs in therapeutic use
	E970-978	Legal intervention

TABLE 6. Alcohol-Related Deaths Based on ICD-9 Diagnoses Cited as Either Underlying or Contributing Causes of Death

Disease category	Underlying cause	Contributing cause
Medical, neurologic and psychiatric	Alcoholic psychoses (291.0-291.9)	
	Alcohol dependence syndrome (303)	
	Nondependent abuse of alcohol (305.0)	
	Alcoholic polyneuropathy (357.5)	
	Alcoholic cardiomyopathy (425.5)	
	Alcoholic gastritis (535.3)	
	Alcoholic liver disease (571.0-571.3)	
	Excessive blood level of alcohol (790.3)	
Accidents (Unintended trauma)	Accidental poisoning by alcohol (E860.0-E860.9)	
	Any other accident	Nondependent abuse of alcohol (305.0) or Excessive blood level of alcohol (790.3)
Other trauma	Suicide, homicide or injury of undetermined intentionality	Nondependent abuse of alcohol (305.0) or Excessive blood level of alcohol (790.3)

TABLE 7. Drug-Related Deaths; Based on ICD-9 Diagnoses Cited as Either Underlying or Contributing Causes of Death

Disease category	Underlying cause	Contributing cause
Drug dependence and abuse	Drug psychoses (292.0-292.9) Drug dependence (304.0-304.9) or Nondependent abuse of drugs other than alcohol or tobacco (305.2-305.9)	Drug dependence (304.0-304.9) or Nondependent abuse of drugs other than alcohol or tobacco (305.2-305.9)
	Any other natural cause or any traumatic cause except accidental poisoning by a drug of abuse*, Suicide by drugs or poisoning by drugs of undetermined intentionality	
Accidental poisoning by drugs	Accidental poisoning by a drug of abuse*	Accidental poisoning by a drug of abuse*
Suicide by drugs or poisoning by drugs, intentionality undetermined	Suicide by drugs (E950.0-E950.5) or Poisoning by drugs, intentionality undetermined (E980.0-E980.5)	Suicide by drugs (E950.0-E950.5) or Poisoning by drugs, intentionality undetermined (E980.0-E980.5)

* Includes the following drug categories:

- Opiates and related narcotics (E850.0)
- Salicylates (E850.1)
- Aromatic analgesics, not elsewhere classified (E850.2)
- Other non-narcotic analgesics (E850.5)
- Other analgesics, antipyretics and antirheumatics (850.8)
- Barbiturates (E851)
- Sedatives and hypnotics (E852.0-E852.9)
- Tranquilizers (E853.0-E853.9)
- Other psychotropic drugs (E854.0-E854.3)
- Other central nervous system depressants (E855.1)
- Local anesthetics (E855.2)
- Glues and adhesives (E866.6)
- Nitrogen oxides (E869.0)

TABLE 8. Summary of Differences in Entry and Military-Service Characteristics Between Vietnam and Non-Vietnam Veterans

Characteristic	Vietnam	Non-Vietnam
Race (% white)	86.8	86.5
Region of birth (% NE, MW)	49.3	50.4
Year of entry (% before 1969)	72.1	60.6
Age at entry (mean, in years)	20.3	20.5
Enlistment status (% draftee)	63.7	65.6
Health status at entry (% with some impairment)		
Physical capacity	0.9	1.2
Upper extremity	0.7	0.9
Lower extremity	2.6	2.7
Hearing	5.6	6.7
Visual acuity	25.5	28.7
Psychiatric functioning	0.2	0.2
Overall physical health	32.1	36.0
General Aptitude Tests (mean scores):		
Verbal ability	104.4	106.9
Arithmetic reasoning	101.5	103.8
Pattern analysis	101.7	103.5
General information	100.3	100.8
General technical	103.1	105.5
Armed Forces Qualification	50.4	52.3

TABLE 8. (continued)

Characteristic	Vietnam	Non-Vietnam
Primary MOS (% tactical operations)	34.3	27.4
Type of unit (% infantry)	26.6	14.6
Duration of active duty (mean, in months)	26.1	25.3
AWOL or confinement time (% with some "bad" time)	11.6	13.3
Type of discharge (% nonhonorably)	2.7	8.9
Pay grade at discharge (% E1-E3)	11.5	20.2

TABLE 9. Number of Men, Deaths, Person-Years at Risk, and Crude Death Rates/1000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965-1983)

	Vietnam	Non-Vietnam
Number of men	9,324	8,989
Number of deaths	246	200
Person-years, postdischarge	127,897	121,330
Crude death rate	1.9	1.7
Rate ratio (95% CI)	1.17 (0.97-1.41)	1.00

TABLE 10. Number of Deaths, Person-Years, and Crude Death Rates/1000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Vietnam			Non-Vietnam			Rate ratio	95% CI
	No. deaths	Person-years	Rate/1000	No. deaths	Person-years	Rate/1000		
≤ 5	110	46,350	2.37	73	44,747	1.63	1.45	1.08 - 1.96
6-10	72	45,855	1.57	74	44,233	1.67	0.94	0.68 - 1.30
11+	64	35,692	1.79	53	32,350	1.64	1.09	0.76 - 1.57
All years	246	127,897	1.92	200	121,329	1.65	1.17	0.97 - 1.41

TABLE 11. Number of Deaths, Person-Years, and Crude Death Rates/1000 Person-Years Among Vietnam Veterans, Veterans with Other Foreign Service (Germany or Korea), and Veterans with No Foreign Service and Rate Ratios, by Time Since Discharge (1965-1983)

Cohort	Years since discharge	No. deaths	Person-years	Rate/1000	Rate ratio	95% CI
Vietnam	≤ 5	110	46,350	2.4	-	-
	6-10	72	45,855	1.6	-	-
	11+	64	35,692	1.8	-	-
	All years	246	127,897	1.9	-	-
Germany/ Korea	≤ 5	44	25,485	1.7	1.37*	0.97 - 1.95
	6-10	47	25,210	1.9	0.84	0.58 - 1.22
	11+	31	18,381	1.7	1.06	0.69 - 1.63
	All years	122	69,076	1.8	1.08	0.88 - 1.35
United States service only	≤ 5	29	19,262	1.5	1.57 ⁺	1.05 - 2.37
	6-10	27	19,023	1.4	1.11	0.71 - 1.72
	11+	22	13,969	1.6	1.14	0.70 - 1.85
	All years	78	52,254	1.5	1.29	1.00 - 1.66

* Rate ratios for Vietnam veterans are relative to veterans with other foreign service (Germany or Korea).

+ Rate ratios for Vietnam veterans are relative to veterans with U.S. service only.

TABLE 12. Summary of Results of Chi-Square Tests (p-values) for Effect Modification of Entry and Military Characteristics, by Time Since Discharge (All-Cause Mortality)

Characteristic	Years since discharge		
	≤5 years	6+ years	All years
Race	0.70	0.78	0.89
Age at discharge	0.45	0.15	0.81
Duty MOS	0.84	0.37	0.54
Enlistment status	0.10	0.52	0.14
Region of birth	0.82	0.70	0.97
Composite index of health	0.08	0.38	0.60
GT score	0.92	0.50	0.60
Type of unit	0.77	0.48	0.52
Duration of active duty	0.20	0.81	0.36
AWOL/confinement time	0.14	0.63	0.18
Year of discharge	0.06	0.69	0.43
Type of discharge	0.39	0.78	0.45
Pay grade at discharge	0.78	0.02	0.02

TABLE 13. Summary of Rate Ratios for Vietnam Service Adjusted for the Specified Characteristic, by Time Since Discharge (All-Cause Mortality)

Characteristic	Years since discharge		
	≤5 years	6+ years	All years
(Unadjusted)	1.45*	1.01	1.17
Race	1.45*	1.00	1.17
Age at discharge	1.51*	1.01	1.19
Primary MOS	1.44*	1.00	1.16
Enlistment status	1.44*	0.99	1.15
Region of birth	1.45*	0.97	1.16
Composite index of health	1.45*	1.00	1.16
GT score	1.42*	0.97	1.13
Type of unit	1.37*	1.00	1.13
Duration of active duty	1.42*	0.95	1.12
AWOL/confinement time	1.50*	1.02	1.19
Year of discharge	1.46*	1.00	1.17
Type of discharge	1.59*	1.09	1.28*
Pay grade at discharge	1.66*	1.14	1.32*

* Ninety-five percent confidence interval excludes 1.00.

TABLE 14. Regression Coefficients, Standard Errors (SE), and Associated P-Values from Reduced Cox Regression Models*, by Time Since Discharge (All-Cause Mortality)

Covariate (category)	Years since discharge											
	≤ 5 years				6+ years				All years			
	Coeff.	(SE)	RR†	p-value	Coeff.	(SE)	RR	p-value	Coeff.	(SE)	RR	p-value
Cohort (Vietnam/ other)	0.457	(0.155)	1.58	<0.01	0.036	(0.127)	1.04	0.78	0.207	(0.098)	1.23	0.03
Age at discharge (in years)	-0.079	(0.048)		0.10	0.022	(0.036)		0.54	-0.015	(0.029)		0.59
Race (white/ other)	-0.227	(0.202)		0.26	-0.588	(0.154)		<0.01	-0.449	(0.122)		<0.01
GT score (in units)	-0.008	(0.004)		0.06	-0.012	(0.003)		<0.01	-0.010	(0.003)		<0.01
Pay grade (E4-E5/ other)	-0.740	(0.176)		<0.01	-0.664	(0.147)		<0.01	-0.692	(0.113)		<0.01
Year of discharge (<1970/1970+)	-0.056	(0.155)		0.72	-0.276	(0.137)		0.04	-0.177	(0.102)		0.08

*Model stratified by MOS and enlistment status.

†RR = rate ratio.

TABLE 15. Summary of Entry and Military Service Characteristics For Vietnam Veterans Killed in Service and Those Discharged Alive

Characteristic	Killed in action* (N=181)	Discharged alive (N=9324)
Race (% white)	86.2	86.8
Enlistment status (% draftee)	64.6	63.7
Physical health (% impaired)		
Overall physical capacity	0.0	0.9
Eyes and vision	11.1	25.5
Hearing and ears	4.4	5.6
Psychological health (% impaired)	0.0	0.2
Aptitude tests:		
GT score (mean)	103.1	104.4
AFQT (mean)	48.4	50.4
Duty MOS (% tactical)	86.2	34.5
Type of unit (% infantry)	70.1	26.6

* Inservice deaths from causes other than hostile enemy action are excluded.

TABLE 16. Distribution of Selected Characteristics Among Vietnam and Non-Vietnam Veterans, by Vital Status at End of Follow-Up

Characteristic	Vietnam		Non-Vietnam	
	Status uncertain (N=590)	Status certain (N=8734)	Status uncertain (N=722)	Status certain (N=8267)
Race (% nonwhite)	27.5	12.1	27.0	12.3
Enlistment status (% draftees)	56.3	64.2	53.1	66.7
Physical health (% with any impairment)	29.3	32.6	31.6	36.8
GT score (mean)	96.4	103.6	96.6	106.3
Primary MOS (% tactical)	35.9	34.2	29.8	27.2
Discharge status (% nonhonorable)	11.4	2.1	29.9	7.1
Age at discharge (mean)	21.7	22.0	21.5	22.1
Pay grade at discharge (% E1-E3)	31.4	10.2	53.5	17.3

TABLE 17. Number of Deaths by Cause (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios (1965 - 1983)

Underlying cause of death (ICD-9)*	Vietnam		Non-Vietnam		Rate ratio+	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Infectious and parasitic diseases (001-139)	1	0.8	1	0.8	-	-
Neoplasms (140-239)	12	9.4	14	11.5	0.82	0.38-1.76
Mental disorders (290-319)	7	5.5	7	5.8	0.95	0.33-2.70
Diseases of nervous system (320-389)	2	1.6	1	0.8	-	-
Diseases of circulatory system (390-459)	12	9.4	23	19.0	0.49	0.25-0.99
Diseases of respiratory system (460-519)	5	3.9	4	3.3	-	-
Diseases of digestive system (520-579)	5	3.9	3	2.5	-	-
Diseases of genitourinary system (580-611)	4	3.1	0	-	-	-
Congenital anomalies (740-759)	1	0.8	1	0.8	-	-

TABLE 17. (continued)

Underlying cause of death (ICD-9)*	Vietnam		Non-Vietnam		Rate ratio†	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Symptoms, signs and ill- defined conditions (780-799)	2	1.6	1	0.8	-	-
External causes (E800-E999)	188	147.0	143	117.9	1.25	1.00-1.55
No death certificate	7	-	2	-	-	-

* No deaths were categorized to diseases of blood and blood-forming organs; endocrine, metabolic, or nutritional diseases; diseases of the skin; or diseases of the musculoskeletal system. Therefore, these categories are not shown.

† If the total number of deaths for a cause-of-death category in both groups combined was less than 10, rate ratios are not shown.

TABLE 18. Number of Deaths Due to Neoplasms (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate 100,000	No. deaths	Rate 100,000		
≤5	5	10.8	6	13.4	0.81	0.25-2.64
6+	7	8.6	8	10.4	0.82	0.30-2.27
All years	12	9.4	14	11.5	0.81	0.38-1.76

TABLE 19. Number of Deaths Due to Neoplasms (from Death Certificate)* Among Vietnam and Non-Vietnam Veterans, by Type and Site of Neoplasm (1965-1983)

Neoplasm type/site (ICD-9)	Vietnam	Non-Vietnam
Cancer of colon and rectum (153-154)	0	1
Cancer of liver (155)	1	1
Cancer of lung (162)	0	1
Cancer of skin (172-173)	1	2
Cancer of testis (186)	2	2
Cancer of brain (191)	0	1
Hodgkin's disease (201)	0	1
Lymphosarcoma and other malignant neoplasm of lymphoid tissue (200, 202)	1	1
Leukemia (204-208)	3	2
Malignant neoplasms of unspecified site (199)	1	1
Neoplasms of uncertain behavior or nature (235-239)	3	1

* Because of small numbers of deaths in all categories, rates and rate ratios are not presented.

TABLE 20. Number of Deaths Due to Circulatory System Diseases (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
≤5	0	-	5	11.2	-	-
6+	12	14.7	18	23.5	0.63	0.30-1.30
All years	12	9.4	23	19.0	0.49	0.25-0.99

TABLE 21. Number of Deaths Due to Circulatory System Diseases (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Type of Circulatory System Disease (1965-1983)

Circulatory disease (ICD-9)	Vietnam		Non-Vietnam		Rate ratio*	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Hypertensive disease (401-405)	0	-	2	1.7	-	-
Ischemic heart disease (410-414)	7	5.5	11	9.1	0.60	0.23-1.56
Other heart disease (420-529)	4	3.1	5	4.1	-	-
Cerebrovascular disease (430-438)	1	0.8	3	2.5	-	-
Diseases of the arteries (440-448)	0	-	1	0.8	-	-
Other disorders of circulatory system (459)	0	-	1	0.8	-	-

* If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 22. Number of Deaths Due to External Causes (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Specific Cause (1965-1983)

External cause (ICD-9)	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Motor-vehicle accidents (E810-E825)	81	63.3	52	42.9	1.48	1.04- 2.09
Accidental poisonings (E850-E869)	13	10.2	5	4.1	2.47	0.88- 6.92
Other accidents*	31	24.2	31	25.6	0.95	0.58- 1.56
Suicide (E950-E959)	29	22.7	28	23.1	0.98	0.58- 1.65
Homicide (E960-E969)	26	20.3	25	20.6	0.99	0.57- 1.71
Undetermined (E980-E989)	8	6.3	2	1.6	3.79	0.81-17.87

* Includes accidental deaths other than motor vehicle accidents and accidental poisonings.

TABLE 23. Numbers of Deaths From External Causes (from Death Certificate) Among Vietnam and Non-Vietnam Veterans Combined and Unadjusted Rate Ratios, by Specific Cause and Time Since Discharge (1965-1983)

External cause	Years since discharge					
	≤ 5 years			6+ years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Motor vehicle accident	66	1.93	1.16-3.22	67	1.16	0.72-1.87
Other accidents ⁺	23	1.05	0.46-2.39	39	0.89	0.48-1.67
Suicide	25	1.72	0.76-3.88	32	0.64	0.32-1.30
Suicide ⁺⁺	39	1.72	0.90-3.32	46	1.12	0.63-2.00
Homicide	18	1.52	0.59-3.91	33	0.78	0.39-1.55

* Number of deaths and RRs for "All years" of follow-up are presented in Table 27.

⁺ Includes accidental deaths other than motor vehicle accidents and accidental poisonings.

⁺⁺ Includes: accidental poisonings (E850-869), suicides (E950-959), injury undetermined whether accidentally or purposefully inflicted (E980-989) and ill-defined or unknown cause of death (799.9).

TABLE 24. Number of Deaths Among Vietnam and Non-Vietnam Veterans Combined and Unadjusted Rate Ratios* for Drug- and Alcohol-Related Causes (from Death Certificate), by Time Since Discharge (1965-1983)

Cause†	Years since discharge								
	≤ 5 years			6+ years			All years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Alcohol-related	4	-	-	17	1.73	0.64-4.66	21	1.27	0.52-3.00
Drug-related	15	1.93	0.66-5.64	11	2.50	0.66-9.44	26	2.13	0.93-4.91

* If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

† See Section 3.1.3 for definitions of alcohol- and drug-related causes of death.

TABLE 25. Information Sources Used by Medical Review Panel to Determine Cause of Death, by Place of Service

Source of information	Vietnam		Non-Vietnam	
	No. deaths	(% of all deaths)	No. deaths	(% of all deaths)
Law enforcement record*	124	(53.2)	121	(62.7)
Autopsy report	125	(53.7)	114	(59.1)
Alcohol level	126	(54.1)	108	(56.0)
Medical examiner's report*	117	(50.2)	115	(59.6)
Hospital record	109	(46.8)	85	(44.0)
Toxicologic report	78	(33.5)	76	(39.4)
Coroner's report [†]	81	(34.8)	69	(35.8)
Histopathology report*	9	(3.9)	17	(8.8)
Physician's record	3	(1.3)	2	(1.0)
Other [†]	5	(2.2)	2	(1.0)

* $p < 0.05$ (difference between percents for Vietnam and non-Vietnam veterans)

[†] Other sources of information were records obtained from the U.S. Bureau of Indian Affairs, the U.S. Bureau of Prisons, the National Personnel Records Center of the National Archives and Records Administration, local fire departments, funeral homes, and a single unsolicited verbal report from a next of kin who was contacted by telephone for permission to obtain medical records.

TABLE 26. Number of Information Sources Available to Medical Review Panel, by Place of Service

Number of sources*	Vietnam		Non-Vietnam	
	No. deaths	%	No. deaths	%
1	39	16.7	20	10.4
2	43	18.5	41	21.2
3	47	20.2	35	18.1
4	41	17.6	19	9.8
5	36	15.5	46	23.8
6	22	9.4	28	14.5
7	5	2.2	4	2.1
Total	233	100.0	193	100.0

* The number of information sources available to the medical review panel differed significantly between cohorts ($\chi^2 = 14.41$, $p = 0.02$).

TABLE 27. Percent Agreement and Kappa Statistic Between Death-Certificate and Medical-Review-Panel Cause of Death, by Selected Cause-of-Death Category and Place of Service

Cause of death (ICD-9)	Vietnam				Non-Vietnam			
	No. deaths		Percent agreement	<u>kappa</u> ⁺	No. deaths		Percent agreement	<u>kappa</u> ⁺
	DC	MR*			DC	MR*		
Neoplasms (140-239)	12	14	100.0	0.92	13	11	84.6	0.91
Mental disorders (290-319)	7	12	28.6	0.18	7	4	28.6	0.35
Circulatory diseases (390-459)	11	10	81.8	0.85	23	19	78.3	0.84
Respiratory diseases (460-519)	5	2	20.0	0.28	4	2	50.0	0.66
Digestive diseases (520-579)	5	6	40.0	0.35	2	6	100.0	0.49
Motor-vehicle accidents (E810-E825)	78	80	98.7	0.96	52	52	96.2	0.95
Accidental poisonings (E850-E869)	13	13	46.2	0.43	5	5	60.0	0.59
Suicide (E950-E959)	28	32	100.0	0.92	26	28	100.0	0.96
Homicide (E960-E969)	26	24	88.5	0.91	25	25	96.0	0.95
Undetermined inter- tionality (E980-E989)	8	6	12.5	0.12	2	3	50.0	0.39
Other causes	40	34	65.0	0.65	34	38	85.3	0.76

* DC = number of deaths determined from death certificate; MR = number of deaths determined by medical review panel.

⁺ All kappa values are statistically significant (p<0.01).

TABLE 28. Number of Deaths and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans, by Cause of Death (From Medical Review) (1965-1983)

Cause of death* (ICD-9)	Vietnam		Non-Vietnam		Rate ratio [†]	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Infectious diseases (001-139)	1	0.8	0	-	-	-
Neoplasms (140-239)	14	10.9	11	9.1	1.21	0.55-2.66
Endocrine, nutritional, and metabolic disorders (240-279)	0	-	1	0.8	-	-
Mental disorders (290-319)	12	9.4	4	3.3	2.85	0.92-8.82
Diseases of nervous system (320-389)	1	0.8	3	2.5	-	-
Diseases of circulatory system (390-459)	10	7.8	19	15.7	0.50	0.23-1.07
Diseases of respiratory system (460-519)	2	1.6	2	1.6	-	-
Diseases of digestive system (520-579)	6	4.7	6	4.9	0.95	0.31-2.94
Diseases of genitourinary system (580-611)	3	2.3	1	0.8	-	-

TABLE 28. (continued)

Cause of death* (ICD-9)	Vietnam		Non-Vietnam		Rate ratio ⁺	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Diseases of musculoskeletal system (710-739)	1	0.8	0	-	-	-
Symptoms, signs and ill-defined conditions (780-799)	2	1.6	2	1.6	-	-
External causes (E800-E999)	181	141.5	144	118.7	1.19	0.96-1.48

* Cause-of-death categories that have no deaths assigned to them are not listed above.

+ If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 29. Number of Deaths Due to Neoplasms (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio*	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
≤5	5	10.8	4	8.9	-	-
6+	9	11.0	7	9.1	1.21	0.45-3.24
All years	14	10.9	11	9.1	1.21	0.55-2.66

* If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 30. Number of Neoplastic Deaths (From Medical Review Panel) Among Vietnam and Non-Vietnam Veterans, by Specific Type (1965-1983)

Neoplasm type* (ICD-9)	Vietnam	Non-Vietnam
Cancer of liver (155)	1	0
Cancer of lung (162)	0	2
Cancer of skin (172)	1	2
Cancer of testis (186)	2	2
Cancer of brain (191)	3	1
Cancer of ill-defined site (195)	1	0
Cancer of unspecified site (199)	0	1
Lymphosarcoma (200)	3	1
Hodgkin's disease (201)	0	1
Leukemia (204-208)	2	1
Neoplasms of uncertain behavior (235-238)	1	0

* Because of the small numbers of deaths in all categories, rates and rate ratios are not presented.

TABLE 31. Number of Deaths from External Causes (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Specific External Cause (1965-1983)

External cause (ICD-9)	Vietnam		Non-Vietnam		Rate ratio*	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Motor vehicle accidents (E810-E825)	80	62.6	52	42.9	1.46	1.03-2.07
Accidental poisonings (E850-E869)	13	10.2	5	4.1	2.47	0.88-6.92
Other accidents	26	20.3	31	25.6	0.80	0.47-1.34
Suicide (E950-E959)	32	25.0	28	23.1	1.08	0.65-1.80
Homicide (E960-E969)	24	18.8	25	20.6	0.91	0.52-1.59
Injuries of undetermined intentionality (E980-E989)	6	4.7	3	2.5	-	-

* If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 32. Number of Motor-Vehicle-Accident (MVA) Deaths (From Medical Review) Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios, by Type of MVA and Time Since Discharge (1965-1983)

Type of MVA death	Years since discharge					
	<u>≤ 5 years</u>			<u>6+ years</u>		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Daytime*	16	2.90	0.93-8.98	24	1.11	0.50-2.48
Nighttime ⁺	24	1.93	0.83-4.51	29	1.16	0.56-2.40
Single vehicle ⁺⁺	27	2.76	1.17-6.52	34	1.19	0.60-2.34
Multiple vehicles**	14	2.41	0.76-7.70	19	1.04	0.42-2.57

* MVAs occurring between 6:00 a.m. and 8:59 p.m.

+ MVAs occurring between 9:00 p.m. and 5:59 a.m.

++ ICD-9, E815.0, E815.2, E816.0, and E816.2.

** ICD-9, E811.0, E811.2, E812.0, E812.2, E813.0, and E813.2.

TABLE 33. Number of Motor-Vehicle-Accident (MVA) Deaths (From Medical Review) Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios, by Alcohol Involvement and Time Since Discharge (1965-1983)

Alcohol involvement	Years since discharge								
	≤ 5 years			6+ years			All years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Yes*	24	1.35	0.60-3.04	29	1.16	0.56-2.40	53	1.23	0.72-2.13
No+	10	2.25	0.58-8.71	19	1.04	0.42-2.57	29	1.34	0.64-2.81
Unknown++	31	2.36	1.08-5.13	19	1.29	0.52-3.21	50	1.84	1.03-3.31

* MVA deaths (ICD-9, E810-E825, E929.0) for which either nondependent abuse of alcohol (ICD-9, 305.0) is cited as a contributing cause of death or for which there is a recorded blood alcohol level of at least 100 mg%.

+ MVA deaths for which alcohol abuse is not cited as a contributing cause of death and for which there is a recorded blood alcohol level of less than 100 mg%.

++ MVA deaths for which alcohol abuse is not cited as a contributing cause of death and for which there is no recorded blood alcohol level.

TABLE 34. Number and Type of Alcohol- and Drug-Associated Deaths Based on Death Certificates and Medical Review, with Associated Percent Agreement and Kappa Statistic

Cause of death*	No. deaths		Percent agreement	<u>Kappa</u> statistic
	Death certificate	Medical review		
<u>Alcohol-associated</u>				
Natural causes	9	30	100.0	0.44
Accidents	8	65	62.5	0.11
Suicide, homicide, injury of undetermined intentionality	4	38	75.0	0.13
Total	21	133	85.7	0.16
<u>Drug-associated</u>				
Drug dependence and abuse	8	28	62.5	0.26
Accidental poisoning by drugs	10	10	50.0	0.49
Suicide or poisoning by drugs, intentionality undetermined	8	2	12.5	0.19
Total	26	40	92.3	0.71

* See Section 3.1.3 for definitions of alcohol- and drug-associated deaths.

TABLE 35. Number and Type of Alcohol-Associated Deaths (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965-1983)

Type of death*	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Natural causes	16	12.5	14	11.5	1.08	0.53-2.22
Accidents	37	28.9	28	23.1	1.25	0.77-2.05
Suicide, homicide, and injury of undetermined intentionality	19	14.9	19	15.7	0.95	0.50-1.79
Total	72	56.3	61	50.3	1.12	0.80-1.57

* See Section 3.1.3 for definitions of alcohol-associated deaths.

TABLE 36. Number and Type of Drug-Associated Deaths (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965-1983)

Type of death*	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
Dependence and abuse	17	13.3	11	9.1	1.47	0.69-3.13
Accidental poisoning by drugs	6	4.7	4	3.3	1.42	0.40-5.04
Suicide or poisonings by drugs, undetermined intentionality	2	1.6	0	-	-	-
Total drug-associated deaths	25	19.5	15	12.4	1.58	0.83-3.00

* See Section 3.1.3 for definitions of drug-related deaths.

TABLE 37. Number of Drug-Associated Deaths* (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio ⁺	95% CI
	No. deaths	Rate/100,000	No. deaths	Rate/100,000		
≤5	10	21.6	8	17.9	1.21	0.48-3.06
6-10	8	17.4	5	11.3	1.54	0.50-4.71
11+	7	19.6	2	6.2	-	-
All years	25	19.5	15	12.4	1.58	0.83-3.00

* See Section 3.1.3 for definition of drug-associated deaths.

+ If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 38. Unadjusted and Adjusted* Rate Ratios Based on Death Certificate and Medical Review Cause of Death, by Selected Cause of Death and Time Since Discharge (1965-1983)

Cause of death [†]	Death Certificate				Medical Review			
	≤5 years		6+ years		≤5 years		6+ years	
	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR
Neoplasms	0.81	0.83	0.82	0.68	-	-	1.21	1.07
Circulatory diseases	-	-	0.60	0.60	-	-	0.56	0.51
Motor vehicle accidents	1.93	1.98	1.16	1.22	1.89	1.96	1.16	1.22
Suicide	1.72	2.54	0.64	0.57	1.64	2.47	0.78	0.74
Homicide	1.52	1.46	0.78	0.85	1.38	1.35	0.73	0.82
Alcohol-related	-	-	1.73	2.23	1.42	1.67	0.99	0.97
Drug-related	1.93	2.86	2.50	2.99	1.21	1.56	2.02	2.57

* Adjusted values are from a Cox Proportional Hazards Model, stratified on MOS and enlistment status, and controlled for age, race, GT score, year of discharge, and pay grade at discharge.

† If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

TABLE 39. Observed and Expected Numbers of Deaths by Cause (From Death Certificate) Among Vietnam and Non-Vietnam Veterans and Standardized Mortality Ratios, by Time Since Discharge (1965-1983)

Years since discharge	Cause of death* (ICDA-8)		Vietnam	Non-Vietnam
≤5	All natural causes (000-796)	Observed	13	16
		Expected ⁺	24.2	23.4
		SMR ⁺⁺	0.54	0.68
		95% CI	0.29-0.92	0.39-1.11
	External causes (E800-E999)	Observed	92	55
		Expected	72.5	69.4
	SMR	1.27	0.79	
	95% CI	1.02-1.56	0.60-1.03	
6+	All natural causes (000-796)	Observed	38	39
		Expected	65.8	63.4
		SMR	0.58	0.62
		95% CI	0.41-0.79	0.44-0.84
	External causes (E800-E999)	Observed	96	88
		Expected	102.7	96.6
	SMR	0.93	0.91	
	95% CI	0.76-1.14	0.73-1.12	
All years	All natural causes (000-796)	Observed	51	55
		Expected	90.0	86.8
		SMR	0.57	0.63
		95% CI	0.42-0.75	0.48-0.82
	External causes (E800-E999)	Observed	188	143
		Expected	175.2	166.0
	SMR	1.07	0.86	
	95% CI	0.93-1.24	0.73-1.01	

* Excludes 9 deaths (7 Vietnam, 2 non-Vietnam) for which death certificates were not recovered.

⁺ Expected number is based on the mortality rates among U.S. males, standardized for age, calendar year, and race.

⁺⁺ SMR=Observed deaths/expected deaths

TABLE 40. Observed and Expected Deaths by Specific Natural Cause (From Death Certificate) Among Vietnam and Non-Vietnam Veterans and Standardized Mortality Ratios (1965-1983)

Cause of death* (ICDA-8)	Vietnam			Non-Vietnam		
	Observed deaths	Expected ⁺ deaths	SMR ⁺⁺ (95% CI)	Observed deaths	Expected deaths	SMR (95% CI)
Infectious diseases (000-136)	1	2.3	-	1	2.2	-
Neoplasms (140-239)	12	21.0	0.57 (0.30-1.00)	14	20.1	0.70 (0.38-1.17)
Mental disorders (290-315)	5	5.7	0.87 (0.29-2.05)	8	5.4	1.49 (0.64-2.91)
Diseases of nervous system (320-389)	2	4.4	-	1	4.2	-
Diseases of circulatory system (390-458)	12	24.8	0.48 (0.25-0.85)	21	24.0	0.87 (0.54-1.34)
Diseases of respiratory system (460-519)	5	6.0	0.84 (0.27-1.96)	4	5.7	-
Diseases of digestive system (520-577)	6	10.8	0.56 (0.20-1.21)	3	10.3	-
Diseases of genitourinary system (580-611)	5	2.0	2.53 (0.82-5.79)	1	1.9	-
Congenital anomalies (740-759)	1	-	-	1	-	-

TABLE 40. (continued)

Cause of death ⁺ (ICDA-8)	Vietnam			Non-Vietnam		
	Observed deaths	Expected ⁺ deaths	SMR ⁺⁺ (95% CI)	Observed deaths	Expected deaths	SMR (95% CI)
Symptoms, signs and ill-defined conditions (780-796)	2	6.7	-	1	6.3	-

* Because causes of death are coded to the Eighth Revision of the International Classification of Diseases, the numbers of deaths for certain causes may not agree with the numbers coded according to the Ninth Revision (see Section 4.3.1). Categories not listed had no deaths assigned to them.

+ Expected number based on the mortality rates among U.S. males and standardized for age, calendar year, and race.

++ SMR = Observed deaths/expected deaths. SMRs are not computed for categories with fewer than five observed deaths.

TABLE 41. Observed and Expected Numbers of Deaths (From Death Certificate) for Specific External Causes Among Vietnam and Non-Vietnam Veterans and Standardized Mortality Ratios (1965-1983)

External cause (ICDA-8)	Vietnam			Non-Vietnam		
	Observed deaths	Expected* deaths	SMR ⁺ (95% CI)	Observed deaths	Expected deaths	SMR (95% CI)
All accidents (E800-E949)	125	103.8	1.20 (1.00-1.43)	88	98.2	0.90 (0.72-1.10)
Motor vehicle accidents (E810-E827)	81	63.2	1.28 (1.02-1.59)	52	59.8	0.87 (0.65-1.14)
Other accidents	44	40.6	1.08 (0.79-1.46)	36	38.4	0.94 (0.66-1.30)
Suicide (E950-E959)	29	29.3	0.99 (0.66-1.42)	28	27.8	1.01 (0.67-1.45)
Homicide and all other external causes (E960-E999)	34	42.3	0.80 (0.55-1.12)	27	40.2	0.67 (0.44-0.98)

* Expected number based on the mortality rates among U.S. males and standardized for age, calendar year and race.

+ SMR = Observed deaths/expected deaths.

APPENDIX A

Detailed Distributions of Veteran Characteristics

TABLE A-1. Descriptive Characteristics of Vietnam Experience Study Veterans at Time of Entry Into U.S. Army, by Duty Location

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Total	9324	100.0	8989	100.0	5120	100.0	3869	100.0
Race:								
White	8097	86.8	7776	86.5	4403	86.0	3373	87.2
Black	1156	12.4	1123	12.5	666	13.0	457	11.8
Other	63	0.7	85	0.9	49	1.0	36	0.9
Unknown	8	0.1	5	0.1	2	0.0	3	0.1
			(X ² = 4.22, p=0.12)		(X ² = 4.62, p=0.10)		(X ² = 3.17, p=0.21)	
Place of birth:								
Northeast	1769	19.0	1781	19.8	1006	19.6	775	20.0
Midwest	2827	30.3	2751	30.6	1607	31.4	1144	29.6
South	2205	23.6	2047	22.8	1188	23.2	859	22.2
West	2193	23.5	1988	22.1	1147	22.4	841	21.7
Foreign	312	3.3	393	4.4	160	3.1	233	6.0
Unknown	18	0.2	29	0.3	12	0.2	17	0.4
			(X ² =21.28, p<0.001)		(X ² = 7.42, p=0.19)		(X ² =55.81, p<0.001)	
Enlistment status:								
Draftee	5943	63.7	5899	65.6	3201	62.5	2698	69.7
Volunteer	3381	36.3	3090	34.4	1919	37.5	1171	30.3
			(X ² = 7.12, p=0.01)		(X ² = 2.11, p=0.15)		(X ² =43.49, p<0.001)	
Age at entry:								
17	443	4.8	590	6.6	357	7.0	233	6.0
18	979	10.5	748	8.3	465	9.1	283	7.3
19	3459	37.1	1967	33.0	1777	34.7	1190	30.8
20	2200	23.7	2001	22.3	1174	21.9	827	21.4
21+	2235	24.0	2683	29.9	1347	26.3	1336	34.5
			(X ² =134.39, p<0.001)		(X ² =49.38, p<0.001)		(X ² =187.80, p<0.001)	

TABLE A-1. (Continued)

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Year of entry:								
1965	1112	11.9	1271	14.1	673	13.1	598	15.5
1966	1997	21.4	1925	21.4	1151	22.5	774	20.0
1967	1659	17.8	983	10.4	632	12.3	306	7.9
1968	1953	21.0	1318	14.7	790	15.4	528	13.7
1969	1702	18.3	1357	15.1	729	14.2	628	16.2
1970	650	7.4	1227	13.7	650	12.7	577	14.9
1971	208	2.2	953	10.6	495	9.7	458	11.8
			(X ² =995.06, p<0.001)		(X ² =626.24, p<0.001)		(X ² =950.91, p<0.001)	

TABLE A-2. Physical and Mental Profile of Vietnam Experience Study Veterans At Time of Entry into U.S. Army, by Duty Location

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Total	9324	100.0	8989	100.0	5120	100.0	3869	100.0
Physical Capacity or Stamina:								
No impairment	9230	99.0	8877	98.8	5053	98.7	3824	98.8
Mild-significant	85	0.9	106	1.2	63	1.2	43	1.1
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² = 3.17, p=0.06)		(X ² = 3.31, p=0.07)		(X ² = 1.13, p=0.29)	
Upper Extremities:								
No impairment	9247	99.2	8904	99.1	5073	99.1	3831	99.0
Mild-significant	68	0.7	79	0.9	43	0.8	36	0.9
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² = 1.28, p=0.26)		(X ² = 0.53, p=0.47)		(X ² = 1.41, p=0.24)	
Lower Extremities:								
No impairment	9075	97.3	8743	97.3	4982	97.3	3761	97.2
Mild-significant	240	2.6	240	2.7	134	2.6	106	2.7
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² = 0.16, p=0.69)		(X ² = 0.02, p=0.88)		(X ² = 0.29, p=0.59)	
Hearing Acuity and Ears:								
No impairment	8794	94.3	8378	93.2	4763	93.0	3615	93.4
Mild-significant	521	5.6	605	6.7	353	6.9	252	6.5
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² =10.32, p=0.001)		(X ² = 9.91, p=0.002)		(X ² = 4.22, p=0.04)	
Eyes and Visual Acuity:								
No impairment	6934	74.4	6404	71.2	3677	71.8	2727	70.5
Mild-significant	2381	25.5	2579	28.7	1439	28.1	1140	29.5
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² =22.95, p<0.001)		(X ² =11.18, p<0.001)		(X ² =21.44, p<0.001)	

TABLE A-2. (Continued)

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Psychiatric								
Functioning:								
No impairment	9300	99.7	8962	99.7	5105	99.7	3857	99.7
Mild-significant	15	0.2	21	0.2	11	0.2	10	0.3
Unknown	9	0.1	6	0.1	4	0.1	2	0.1
			(X ² = 1.23, p=0.27)		(X ² = 0.54, p=0.46)		(X ² = 1.37, p=0.24)	
Composite Index								
of Health:								
No impairment	6297	67.5	5712	63.5	3270	63.9	2442	63.1
Mild-significant	2990	32.1	3232	36.0	1823	35.6	1409	36.4
Other than minor	26	0.3	36	0.4	20	0.4	16	0.4
Unknown	11	0.1	9	0.1	7	0.1	2	0.1
			(X ² =33.47, p<0.001)		(X ² =20.43, p<0.001)		(X ² =25.13, p<0.001)	

TABLE A-3. Mean Scores of Vietnam Experience Study Veterans on Aptitude Tests Given as Part of the Entrance Examination for the U.S. Army, by Duty Location

Aptitude Test	Vietnam			Total Non-Vietnam			Germany/Korea			United States Only		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Army Classification Battery:												
Verbal ability	9136	104.4	21.9	8863	106.9	22.1 (t=-7.55, p<0.001)	5067	105.2	22.1 (t=-2.17, p=0.03)	3796	109.0	21.9 (t=-11.00, p<0.001)
Arithmetic reasoning	9135	101.5	21.5	8865	103.8	22.1 (t=-7.26, p<0.001)	5068	102.3	21.8 (t=-2.13, p=0.03)	3797	105.9	22.3 (t=-10.6, p<0.001)
Pattern analysis	9136	101.7	22.5	8864	103.5	22.3 (t=-5.42, p<0.001)	5068	102.8	22.0 (t=-2.66, p=0.008)	3796	104.6	22.7 (t=-6.52, p<0.001)
General information	9117	100.3	18.4	8844	100.8	18.5 (t=-1.85, p=0.07)	5060	100.2	18.3 (t= 0.30, p=0.77)	3784	101.6	18.9 (t=-3.68, p<0.001)
General technical	9200	103.1	19.9	8914	105.5	20.4 (t=-8.08, p<0.001)	5087	104.0	20.2 (t=-2.52, p=0.01)	3827	107.6	20.6 (t=-11.5, p<0.001)
Armed Forces Qualification Test	9280	50.4	25.5	8950	52.3	26.0 (t=-5.06, p<0.001)	5102	50.8	25.7 (t=-0.97 p=0.33)	3848	54.3	26.3 (t=-7.94, p<0.001)

TABLE A-4. Military-Service Characteristics of Vietnam Experience Study Veterans, by Duty Location

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Total	9324	100.0	8989	100.0	5120	100.0	3869	100.0
Military Occupational Specialty*:								
Tactical	3196	34.3	2462	27.4	1577	30.8	885	22.9
Missile and fire control	48	0.5	166	1.6	116	2.3	50	1.3
electronic maintenance								
General electronics maintenance	591	6.3	621	6.9	431	8.4	190	4.9
Precision maintenance	147	1.6	162	1.8	93	1.8	69	1.8
Auxillary services	441	4.7	333	3.7	199	3.9	134	3.5
Motors	1776	19.1	1223	13.6	761	14.9	462	11.9
Clerical	1763	18.9	1907	21.2	992	19.4	915	23.7
Graphics	106	1.1	170	1.9	82	1.6	88	2.3
General technical	1002	10.8	1579	17.6	685	13.4	894	23.1
Special assignment	254	2.7	366	4.1	184	3.6	182	4.7
			(X ² =442.5, p<0.001)		(X ² =194.6, p<0.001)		(X ² =616.3, p<0.001)	

TABLE A-4. (Continued)

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Type of Unit:								
Infantry	2477	26.6	1313	14.6	906	17.7	407	10.5
Engineer	911	9.8	542	6.0	368	7.2	174	4.5
Armor	123	1.3	508	5.7	376	7.3	132	3.4
Cavalry	792	8.5	203	2.3	127	2.5	76	2.0
Artillery	1021	11.0	1462	16.3	1061	20.7	401	10.4
Other	3920	42.0	4926	54.8	2264	44.2	2662	68.8
Unknown	80	0.9	35	0.4	18	0.4	17	0.4
			(X ² =1223.2, p<0.001)		(X ² =892.3, p<0.001)		(X ² =1045.2, p<0.001)	
Number of Months of Active Duty:								
1-12	484	5.1	445	5.0	62	1.2	383	9.9
13-24	6208	66.6	6315	70.3	3560	69.5	2755	71.2
25-36	2632	28.2	1946	21.6	1367	26.7	579	15.0
37+	0	0.0	283	3.1	131	2.6	152	3.9
			(X ² =436.0, p<0.001)		(X ² =19.8, p=0.003)		(X ² =1070.9, p<0.001)	

*Job specialty for which the man was trained.

TABLE A-5. Military Characteristics of Vietnam Experience Study Veterans at Discharge from Active Duty, by Duty Location

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Total	9324	100.0	8989	100.0	5120	100.0	3869	100.0
Ever AWOL or Confinement Time:								
No	8163	87.5	7744	86.2	4668	91.2	3076	79.5
Yes	1081	11.6	1197	13.3	422	8.2	775	20.0
Unknown	80	0.9	48	0.5	30	0.6	18	0.5
			($\chi^2=11.9$, $p<0.001$)		($\chi^2=40.5$, $p<0.001$)		($\chi^2=158.8$, $p<0.001$)	
Type of Discharge:								
Honorable	9067	97.2	8183	91.0	4866	95.0	3317	85.7
Other	249	2.7	802	8.9	252	4.9	550	14.2
Unknown	8	0.1	4	0.1	2	0.1	2	0.1
			($\chi^2=333.6$, $p<0.001$)		($\chi^2=51.0$, $p<0.001$)		($\chi^2=640.8$, $p<0.001$)	
Pay Grade at Discharge:								
E-1	249	2.7	649	7.2	185	3.6	464	12.0
E-2	212	2.3	499	5.6	180	3.5	319	8.3
E-3	614	6.6	668	7.4	362	7.1	306	7.9
E-4	4608	49.4	4278	47.6	2642	51.6	1636	42.3
E-5	3641	39.1	2895	32.2	1751	34.2	1144	29.6
			($\chi^2=387.7$, $p<0.001$)		($\chi^2=53.7$, $p<0.001$)		($\chi^2=786.0$, $p<0.001$)	
Age at Discharge:								
<19	11	0.1	172	1.9	68	1.3	104	2.7
19	173	1.9	320	3.6	152	3.0	168	4.3
20	841	9.0	774	8.6	421	8.2	353	9.1
21	3421	36.7	2776	30.9	1704	33.3	1072	27.7
22	2374	25.5	2032	22.6	1268	24.8	764	19.8
23	1094	11.7	1145	12.7	661	12.9	484	12.5
24	632	6.8	755	8.4	378	7.4	377	9.7
25+	778	8.3	1015	11.3	468	9.1	547	14.1
			($\chi^2=319.3$, $p<0.001$)		($\chi^2=128.5$, $p<0.001$)		($\chi^2=499.2$, $p<0.001$)	

TABLE A-5. (Continued)

Characteristic	Vietnam		Total Non-Vietnam		Germany/Korea		United States Only	
	No.	%	No.	%	No.	%	No.	%
Year of Discharge:								
1965-1966	21	0.2	94	1.1	22	0.4	72	1.9
1967-1968	2482	26.6	2787	31.0	1516	29.6	1271	32.9
1969-1970	4011	43.0	2395	26.6	1565	30.6	830	21.5
1971-1972	2571	27.6	2811	31.3	1521	29.7	1290	33.3
1973-1974	234	2.5	856	9.5	488	9.5	368	9.5
1975-1977	5	0.1	46	0.5	8	0.2	38	1.0
			(X ² =864.4, p<0.001)		(X ² =483.2, p<0.001)		(X ² =884.9, p<0.001)	

VIETNAM EXPERIENCE STUDY — Mortality

APPENDIX B

Detailed Examination of All-Cause
Mortality by Selected Covariates

In this section, we present a detailed examination of factors that might modify the effect of Vietnam service on mortality. Because the increased rate of mortality associated with service in Vietnam appears to be limited to the first 5 years of follow-up, and because covariates potentially can have different effects in different time periods, all covariates are examined with respect to time since discharge.

1. Entry Characteristics

Race (Table B-1): The effect of Vietnam service on mortality in the early postservice period is slightly higher for whites (RR=1.50) than for persons of races other than white (RR=1.30) but the test for effect modification is not significant. After the first 5 years of follow-up, there is little or no effect of Vietnam service on mortality in whites or in nonwhites.

Region of birth (Table B-2): Although the rate ratios appear to vary somewhat among the various regions of birth, the variation is not statistically significant. In general, regardless of where they were born, Vietnam veterans were more likely to die within the first 5 years after discharge than non-Vietnam veterans. After 5 years, again regardless of region of birth, little increase in the relative rate of mortality among Vietnam veterans is seen.

GI score (Table B-3): Overall, level of performance on the GI test does not appear to modify the effect of Vietnam service on mortality. Although not shown, similar conclusions can be drawn from an examination of the potential modifying effect of the other components of the Army Classification Battery and the Armed Forces Qualification Test.

Physical health profile (Table B-4): In the first 5 years after discharge, the rate ratios associated with service in Vietnam appear to differ somewhat among those with and without physical impairment. Among those with some type of physical impairment, over a twofold increase in the rate of mortality was found for those who served in Vietnam relative to those who had not. In contrast, there is only a 20% increase among veterans with no impairment in functioning. This departure from homogeneity is of borderline significance ($X^2=3.10$, $p = 0.08$). After the initial 5 years, the rate ratios are 1.1 for veterans with no impairment and 0.9 for those with any impairment. Although not shown, the patterns for the individual physical components mirror those seen with the summary measure.

Enlistment status (Table B-5): The rate ratios in the first 5 years after discharge differ somewhat among those who volunteered for military service compared to those who were drafted. Vietnam veterans who were drafted into service were 1.8 times more likely to die in the first five years postservice, but Vietnam veterans who volunteered were only 1.1 times more likely. The test of effect modification is of borderline significance ($p=0.09$). After the first 5 years, both rate ratios are at or below 1.0, indicating no association between Vietnam service and likelihood of dying in that time period for either volunteers or draftees.

2. Military and Discharge Characteristics

Military occupational speciality (Table B-6): The categorization of MOS into "tactical" and "nontactical" jobs is a rough surrogate for combat exposure; Vietnam veterans assigned a tactical MOS are more likely to have experienced combat than those with nontactical MOSs. In general, service

in a tactical MOS does not appear to influence the effect of Vietnam service on likelihood of dying. In the initial follow-up period, service in Vietnam has a slightly greater effect on mortality among those with a nontactical MOS. The opposite pattern is apparent after five years. Neither difference is statistically significant.

Type of unit (Table B-7): In the first 5 years after discharge, the death rate is increased among Vietnam veterans who served in each type of unit except engineering units. The rate ratios are especially high among those in the infantry (RR=2.02) and armor (RR=2.07). The overall test for effect modification is, however, not statistically significant. In addition, Vietnam veterans assigned to engineering units do not appear to be at greater risk of dying than Vietnam veterans in other units. Only 23% of men in engineering units, however, had an MOS that could be classified as an actual engineering occupation. When the analysis was restricted to such veterans, similar results were found.

AWOL or confinement time (Table B-8): In the first five years after discharge, the rate ratio associated with service in Vietnam is higher among those who never had AWOL or confinement time than for those who had been AWOL or had served confinement time, but this difference is not statistically significant. After 5 years both rate ratios are close to unity.

Duration of active duty (Table B-9): Vietnam veterans who served less than 12 months of active duty in the Army had an appreciably higher relative death rate than those serving more than 12 months. Although further exploration was not possible because of the small numbers, this departure from homogeneity is not statistically significant.

Age at discharge (Table B-10): The effect of Vietnam service on mortality is somewhat stronger among those who were less than 21 years at the time of discharge than among those 21 years or older. The reverse is true in the later follow-up period. This finding may be the result of chance fluctuation, since the tests for effect modification in both follow-up periods are nonsignificant.

Year of discharge (Table B-11): A modifying effect of borderline significance ($p=0.06$) is seen for year of discharge during the initial follow-up period. For those discharged before 1970, and who therefore served sometime between 1965 and 1969, the death rate among Vietnam veterans is more than twice that of veterans who did not serve in Vietnam. In contrast, the increase for those discharged in 1970 and after is only 16%. There is no difference in the rate ratios for those discharged before and after 1970 in the 6-plus-year follow-up period, both ratios being about 1.00. The results in the first 5 years after discharge may be due to differences in the characteristics of Vietnam veterans who served before 1970 compared with those who served later. For example, those serving earlier were younger at discharge and more likely to have been drafted than those serving later. When these and other factors are controlled, the excess risk in Vietnam veterans discharged before 1970 is still apparent.

Type of discharge (Table B-12): There is no significant difference in the relative rate of mortality associated with Vietnam service between honorably or nonhonorably discharged veterans in either follow-up interval, although in the initial postservice period, Vietnam veterans with honorable discharges had higher relative mortality than Vietnam

veterans with nonhonorably discharges. These estimates, however, are based on small numbers of deaths and, therefore, are unstable.

Pay grade at discharge (Table B-13): In the earlier follow-up interval, all rate ratios are greater than 1.0. Although a lower pay grade is associated with a higher rate of mortality, this effect is seen among both Vietnam and non-Vietnam veterans. Consequently, a test of interaction comparing the relative rates among the five categories in the first 5-year period is not statistically significant. Although there does not appear to be any consistent pattern across categories, the chi-square test indicates a lack of homogeneity among the five pay grade categories in the later and total follow-up period.

TABLE B-2. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Region of Birth, and Time Since Discharge (1965-1983)

Years since discharge	Region of birth*	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	Northeast	16	1.8	15	1.7	1.07	0.53 - 2.17
	Midwest	37	2.6	23	1.7	1.57	0.93 - 2.64
	South	25	2.3	16	1.6	1.45	0.78 - 2.72
	West	32	2.6	19	1.6	1.60	0.91 - 2.83
6+	Northeast	25	1.6	18	1.2	1.37	0.75 - 2.51
	Midwest	36	1.5	34	1.5	1.00	0.62 - 1.59
	South	39	2.0	37	2.1	0.96	0.61 - 1.50
	West	36	1.7	38	1.9	0.87	0.55 - 1.38
All years	Northeast	41	1.7	33	1.4	1.23	0.78 - 1.95
	Midwest	73	1.9	57	1.5	1.22	0.86 - 1.73
	South	64	2.1	53	1.9	1.11	0.77 - 1.59
	West	68	2.0	57	1.8	1.11	0.78 - 1.58

*Foreign places of birth grouped with West category.

Tests for effect modification of region of birth: ≤5 years: $\chi^2 = 0.91$, $p = 0.82$
 6+ years: $\chi^2 = 1.42$, $p = 0.70$
 All years: $\chi^2 = 0.27$, $p = 0.97$

TABLE B-3. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, General Technical Test (GT) Score, and Time Since Discharge (1965-1983)

Years since discharge	GT score	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	<100	60	3.0	37	2.1	1.41	0.93-2.12
	100+	48	1.8	35	1.3	1.43	0.92-2.20
6+	<100	73	2.1	68	2.3	0.90	0.64-1.25
	100+	61	1.3	58	1.2	1.07	0.75-1.53
All years	<100	133	2.4	105	2.3	1.07	0.83-1.39
	100+	109	1.5	93	1.2	1.20	0.91-1.58

Tests for effect modification of GT score: ≤5 years: $\chi^2 = 0.004$, $p = 0.95$
 6+ years: $\chi^2 = 0.53$, $p = 0.47$
 All years: $\chi^2 = 0.33$, $p = 0.57$

TABLE B-4. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Composite Index of Health, and Time Since Discharge (1965-1983)

Years since discharge	Composite index of health	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	No impairment	69	2.2	52	1.8	1.20	0.64 - 1.73
	Some impairment	41	2.7	21	1.3	2.12	1.25 - 3.59
6+	No impairment	100	1.8	82	1.7	1.08	0.80 - 1.44
	Some impairment	36	1.4	45	1.6	0.85	0.55 - 1.32
All years	No impairment	169	2.0	134	1.7	1.12	0.90 - 1.41
	Some impairment	77	1.9	66	1.5	1.25	0.90 - 1.74

Tests for effect modification of composite index of health:

≤5 years: $\chi^2 = 3.10, p = 0.08$
 6+ years: $\chi^2 = 0.78, p = 0.38$
 All years: $\chi^2 = 0.27, p = 0.60$

TABLE B-5. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Enlistment Status and Time Since Discharge (1965-1983)

Years since discharge	Enlistment status	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
<5	Volunteers	43	2.6	36	2.4	1.09	0.70 - 1.70
	Draftees	67	2.3	37	1.3	1.80	1.21 - 2.69
6+	Volunteers	57	2.1	54	2.3	0.91	0.63 - 1.32
	Draftees	79	1.5	73	1.4	1.06	0.77 - 1.45
All years	Volunteers	100	2.3	90	2.3	0.98	0.74 - 1.30
	Draftees	146	1.8	110	1.3	1.31	1.02 - 1.67

Tests for effect modification of enlistment status: <5 years: $\chi^2 = 2.72, p = 0.09$
 6+ years: $\chi^2 = 0.34, p = 0.55$
 All years: $\chi^2 = 2.20, p = 0.14$

TABLE B-6. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Military Occupational Specialty (MOS) Category and Time Since Discharge (1965-1983)

Years since discharge	MOS* category	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	Tactical	39	2.4	24	2.0	1.19	0.71-1.97
	Nontactical	71	2.3	49	1.5	1.58	1.10-2.27
6+	Tactical	53	1.8	36	1.8	1.04	0.68-1.59
	Nontactical	83	1.6	91	1.6	0.97	0.72-1.30
All years	Tactical	92	2.1	60	1.9	1.10	0.79-1.52
	Nontactical	154	1.8	140	1.6	1.18	0.94-1.48

*Based on MOS assignment held while on active duty.

Tests for effect modification of MOS: ≤5 years: $\chi^2 = 0.81$, $p = 0.37$
 6+ years: $\chi^2 = 0.08$, $p = 0.78$
 All years: $\chi^2 = 0.12$, $p = 0.73$

TABLE B-7. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Type of Unit and Time Since Discharge (1965-1983)

Years since discharge	Type of unit	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	Infantry	38	3.1	10	1.5	2.02	1.01 - 4.06
	Engineer	8	1.8	5	1.9	0.95	0.31 - 2.90
	Armor	2	3.3	4	1.6	2.07	0.38 - 11.3
	Cavalry	13	3.3	2	2.0	1.68	0.38 - 7.43
	Artillery	14	2.8	17	2.3	1.18	0.58 - 2.39
	Other	33	1.7	35	1.4	1.18	0.74 - 1.91
6+	Infantry	37	1.7	20	1.8	0.94	0.55 - 1.63
	Engineer	13	1.6	10	2.2	0.74	0.32 - 1.68
	Armor	2	1.9	7	1.6	1.19	0.25 - 5.74
	Cavalry	15	2.2	3	1.8	1.23	0.36 - 4.26
	Artillery	22	2.4	18	1.4	1.72	0.92 - 3.20
	Other	46	1.3	67	1.6	0.84	0.58 - 1.22
All years	Infantry	75	2.2	30	1.7	1.30	0.85 - 1.98
	Engineer	21	1.7	15	2.1	0.81	0.42 - 1.56
	Armor	4	2.4	11	1.6	1.51	0.48 - 4.75
	Cavalry	28	2.6	5	1.9	1.40	0.54 - 3.64
	Artillery	36	2.5	35	1.8	1.46	0.91 - 2.32
	Other	79	1.5	102	1.5	0.96	0.71 - 1.28

Tests for effect modification of type of unit: ≤5 years: $\chi^2 = 2.5$, $p = 0.77$
 6+ years: $\chi^2 = 4.5$, $p = 0.48$
 All years: $\chi^2 = 4.2$, $p = 0.52$

TABLE B-8. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Presence of AWOL or Confinement Time, and Time Since Discharge (1965-1983)

Years since discharge	AWOL or confinement time	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
<u><5</u>	Ever	19	3.6	21	3.5	1.00	0.54 - 1.86
	Never	91	2.2	51	1.3	1.70	1.20 - 2.39
6+	Ever	30	3.5	34	3.7	0.92	0.56 - 1.51
	Never	106	1.5	93	1.4	1.06	0.80 - 1.40
All years	Ever	49	3.5	55	3.7	0.95	0.65 - 1.40
	Never	197	1.8	144	1.4	1.28	1.03 - 1.59

Tests for effect modification of AWOL or confinement time: ≤ 5 years: $\chi^2 = 2.13, p = 0.14$
 $\bar{6}+$ years: $\chi^2 = 0.23, p = 0.63$
All years: $\chi^2 = 1.76, p = 0.18$

TABLE B-9. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Duration of Active Duty, and Time Since Discharge (1965-1983)

Years since discharge	Duration of active duty (in months)	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
<u><5</u>	<12	2	9.2	3	1.5	6.17	1.03 - 36.86
	12-23	66	2.2	42	1.4	1.59	1.08 - 2.34
	24+	42	2.6	28	2.3	1.16	0.72 - 1.86
6+	<12	1	2.5	6	1.6	1.57	0.19 - 13.07
	12-23	72	1.3	77	1.4	0.92	0.67 - 1.27
	24+	63	2.4	44	2.3	1.04	0.71 - 1.53
All years	<12	3	4.9	9	1.6	3.13	0.85 - 11.54
	12-23	138	1.6	119	1.4	1.15	0.90 - 1.47
	24+	105	2.5	72	2.3	1.08	0.80 - 1.46

Tests for effect modification of duration of active duty: <5 years: $X^2 = 3.20, p = 0.20$
 6+ years: $X^2 = 0.41, p = 0.81$
 All years: $X^2 = 2.02, p = 0.36$

TABLE B-10. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Age at Discharge and Time Since Discharge (1965-1983)

Years since discharge	Age at discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
<u>≤5</u>	<21	28	5.5	19	3.0	1.83	1.02 - 3.27
	21+	82	2.0	54	1.4	1.41	1.00 - 1.99
6+	<21	15	1.8	27	2.7	0.67	0.36 - 1.26
	21+	121	1.7	100	1.5	1.10	0.84 - 1.43
All years	<21	43	3.2	46	2.8	1.14	0.75 - 1.73
	21+	203	1.8	154	1.5	1.21	0.98 - 1.49

Tests for effect modification of age at discharge: ≤5 years: $\chi^2 = 0.56$, $p = 0.45$
6+ years: $\chi^2 = 2.09$, $p = 0.15$
All years: $\chi^2 = 0.06$, $p = 0.81$

TABLE B-12. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Type of Discharge, and Time Since Discharge (1965-1983)

Years since discharge	Type of discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	Honorable	104	2.3	56	1.4	1.68	1.21 - 2.32
	Other	5	4.1	17	4.3	0.94	0.35 - 2.55
6+	Honorable	128	1.6	102	1.4	1.11	0.86 - 1.45
	Other	8	4.4	25	4.3	1.02	0.46 - 2.25
All years	Honorable	232	1.9	158	1.4	1.31	1.07 - 1.61
	Other	13	4.2	42	4.3	0.99	0.53 - 1.84

Tests for effect modification of type of discharge: ≤5 years: $\chi^2 = 0.73$, $p = 0.39$
6+ years: $\chi^2 = 0.08$, $p = 0.78$
All years: $\chi^2 = 0.56$, $p = 0.45$

TABLE B-13. Number of Deaths, Crude Rates/1000 Person-Years and Rate Ratios, by Cohort Status, Pay Grade at Discharge and Time Since Discharge (1965-1983)

Years since discharge	Pay grade at discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
		No. deaths	Rate/1000	No. deaths	Rate/1000		
≤5	E1	6	4.9	11	3.4	1.42	0.52 - 3.84
	E2	6	5.8	5	2.0	2.86	0.87 - 9.36
	E3	19	6.3	11	3.3	1.89	0.90 - 3.98
	E4	52	2.3	29	1.4	1.67	1.06 - 2.63
	E5	27	1.5	17	1.2	1.26	0.69 - 2.32
6+	E1	5	2.6	24	5.2	0.51	0.20 - 1.34
	E2	12	7.2	7	1.6	4.40	1.73 - 11.17
	E3	16	3.0	16	2.9	1.06	0.53 - 2.12
	E4	68	1.7	50	1.4	1.20	0.84 - 1.73
	E5	35	1.1	30	1.2	0.95	0.58 - 1.54
All years	E1	11	3.5	35	4.5	0.79	0.40 - 1.56
	E2	18	6.6	12	1.8	3.74	1.80 - 7.77
	E3	35	4.2	27	3.0	1.39	0.84 - 2.30
	E4	120	1.9	79	1.4	1.37	1.03 - 1.82
	E5	62	1.2	47	1.2	1.06	0.73 - 1.55

Tests for effect modification of pay grade at discharge: ≤5 years: $\chi^2 = 1.77$, $p = 0.78$
6+ years: $\chi^2 = 12.22$, $p = 0.02$
All years: $\chi^2 = 11.75$, $p = 0.02$

APPENDIX C

Detailed Characteristics of Men Killed in Action

TABLE C-1. Descriptive Characteristics of Vietnam Veterans, by Vital Status at Discharge from Active Duty

Characteristic	Killed in Action*		Discharged Alive		χ^2+ (p-value)
	No.	%	No.	%	
Total	181	100.0	9324	100.0	
Race:					
White	156	86.2	8097	86.8	0.50
Black	23	12.7	1156	12.4	(0.78)
Other	2	1.1	63	0.7	
Unknown	0	0.0	8	0.1	
Place of Birth:					
Northeast	24	13.3	1769	19.0	8.75
Midwest	52	28.7	2827	30.3	(0.07)
South	38	21.0	2205	23.7	
West	57	31.5	2193	23.5	
Other	7	3.9	312	3.3	
Unknown	3	1.7	18	0.2	
Enlistment Status:					
Draftee	117	64.6	5943	63.7	0.06
Volunteer	64	35.4	3381	36.3	(0.80)

*Deaths in service from causes other than hostile enemy action are excluded.

+The chi-square statistic tests the similarity of the distributions of each characteristic between those killed in action and those discharged alive, after the unknown category has been excluded.

TABLE C-2. Physical Profile of Vietnam Veterans, by Vital Status at Discharge from Active Duty

Characteristic	<u>Killed in Action*</u>		<u>Discharged Alive</u>		χ^2+ (p-value)
	No.	%	No.	%	
Total	181	100.0	9324	100.0	
Physical Capacity or Stamina:					
No impairment	181	100.0	9230	99.0	1.67
Mild-significant impairment	0	0.0	85	0.9	(0.20)
Unknown	0	0.0	9	0.1	
Upper Extremities:					
No impairment	181	100.0	9247	99.2	1.33
Mild-significant impairment	0	0.0	68	0.7	(0.25)
Unknown	0	0.0	9	0.1	
Lower Extremities:					
No impairment	180	99.5	9075	97.3	2.94
Mild-significant impairment	1	0.5	240	2.6	(0.09)
Unknown	0	0.0	9	0.1	
Hearing and Ears:					
No impairment	173	95.6	8794	94.3	
Mild-significant impairment	8	4.4	521	5.6	0.47
Unknown	0	0.0	9	0.1	(0.50)

TABLE C-2. (continued)

Characteristic	Killed in Action*		Discharged Alive		χ^2+ (p-value)
	No.	%	No.	%	
Eyes and Visual Acuity:					
No impairment	161	89.0	6934	74.4	19.79
Mild-significant impairment	20	11.1	2381	25.5	(<0.001)
Unknown	0	0.0	9	0.1	
Psychological Functioning:					
No impairment	181	100.0	9300	99.7	0.29
Mild-significant impairment	0	0.0	15	0.2	(0.59)
Unknown	0	0.0	9	0.1	
Composite Measure of Physical Health:					
No impairment	153	84.5	6297	67.5	23.44
Minor impairment	28	15.5	2990	32.1	(<0.001)
Other than/minor impairment	0	0.0	26	0.3	
Unknown	0	0.0	11	0.1	

*Deaths in service from causes other than hostile enemy action are excluded.

+ The chi-square statistic tests the similarity of the distributions of each characteristic between those killed in action and those discharged alive, after the unknown category has been excluded.

TABLE C-3. Aptitude Test Scores of Vietnam Veterans, by Vital Status at Discharge from Active Duty

Aptitude Test	Killed in Action*			Discharged Alive			t-statistic ⁺⁺ (p-value)
	No.+	Mean	SD	No.+	Mean	SD	
Army Classification							
Battery:							
Verbal Ability	177	103.1	22.1	9136	104.4	21.9	0.79 (0.43)
Arithmetic Reasoning	177	100.3	20.1	9135	101.5	21.5	0.71 (0.47)
Pattern Analysis	177	101.7	20.6	9136	101.7	22.5	0.00 (1.00)
General Information	175	99.6	19.6	9117	100.3	18.4	0.48 (0.63)
General Technical	179	101.6	19.5	9200	103.1	19.9	0.98 (0.33)
Armed Forces Qualification Test	180	48.4	26.3	9280	50.4	25.5	1.05 (0.29)

*Deaths in service from causes other than hostile enemy action are excluded.

+Number of veterans for whom test scores were available.

++The t-statistic tests the differences between the mean scores of those killed in action and those discharged alive.

TABLE C-4. Military Service Characteristics of Vietnam Veterans, by Vital Status at Discharge from Active Duty

Characteristic	Killed in Action*		Discharged Alive		χ^2+ (p-value)
	No.	%	No.	%	
Total	181	100.0	9324	100.0	
Military Occupational Specialty:					
Tactical operations	156	86.2	3217	34.5	207.21 (<0.001)
Other and unknown	25	13.8	6107	65.5	
Type of Unit:					
Infantry	127	70.2	2477	26.6	192.54 (<0.001)
Engineer	2	1.1	911	9.8	
Armor	2	1.1	123	1.3	
Cavalry	23	12.7	792	8.5	
Artillery	7	3.9	1021	11.0	
Other	19	10.5	3920	42.0	
Unknown	1	0.6	80	0.9	

* Deaths in service from causes other than hostile enemy action are excluded.

+ The chi-square statistic tests the similarity of the distributions of each characteristic between those killed in action and those discharged alive, after the unknown category has been excluded.

APPENDIX D

Mortality from Motor Vehicle Accidents,
Suicide and Drug-Related Causes by Selected
Covariates

TABLE D-1. Number of Deaths Due to Motor Vehicle Accidents (as Determined by Death Certificate) Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge and Selected Characteristics (1965-1983).

Characteristic	Time Since Discharge					
	< 5 years			6+ years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Race:						
White	57	1.92	1.11-3.35	60	1.31	0.78-2.19
Other	9	1.98	0.49-7.91	7	0.38	0.07-1.96
GT score:						
<100	33	2.00	0.95-4.21	35	0.79	0.41-1.53
100+	33	1.82	0.89-3.71	32	1.70	0.83-3.48
Enlistment status:						
Draftee	42	2.22	1.15-4.27	41	1.52	0.81-2.86
Volunteer	24	1.52	0.67-3.48	26	0.74	0.34-1.60
Duty MOS:						
Tactical	28	1.39	0.64-3.01	22	1.08	0.46-2.53
Other	38	2.31	1.16-4.58	45	1.18	0.66-2.13
Age at discharge:						
<21 years	9	1.55	0.42-5.78	13	1.03	0.35-3.07
21+ years	57	2.02	1.16-3.53	54	1.22	0.71-2.10
Year of discharge:						
<1970	37	2.79	1.31-5.90	32	1.54	0.75-3.15
1970+	29	1.26	0.61-2.64	35	0.90	0.47-1.75
Pay grade at discharge:						
E1-E3	17	3.12	1.16-8.43	18	0.63	0.23-1.77
E4-E5	49	1.80	0.99-3.26	49	1.60	0.89-2.89

TABLE D-2. Number of Deaths Due to Suicide (as Determined by Death Certificate) Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge and Selected Characteristics (1965-1983).

Characteristic	Time Since Discharge					
	≤ 5 years			6+ years		
	No. deaths	Rate ratio*	95% CI	No. deaths	Rate ratio*	95% CI
Race:						
White	22	2.06	0.84-5.05	30	0.62	0.30-1.30
Other	3	-	-	2	-	-
GI score:						
<100	8	-	-	14	0.63	0.22-1.81
100+	17	1.48	0.57-3.91	18	0.65	0.25-1.68
Enlistment status:						
Draftee	14	1.79	0.60-5.35	13	1.14	0.38-3.39
Volunteer	11	1.60	0.47-5.46	19	0.40	0.15-1.05
Duty MOS						
Tactical	5	-	-	9	-	-
Other	20	1.98	0.79-4.97	23	0.80	0.35-1.82
Age at discharge:						
<21 years	4	-	-	10	0.13	0.02-1.06
21+ years	21	2.33	0.90-6.00	22	1.09	0.47-2.52
Year of discharge:						
<1970	9	-	-	16	0.55	0.20-1.53
1970+	16	1.32	0.49-3.56	16	0.74	0.28-2.00
Pay grade at discharge:						
E1-E3	8	-	-	7	-	-
E4-E5	17	2.09	0.74-5.93	25	0.67	0.30-1.48

*RRs are not computed for categories with less than 10 deaths among Vietnam and non-Vietnam veterans combined.

TABLE D-3. Number of Drug-Associated Deaths (as Determined by Medical Review) Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Selected Characteristics (1965-1983).

Characteristic	Number of Deaths		Rate ratio*	95% CI
	Vietnam	Non-Vietnam		
Race:				
White	18	10	1.70	0.79-3.69
Other	7	5	1.35	0.43-4.26
GT score:				
<100	13	11	1.00	0.45-2.24
100+	12	4	3.09	1.00-9.57
Enlistment status:				
Draftee	11	1	10.81	1.39-83.79
Volunteer	14	14	0.88	0.42-1.85
Duty MOS:				
Tactical	8	1	-	-
Other	17	14	1.27	0.63-2.58
Age at discharge:				
<21 years	8	10	0.97	0.38-2.47
21+ years	17	5	3.12	1.15-8.45
Year of discharge:				
<1970	5	4	-	-
1970+	20	11	1.79	0.86-3.74
Pay grade at discharge:				
E1-E3	10	11	1.52	0.64-3.57
E4-E5	15	4	3.22	1.07-9.71

*RRs are not computed for categories with less than 10 deaths among Vietnam and non-Vietnam veterans combined.

VIETNAM EXPERIENCE STUDY — Mortality

APPENDIX E

Details of Medical-Review-Panel Findings

The following is a description of medical review panel findings for all deaths in which cause of death via medical review differed from cause as determined by death certificate (see Table E-1 and E-2 for the cross-classification of death certificate and medical review cause of death).

1. Infectious diseases. The two deaths attributed to infectious diseases by the death certificates were both classified elsewhere by the panel. In one case, an alcoholic man died as an immediate consequence of an overwhelming infection. The death certificate underlying cause of death was septicemia due to other gram-negative organisms (ICD-9, 038.4). The panel attributed the fatal infection to impaired host defense mechanisms associated with the decedent's alcoholism and cited alcohol dependence syndrome as the underlying cause of death (ICD-9, 303). In the other case, an intravenous drug abuser with acquired immunodeficiency disorder died as a result of pneumocystis carinii pneumonia. The death certificate diagnosis was pneumocystosis (ICD-9, 136.3), while the panel attributed the death to deficiency of cell-mediated immunity (ICD-9, 279.1).

2. Neoplasms. The panel recategorized 2 of the 25 deaths that had been attributed to neoplasm according to the death certificate (see Table E-3). The panel determined that both deaths were caused by operative misadventures on the basis of hospital records and autopsy findings. In one case, the panel attributed the death to an accidental cut during a surgical operation (ICD-9, E870.0). The cut, to the mesenteric vein, complicated an operation to remove a colon cancer. Further complications led to additional bowel resections. "Short bowel syndrome" developed, and the veteran eventually died as a consequence of severe dehydration and malabsorption. At autopsy, no metastatic lesions were detected. In the other case, the veteran had previously undergone an operation to remove a bronchial adenoma. During a subsequent operation to repair a bronchopleural fistula, the endotracheal tube was not correctly placed, and he had a cardiac arrest (ICD-9, E876.3). The pathologist who performed the autopsy attributed the death to "respiratory insufficiency" and noted that "the death of this patient is not related to the tumor itself."

The panel cited a neoplasm as the underlying cause of two deaths attributed to nonneoplastic causes according to the death certificates (see Table E-3). One is discussed below in section "16. Other external cause." The panel determined that a pineal gland neoplasm was the cause of death, but the death certificate determination was "head trauma," coded as an accident of unspecified cause. The other death is discussed below in section "5. Circulatory diseases." The panel attributed the death to Burkitt's tumor (ICD-9, 200.2); the death certificate attributed it to "cardiopulmonary arrest" (ICD-9, 427.5).

In 23 cases both the panel and death certificate determinations resulted in deaths being coded as neoplasms, but in 11 the determinations did not agree to the fourth digit of the ICD-9 code (see Table E-3). In each of the 11 cases, the lack of complete agreement can be attributed to statements on the death certificate that lack precision or do not contain available diagnostic information.

The major features of a tumor, according to the ICD-9 classification system, are its anatomic location, whether it is benign or malignant, and

whether it is a primary or secondary lesion. The underlying cause of death on three death certificates was "brain tumor," and each was appropriately coded as neoplasm of unspecified nature (ICD-9, 239.6). On the basis of its review of hospital records pertaining to these cases, the panel included the specific cerebral site and the malignant nature of the three tumors in its cause-of-death determinations (see Table E-3). Two other deaths were due to malignant neoplasm, unspecified site (ICD-9, 199.1), according to the death certificates; the panel localized one to the bronchus and lung (ICD-9, 162.9), and the other to the head, neck, and face (ICD-9, 195.0). The panel, on the basis of medical records, localized a death attributed to malignant melanoma, site unspecified (ICD-9, 172.9) according to the death certificate to the scalp and neck (ICD-9, 172.4). The panel, using hospital records and an autopsy report, described a malignant testicular tumor as affecting an undescended testicle (ICD-9, 186.0), but the affected testicle was not specified as to its descent on the death certificate (ICD-9, 186.9). Another death was due to metastatic carcinoma of unknown primary site, which secondarily involved the liver. The death certificate described the cause of death simply as "liver cancer," which resulted in the appropriate code for malignant neoplasm of the liver, not specified as primary or secondary (ICD-9, 155.2). If the death certificate had mentioned that the "liver cancer" was secondary, then the death would have been coded differently by ICD-9 rules. The panel, on the basis of hospital records and histopathology reports, correctly attributed the death to malignant neoplasm of unspecified primary site (ICD-9, 199.1).

In three cases of malignant neoplasms of lymphatic and hematopoietic tissue, the tumor histology, which was available from medical records, allowed the panel to arrive at more accurate or specific diagnoses than did the original certifiers (see Table E-3). In one instance, "leukemia" was listed as the cause of death on the certificate, and this resulted in the appropriate code for leukemia of unspecified cell type (ICD-9, 208.9). The panel had access to the decedent's hospital record, which documented acute myeloid leukemia (ICD-9, 205.0) on several bone marrow aspirates. In a second case, the underlying cause on the death certificate was "terminal Hodgkin's disease," which was appropriately coded to Hodgkin's disease unspecified (ICD-9, 201.9). Antemortem lymph node biopsy findings allowed the panel to specify the Hodgkin's disease as nodular sclerosis type (ICD-9, 201.5). In the third case, the decedent had a lymphoblastic lymphoma which was subsequently complicated by leukemia. The decedent died in the hospital, and the diagnosis was "lymphoblastic lymphoma with leukemia." The death certificate cause-of-death statement mentions only the lymphoblastic leukemia which was appropriately coded as acute lymphoid leukemia (ICD-9, 204.0). On the basis of the medical record, the panel cited lymphoblastic lymphoma (ICD-9, 200.1) as the underlying cause of death.

3. Mental disorders. Fourteen deaths were attributed to mental disorders as a result of death certificate findings, and the panel categorized 10 elsewhere (see Table E-4). In one of the cases, the death certificate was improperly completed and the coded cause of death, simple schizophrenia (ICD-9, 295.0), was the first diagnosis in a continuous statement which contained a total of five diagnoses. The last listed cause of death, "episodes of G.I. bleeding," which could not be coded as

the underlying cause according to ICD-9 rules, was similar to the panel's determination, hemorrhage of gastrointestinal tract, unspecified (ICD-9, 578.9).

In the remaining nine recategorized cases, death was due to either substance dependence or abuse according to the coded death certificates. In all nine cases the panel's determinations included diagnoses pertaining to misuse of drugs or alcohol, but the diagnostic reasoning or descriptive terms differed significantly from those used on the death certificates. Consequently, the underlying cause of death the panel assigned is categorically different from that assigned on the basis of the death certificate.

The ICD-9 rules governing selection of the underlying cause of death give preference to diagnostic terms that provide the most specificity regarding the site or nature of the fatal condition. For example, alcoholic liver disease (ICD-9, 571.0-571.3) is preferred to alcohol dependence syndrome (ICD-9, 303). In two cases, the panel cited alcoholic liver damage, unspecified (ICD-9, 571.3), whereas the death certificate findings were coded as alcohol dependence syndrome (ICD-9, 303). In another case, the panel cited alcoholic fatty liver (ICD-9, 571.0), whereas the certificate was coded as nondependent abuse of alcohol (ICD-9, 305.0).

In two additional cases, both coded to alcohol dependence syndrome (ICD-9, 303) on the basis of death certificates, the panel cited alcohol dependence as contributing to death, but specified compression of the brain stem (ICD-9, 348.4) and pneumococcal pneumonia (ICD-9, 481.0) as the underlying causes of death. In the first case, hospital records indicate that the decedent's rapid neurological deterioration was due to a "cerebral abscess/neoplasm or infarction," with no clear causal connection with alcoholism. In the second case, the panel determined that an alcoholic man died as a direct result of pneumococcal pneumonia. In this case the panel was mistaken; the priority placed on alcohol dependence on the death certificate is more reasonable, because the infection that the veteran did not survive was probably secondary to impaired host defense mechanisms associated with alcoholism.

The original death certifiers attributed the other 4 recategorized deaths in the mental disorder category to either drug dependence or drug abuse. The ICD-9 manual defines drug dependence as a "compulsion to take a drug on a continuous or periodic basis in order to experience its psychic effects, and sometimes to avoid the discomfort of its absence." The manual also states that the diagnosis of nondependent abuse of drugs (ICD-9, 305.0-305.9) is only appropriate "when no other diagnosis is possible." A drug abuse code should not be selected as the underlying cause of death if either drug dependence or drug poisoning is a possible cause of death. The panel adhered to the ICD-9 drug-related definitions and diagnostic preferences, which accounts for the recategorization of these 4 deaths.

In 3 deaths attributed to drug dependence on the basis of death certificates, the corresponding panel diagnoses were accidental poisonings, because the panel had no information to document compulsion to use drugs at the time of death. The coded death certificate cause of death in one instance was other drug dependence (ICD-9, 304.6) and in the other two cases it was unspecified drug dependence (ICD-9, 304.9). The

corresponding panel determinations were accidental poisoning by glue (ICD-9, E866.6), accidental poisoning by other drugs (ICD-9, E858.8), and accidental poisoning by unspecified drugs (ICD-9, E858.9).

Finally, the original death certifier attributed a death to unspecified nondependent drug abuse (ICD-9, 305.9), but the panel, which adhered to the ICD-9 preference for the accidental poisoning diagnosis, classified it as an accidental poisoning by opiates and narcotics (ICD-9, E850.0).

In addition to the 10 recategorized deaths described above, the panel attributed to mental disorders 12 deaths that were placed in other disease categories on the basis of the death certificates (see Table E-4). These 12 deaths are discussed in detail in the following sections: 1. Infectious diseases, 6. Respiratory diseases, 7. Digestive diseases, 12. Accidental poisonings, and 15. Injury of undetermined intentionality. In most of the 12 cases, both the death certificate and panel diagnoses pertained to misuse of drugs or alcohol, but the specific ICD-9 codes were categorically different.

4. Diseases of the nervous system and sense organs. The panel disagreed with the original death certifier on one of the three deaths attributed to neurologic disorders. The decedent was a previously healthy man who had overwhelming septicemia and meningitis due to Haemophilus influenzae. There was no recognizable primary source of infection and no obvious defect in host-defense mechanisms. The pathologist who performed the autopsy described the primary diagnosis as "overwhelming septicemia and meningitis with Haemophilus influenzae, type B." The physician who completed the death certificate cited "Haemophilus influenzae meningitis" as the underlying cause, appropriately coded to ICD-9, 320.0. In view of the absence of a primary source of infection, the panel attributed the death to septicemia due to other gram-negative organisms (ICD-9, 038.4), which placed the death in the infectious disease category.

5. Circulatory diseases. The panel categorized elsewhere 7 of the 34 deaths coded on the basis of death certificates to circulatory disease. In four, the panel's findings differed from the diagnosis of either cardiac arrest (ICD-9, 427.5) or myocardial infarction (ICD-9, 410) cited on the death certificates. In one case, described briefly in section "2. Neoplasm," the panel determined that Burkitt's tumor (ICD-9, 200.2) was the cause of death. The veteran had had several antemortem bone marrow biopsies that established the diagnosis of Burkitt's lymphoma. He received two courses of chemotherapy and subsequently died as a direct consequence of an intracerebral hemorrhage. At autopsy, no tumor was found, and the death certifier stated that the death was due to "cardiopulmonary arrest," although she mentioned "probably Burkitt's (sic) lymphoma" as a nonunderlying cause of death. The panel attributed the absence of tumor at postmortem examination either to an incomplete dissection or to the effects of chemotherapy. In view of the poor prognosis associated with disseminated Burkitt's lymphoma, the panel cited the neoplasm as the underlying cause of death.

In another death described as "cardiopulmonary arrest" on the death certificate, the panel diagnosis was sudden death within 24 hours of onset of symptoms (ICD-9, 798.2). An emergency room record stated that

the decedent had gone to bed complaining of "epigastric discomfort and nausea" and that his mother found him dead 3 hours later. No autopsy was done.

In the case of both recategorized myocardial infarctions (ICD-9, 410.0), the coroners who completed the death certificates stated that the deaths were due to a "heart attack." Both veterans had died at home and in neither instance was an autopsy performed. In each case, the panel based its diagnosis, sudden death within 24 hours of onset of symptoms (ICD-9, 798.2), on the medical history contained in the coroner's records.

The remaining three circulatory disease deaths, for which the panel and death certificate determinations differ, were originally attributed to hypertensive renal disease, not specified as benign or malignant (ICD-9, 403.9); cardiovascular disease, unspecified with mention of arteriosclerosis (ICD-9, 429.2); and compression of the superior vena cava (ICD-9, 459.2). In the first death, the only information available to the panel was an emergency room record indicating that the decedent had a cardiac arrest as a result of chronic renal failure. The record contained no information on the etiology of the kidney disease, so the panel determination was renal failure, unspecified (ICD-9, 586.0), which placed the death in the genitourinary disease category. The original death certifier apparently was aware that the renal disease had been attributed to hypertension, and this causal sequence is indicated on the death record. In the second death, the medical examiner apparently cited "arteriosclerotic heart disease" as the cause of death on the basis of the decedent's past medical history. The panel attributed the death to a hemorrhage of the gastrointestinal tract, unspecified (ICD-9, 578.9). The police records show that the decedent was found at home, with "a great deal of blood on his facial area, and also in the bathroom sink." There was no evidence for a traumatic death. The panel inferred that gastrointestinal hemorrhage was the most likely cause of death on the basis of the medical examiner's report that the decedent was an alcoholic. No autopsy was performed. The third death, which the original death certifier attributed to superior vena cava syndrome, resulted from a crush injury that occurred when the automobile the veteran was repairing fell on his chest. The panel listed struck by falling object (ICD-9, E916) as the cause of death, in accordance with ICD-9 underlying cause selection rules, which give preference to the circumstances that resulted in injury rather than to the anatomic location of the injury.

6. Respiratory diseases. The panel recategorized 6 of the 9 deaths originally attributed to respiratory disease. In 4 cases, the death certificate findings were bronchopneumonia, organism unspecified (ICD-9, 485). The corresponding panel-determined causes of death were: glomerulonephritis, not otherwise specified (ICD-9, 583.9), systemic lupus erythematosus (ICD-9, 710.0), passenger on a motorcycle involved in a collision with another motor vehicle (ICD-9, 812.3), and accidental poisoning by other drugs (ICD-9, E858.8). In the first case, the medical record documented that at the time of his death the veteran was receiving hemodialysis for end-stage renal disease due to glomerulonephritis of undetermined etiology. The panel attributed his fatal pneumonia to impaired host defenses associated with severe chronic renal failure. In the second case, the veteran was found on autopsy to have systemic lupus

erythematosus with renal and central nervous system involvement, and the panel determined that lupus was responsible for susceptibility to the fatal infection. In the third case, the death certificate was improperly completed and did not reflect the coroner's autopsy-determined cause of death, "accidental-motorcycle fatality." In the fourth case, the decedent was admitted to a hospital following an "overdose with cardiopulmonary arrest." He died 7 days later in the hospital, following a hospital course complicated by pneumonia. The panel attributed the death to poisoning by a mixture of drugs.

In another recategorized respiratory disease death, the death certificate determination was acute edema of the lung, unspecified (ICD-9, 518.4), while the panel diagnosis was morphine-type drug dependence (ICD-9, 304.0). The decedent had many prior hospitalizations for medical problems due to heroin dependency. He was found dead at home, and autopsy findings included evidence of a recent intravenous injection and pulmonary edema. The toxicologic analysis of body fluids showed no evidence of morphine but the panel, on the basis of the medical history and autopsy findings, attributed the death to drug dependence.

In the final recategorized case, the death certificate determination of "hemorrhagic interstitial pneumonitis," appropriately coded as other alveolar and parietoalveolar pneumopathy (ICD-9, 516.8), omitted available diagnostic information. The veteran had received an antemortem diagnosis of Goodpasture's syndrome, a disorder which affects both the kidneys and the lungs, and the diagnosis was confirmed at autopsy. The panel attributed the death to hypersensitivity angiitis (ICD-9, 446.2), an entity classified as a circulatory disease and the correct ICD-9 code for Goodpasture's syndrome.

7. Digestive diseases. The death certificates attributed seven deaths to digestive diseases, but the panel attributed three of the seven to alcohol dependence syndrome (ICD-9, 303). In the first case, the death certificate citation was "alcoholic hepatitis," appropriately coded to acute alcoholic hepatitis (ICD-9, 571.1). The panel, on the basis of the hospital record and autopsy report, determined that the decedent, at the time of his death, had many complications of alcoholism, but the panel did not attribute the death to a particular alcohol-related disease. The panel listed alcohol dependence syndrome as the underlying cause of death, which placed the case in the mental disorder category. The second and third cases were both coded as acute pancreatitis (ICD-9, 577.0) on the basis of the death certificates, neither one of which mentioned that the decedents were dependant on alcohol. The panel used available medical records to establish that in both cases, pancreatitis was a direct sequel of alcohol dependence, and classified the deaths accordingly.

8. Genitourinary diseases. The panel, using the available diagnostic information, recategorized three of the four deaths that the original death certifiers had attributed to genitourinary diseases. In one case, the underlying cause on the death certificate was coded as renal failure, unspecified (ICD-9, 586), but the panel's determination was coded as alcoholic cirrhosis of the liver (ICD-9, 571.2). The panel had access to the record of the hospitalization during which the veteran died, and the record indicated that both renal failure and coma were secondary to liver disease. The pathologist who performed the autopsy attributed the death

to "cirrhosis of the liver, advanced (history of ethanol use)." The second recategorized death was coded as a urinary tract infection, site unspecified (ICD-9, 599) on the basis of the death certificate, but the panel diagnosis was late effects of motor vehicle accident (ICD-9, E929.0). The decedent was quadriplegic and incontinent of urine after a motor vehicle accident that occurred 4 years before his death. The panel attributed the immediate cause of death, urinary tract infection, to his traumatic neurologic impairment. The third recategorized death was also coded as a urinary tract infection, site unspecified (ICD-9, 599) on the basis of the death certificate. The certificate did not contain the primary discharge diagnosis listed on the hospital record, "suicidal drug overdose with cardiac and subsequent respiratory arrest." The panel used the medical history of a self-inflicted mixed drug poisoning to describe the death as suicide by other specified drugs (ICD-9, E950.2).

9. Congenital anomalies. The panel, on the basis of autopsy findings, categorized elsewhere two deaths attributed to congenital disorders on the death certificates. Before death, one veteran had had a diagnosis of and surgical treatment for a congenital cerebral arteriovenous malformation. His death was preceded by rupture of the aneurysm and rapid neurological deterioration. The nosologist coded the underlying cause of death as congenital anomaly of cerebral vessels (ICD-9, 747.8) on the basis of the death certificate statement that the decedent was "status post removal right frontal arteriovenous malformation." The postmortem examination records, which were available to the panel, indicated that the fatal cerebrovascular event began prior to the decedent's operation, and the panel cited the appropriate cause of death, subarachnoid hemorrhage (ICD-9, 430). In the other death, the coded death certificate cause was coarctation of the aorta (ICD-9, 747.1). At autopsy the death was shown to be due to rupture of a surgically implanted aortic graft. The postmortem findings are reflected in the panel's determination of the underlying cause, late complication of aortic graft placement (ICD-9, E878.1).

10. Symptoms, signs and ill-defined conditions. Autopsy results account for the diagnostic disagreement in one of the two deaths placed in the signs, symptoms and ill-defined conditions category on the basis of the death certificates. The death certificate shows "pending further study" as the underlying cause, which was coded to other unknown and unspecified cause of mortality (ICD-9, 799.9). No revised death certificate was available. The panel based its determination, alcoholic cirrhosis of the liver (ICD-9, 571.2), on the autopsy report.

11. Motor vehicle accidents. The panel recategorized three motor vehicle traffic deaths. In two instances, the panel assigned the deaths to suicide by crashing of a motor vehicle (ICD-9, E958.5). In one, police records indicated that the veteran repeatedly drove his car into the path of oncoming traffic and made no effort to avoid a collision with an oncoming truck. In the other, police records contained a report of a distress call from the veteran's spouse following a domestic quarrel. The spouse was concerned about his self-destructive intentions. The panel recategorized the third motor vehicle death as a homicide on the basis of a coroner's report. The decedent, a pedestrian, had "confronted" the driver of a motor vehicle immediately before he was struck by the vehicle and dragged for "about six blocks." The death

certificate listed "auto-pedestrian" as the underlying cause and "homicide" as the manner of death. The certificate did not contain a statement of intentionality in either the "cause of death" or the "circumstances of injury" sections, and, as a result, the nosologist coded the fatality as a motor vehicle accident, in accordance with the coding practices of the National Center for Health Statistics.

12. Accidental poisoning. The panel categorized elsewhere 9 of the 18 deaths attributed to accidental poisoning according to the death certificates. In 4 cases of heroin or morphine-type drug poisoning, the panel recategorized the deaths to chronic morphine dependence (ICD-9, 304.0) on the basis of historical and postmortem evidence of drug dependence. In two instances of accidental poisoning by motor vehicle exhaust gas (ICD-9, E868.2), law enforcement records were not available, and the panel could not characterize the decedents' intentions. Consequently, the panel's underlying cause of death for both was poisoning by motor vehicle gas, undetermined whether accidentally or purposely inflicted (ICD-9, E982.0). The causes of death on the death certificates in two other accidental poisoning fatalities were "apparent accidental drug overdose" and "intoxication of unknown origin," which the nosologist coded as accidental poisoning by unspecified drugs (ICD-9, E858.9) and accidental poisoning by unspecified substance (ICD-9, 866.9), respectively. In the first case, the panel attributed the death to drug dependence, unspecified (ICD-9, 304.9) on the basis of hospital records. In the second case, an autopsy showed that the decedent aspirated gastric material, a finding that warranted toxicologic investigation, according to the pathologist. No toxicologic results were available to the panel, and it determined that the cause of death was inhalation of food causing obstruction of the respiratory tract (ICD-9, E911).

In the ninth recategorized accidental poisoning, the death certificate cited "synergistic action of alcohol and diazepam" as the underlying cause of death, which was coded as accidental poisoning by benzodiazepine-based tranquilizer (ICD-9, E853.1). The panel had access to the medical history, autopsy results, and toxicologic analysis—all of which indicated that death resulted from aspiration of gastric contents as a consequence of alcohol intoxication (ICD-9, 305.0).

13. Suicide. The panel categorized all 54 of the suicides listed on the death certificates as suicides. The panel identified an additional, six suicides, which are discussed in sections 8. Genitourinary diseases, 11. Motor vehicle accidents, and 16. Other external causes.

14. Homicide. For 47 homicides, the panel agreed with the categorization based on the death certificates. In four deaths, disagreements between the certificates and panel occurred. In one case, the veteran was shot in the head by a "friend" while the two men were "fooling around." The "friend" was charged with involuntary manslaughter, and the death certificate lists "homicide" as the manner of death. The panel attributed the death to an accident caused by a handgun (ICD-9, 922.0). In three other recategorized deaths, the certificates cite homicide as the underlying cause but do not mention that the decedents were killed by law enforcement agents. Consequently, the death certificate codings, each of which was assault by unspecified firearm (ICD-9, E965.4), differ from the panel's codings, each of which was injury due to legal intervention by firearms (ICD-9, E970.0).

15. Injury of undetermined intentionality. The panel assigned to other categories 8 of the 10 deaths coded as injuries of undetermined intentionality according to the death certificates. In five deaths, drug poisoning was listed on the certificate as the underlying cause of death and "undetermined" as the manner of death. The panel recategorized all five. It determined that three of the deaths were accidental drug poisonings on the basis of either medical examiner interviews with family and friends, which indicated the absence of suicidal intent, or law enforcement investigations, which documented that recreational drugs were being used at the death scene. The panel recategorized the other two deaths to natural causes. In one case, police records included reports of a scene investigation and an interview with the decedent's brother that provided sufficient evidence for the panel to cite morphine-type drug dependence (ICD-9, 304.0) as the underlying cause of death. In the other case, "acute multiple drug intoxication" was cited as the underlying cause on the death certificate. The panel, on the basis of a review of the hospital record and autopsy findings, attributed the death to renal failure due to acute tubular necrosis (ICD-9, 584.5). There was no historical or laboratory evidence to support a toxic etiology.

In a sixth case, "ethanol poisoning" was cited as the underlying cause on the death certificate, and "undetermined" was listed as the manner of death. The veteran had been drinking alcohol with two friends, who had been "teasing" him into drinking to excess according to police records. The decedent died at home and was found to have a lethal blood alcohol level. Criminal charges were not filed against the friends, and the panel attributed the death to accidental poisoning by alcoholic beverages (ICD-9, E860.0).

In two other deaths, injury by firearm and injury by fire were listed as causes on the certificate. In the firearm injury death, despite a coroner's jury finding that the victim was shot by his wife, the certificate specifies that the manner of death was "undetermined." The panel attributed the death to assault by an unspecified firearm (ICD-9, E965.4). Similarly, in the fire injury death, the coroner's autopsy report describes the death as an "accident," but the manner was "undetermined" according to the death certificate. In the absence of any evidence to suggest either homicide or suicide, the panel attributed the death to accident caused by smoke and fumes from a conflagration (ICD-9, E890.2).

16. Other external causes. The panel recategorized 14 of 61 deaths that had been placed in the other external cause group on the basis of death certificate determinations. Of the 14, the panel attributed 11 to the specific external cause categories discussed above and 3 to natural causes.

The panel categorized as suicides three deaths that the original death certifiers had categorized as accidents. In one case, involving a drowning, medical examiner's records describe the decedent as a newlywed in "extreme financial difficulty" who "walked off his job without notice" and was found drowned in a lake 3 days later. The panel inferred self-destructive intent from the victim's life circumstances, and cited suicide by drowning (ICD-9, E954) as the underlying cause of death. In the second case, in which the veteran was crushed by a train, the panel based the diagnosis of suicide on eyewitness accounts that the the

decedent "ran out from buses and laid on the tracks in front of (a) train." In the third case, a death from a self-inflicted gunshot wound, the death certificate apparently was not amended after the medical examiner's determination of suicide.

For five other death certificate-determined causes in this category, the panel could not rule out either suicide or homicide, and it placed these deaths in the accident of undetermined intentionality category. Law enforcement records raised the possibility that two of the five deaths might have been suicides. In one case, a gun hobbyist cleaning a revolver sustained a lethal head injury, and the trajectory of the bullet was consistent with either an intended or unintended injury. In the other case, the fatal self-inflicted gunshot wound occurred immediately after a domestic quarrel that reportedly involved the issue of the paternity of one of the decedent's children. A third death involved an alcohol dependent man who was observed to be lying on the railroad tracks before being crushed by a train. The panel could not rule out suicidal intent and listed the underlying cause of death as injury by lying before moving object, intentionality undetermined (ICD-9, E988.0). In the fourth case, the original death certifier attributed the death to an accident caused by fire. The coroner subsequently reported that he could not rule out "foul play," and the panel cited injury by fire, intentionality undetermined (ICD-9, E988.1) as the underlying cause of death. The fifth case was that of a veteran who drowned, and the panel had no information other than an emergency room report that the decedent was dead on arrival as a result of drowning. The panel could not exclude self-inflicted injury, so it attributed the death to drowning, intentionality undetermined (ICD-9, E984).

The panel considered three other deaths to be motor vehicle accidents. In two, the anatomic sites of the injury, but not the circumstances of injury, were stated on the death certificate. The panel, on the basis of medical records, assigned these two deaths to the motor vehicle accident category. In the third, a fatal accident involving the driver of a "skidder" was coded to accident caused by lifting machine and appliance (ICD-9, E919.2) on the basis of medical statements in the death certificate. The panel coded it to motor vehicle traffic accident due to loss of control without collision on the highway (ICD-9, E816.0).

As stated earlier, the panel recategorized 3 of these deaths to natural causes. Two had been coded to an accidental fall (ICD-9, E888) on the basis of the death certificates, but the panel, on the basis of medical documentation of antecedent seizure activity, coded them to other categories. In one case, the decedent injured his head during an observed alcohol withdrawal seizure; the panel therefore attributed the death to alcohol dependence syndrome (ICD-9, 303). In the other case, the decedent, known to have epilepsy, sustained a fatal head injury during an observed seizure; the panel therefore diagnosed generalized convulsive epilepsy (ICD-9, 345.1). The third death, attributed to "head trauma" on the death certificate, had been coded to unspecified accident (ICD-9, E928.9). The panel, on the basis of the autopsy report, coded it to pineal gland neoplasm (ICD-9, 237.1). The pathologist who performed the autopsy concluded that the onset of the decedent's head trauma was a

coincidence. The post-mortem examination showed "no signs of traumatic injury to the skull or brain."

TABLE E-1. Comparison of Death Certificate and Medical Review Panel Results by Major Cause of Death Category*

Death certificate	Medical review panel											Total	
	Infectious	Neoplasms	Endocrine	Mental Dis.	Nervous	Circulatory	Respiratory	Digestive	Genitourinary	Musculoskel.	Ill-defined		External
Infectious Diseases	0	0	1	1	0	0	0	0	0	0	0	0	2
Neoplasms	0	23	0	0	0	0	0	0	0	0	0	2	25
Mental Disorders	0	0	0	4	1	0	1	4	0	0	0	4	14
Nervous System	1	0	0	0	2	0	0	0	0	0	0	0	3
Circulatory System	0	1	0	0	0	27	0	1	1	0	3	1	34
Respiratory System	0	0	0	1	0	1	3	0	1	1	0	2	9
Digestive System	0	0	0	3	0	0	0	4	0	0	0	0	7
Genitourinary	0	0	0	0	0	0	0	1	1	0	0	2	4
Congenital	0	0	0	0	0	1	0	0	0	0	0	1	2
Ill-Defined	0	0	0	0	0	0	0	1	0	0	1	0	2
External Causes	0	1	0	7	1	0	0	1	1	0	0	313	324
Total	1	25	1	16	4	29	4	12	4	1	4	325	426

*Categories not shown have no deaths assigned to them.

TABLE E-2. Comparison of Death Certificate and Medical Review Panel Results for Major External-Cause-of-Death Categories

Death certificate	Medical review panel						Total
	MVA	Accidental poisoning	Other acc.	Suicide	Homicide	Undetermined	
Motor-vehicle accidents (MVA)	127	0	0	2	1	0	130
Accidental poisoning	0	9	1	0	0	2	12
Other accidents	3	0	47	3	0	5	58
Suicide	0	0	0	54	0	0	54
Homicide	0	0	4	0	47	0	51
Undetermined	0	4	1	0	1	2	8
Total	130	13	53	59	49	9	313

TABLE E-3. Deaths Due to Neoplasms in Which the Death Certificate and Medical Review Panel Determinations Disagree

Case	ICD-9	Death certificate cause	ICD-9	Medical review cause
1	153.6	Malignant neoplasm of ascending colon	E870.0	Accidental cut during surgical operation
2	235.7	Neoplasm of uncertain behavior, respiratory tract	E876.3	Endotracheal tube wrongly placed during anesthesia
3	E928.9	Unspecified accident	237.1	Neoplasm of uncertain behavior of pineal gland
4	427.5	Cardiac arrest	200.2	Burkitt's tumor
5	239.6	Neoplasm of unspecified nature, brain	191.2	Malignant neoplasm of brain, temporal lobe
6	239.6	Neoplasm of unspecified nature, brain	191.2	Malignant neoplasm of brain, unspecified
7	239.6	Neoplasm of unspecified nature, brain	191.1	Malignant neoplasm of brain, frontal lobe
8	199.1	Malignant neoplasm, unspecified site	162.9	Malignant neoplasm of bronchus and lung
9	199.1	Malignant neoplasm unspecified site	195.0	Malignant neoplasm of head, face and neck
10	172.9	Malignant melanoma	172.4	Malignant melanoma of scalp and neck
11	186.9	Malignant neoplasm of testes, unspecified	186.0	Malignant neoplasm of testes, undescended
12	208.9	Leukemia of unspecified cell type	205.0	Acute myeloid leukemia
13	204.0	Acute lymphoid leukemia	200.1	Lymphosarcoma
14	155.2	Malignant neoplasm of liver, unspecified origin	199.1	Malignant neoplasm, unspecified site
15	201.9	Hodgkin's disease, unspecified	201.5	Hodgkin's disease, nodular sclerosis

TABLE E-4. Deaths Due to Mental Disorders in Which the Death Certificate and Medical Review Panel Determinations Disagree

Case	ICD-9	Death certificate cause	ICD-9	Medical review cause
1	295.0	Simple schizophrenia	578.9	Gastrointestinal tract hemorrhage, unspecified
2	303	Alcohol dependence	571.3	Alcoholic liver damage, unspecified
3	303	Alcohol dependence	571.3	Alcoholic liver damage, unspecified
4	303	Alcohol dependence	348.4	Compression of brain
5	303	Alcohol dependence	481.0	Pneumococcal pneumonia
6	305.0	Nondependent abuse of	571.0	Alcoholic fatty liver alcohol
7	304.6	Other drug dependence	E866.6	Accidental poisoning by glue
8	304.9	Unspecified drug dependence	E858.8	Accidental poisoning by other drugs
9	304.9	Unspecified drug dependence	E858.9	Accidental poisoning by other drugs, unspecified
10	305.9	Nondependent abuse of drugs	E850.0	Accidental poisoning by opiates
11	038.4	Septicemia due to other gram negative organisms	303	Alcohol dependence
12	518.4	Acute edema of lung, unspecified	304.0	Morphine type drug dependence
13	571.1	Acute alcoholic hepatitis	303	Alcohol dependence

TABLE E-4. (continued)

Case	ICD-9	Death certificate cause	ICD-9	Medical review cause
14	577.0	Acute pancreatitis	303	Alcohol dependence
15	577.0	Acute pancreatitis	303	Alcohol dependence
16	E850.0	Accidental poisoning by opiates	304.0	Morphine type drug dependence
17	E850.0	Accidental poisoning by opiates	304.0	Morphine type drug dependence
18	E850.8	Accidental poisoning by other analgesics	304.0	Morphine type drug dependence
19	E850.8	Accidental poisoning by other analgesics	304.0	Morphine type drug dependence
20	E853.2	Accidental poisoning by benzodiazepine tranquilizer	305.0	Nondependent abuse of alcohol
21	E858.9	Accidental poisoning by unspecified drugs	304.9	Unspecified drug dependence
22	E980	Poisoning by analgesics, intentionality undetermined	304.0	Morphine type drug dependence

APPENDIX F

The Cox Regression Model

The Cox proportional hazards regression procedure models the risk of death and, correspondingly, the risk ratio when comparing two cohorts. The model assumes that the risk ratio is constant during the period of follow-up modeled. The model contains an underlying risk function, which may depend on time. This function is assumed to be modified by various covariates under consideration, such as in this study, Vietnam status, age, and race. When there are several groups defined by potential confounders, a stratified analysis can be done to allow different underlying risk functions in the different groups. With a stratified analysis, the proportional hazards assumption (that of a constant risk ratio) must hold in each group (stratum). If the intent is to estimate a common risk ratio over the strata, the risk ratio for the various strata should be similar.

Let

X_0, X_1, \dots, X_p be the covariates of interest

b_0, b_1, \dots, b_p be unknown regression coefficients, to be estimated.

In particular, let X_0 be 1 if an individual served in Vietnam and 0 otherwise. Then the Cox model estimates the rate ratio for an individual with covariates X_0, \dots, X_p relative to one with covariates Y_0, \dots, Y_p as $\log(RR) = b_0(X_0 - Y_0) + \dots + b_p(X_p - Y_p)$

The risk ratio for service in Vietnam is estimated as $\exp(b_0)$. The SAS program PHGLM² was used to provide estimates of the parameters, their standard errors, and likelihood ratio statistics for tests of hypotheses. The program also computes a statistic to test the proportional hazards assumption³. This statistic has a distribution which is approximately that of a standard normal variable.

Table F-1 contains values of the test statistic for the proportional hazards assumption for the simple model with cohort (service in Vietnam) as the only covariate. The values of this statistic for the model including the covariates age, race, GT score, year of discharge, and pay grade at discharge were very similar. The assumption appears reasonable within each time period and stratum, with a departure of marginal significance only for the first five years of follow-up for volunteers with a tactical MOS ($Z=2.02, p=.04$). The proportional hazards assumption does seem reasonable during this period for the model with the four strata combined ($Z=1.35, p=.18$). For the remaining period of follow-up, the assumption seems very well satisfied. If there is a modest departure from uniformity in the first time period, the estimate obtained from the model will be an average measure over this interval.

The validity of the proportionality assumption was also checked for the cause-specific analyses. There was substantial evidence for non-proportionality only for deaths due to homicide, according to the clinical review, in the later time period ($Z=2.7$).

Table F-2 contains the estimates of the regression coefficients for cohort (service in Vietnam) and their standard errors. The standard errors are interpreted as those from a standard normal distribution. There is some variability among strata in the rate ratio for the first five years of follow-up. In particular, the rate ratio is less than 1 for one of the four strata, that of volunteers with a tactical MOS. However, this is the smallest stratum, with less than half the number of men and about half the number of deaths as the next smallest stratum. In addition, this rate ratio is not significantly less than 1, and the difference between the largest and smallest coefficients is not particularly large compared to their standard errors. Therefore, it is reasonable to use the estimate from the stratified model as a summary estimate, regarding it as an average of the effects in the four strata. Relatively small numbers of deaths in many strata makes this homogeneity check unreliable for the cause-specific analyses.

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TABLE F-1. Test Statistics* for Validity of Proportionality Assumption for Cox Regression Model Stratified on Enlistment Status and MOS, by Time Since Discharge.

Stratum	Years since discharge		
	≤ 5 years	6+ years	All years
Tactical			
Draftee	0.5	0.2	-0.9
Volunteer	2.0	-0.4	1.2
Nontactical			
Draftee	-0.1	-0.1	-1.4
Volunteer	0.8	-0.1	-1.0
All strata	1.4	-0.1	-1.4

*Test statistic has approximately a standard normal distribution. Results shown are for a model that includes place of service but no covariates.

TABLE F-2. Uniformity of Vietnam Effect Over Strata for Cox Regression Models Stratified on Enlistment Status and MOS, by Time Since Discharge (All-Cause Mortality)

Stratum	Years since discharge					
	<u>≤5 years</u>		6+ years		<u>All years</u>	
	Beta	SE	Beta	SE	Beta	SE
Vietnam service only:						
Tactical						
Draftee	0.77	0.36	0.16	0.27	0.40	0.22
Volunteer	-0.22	0.42	0.29	0.40	0.05	0.29
Nontactical						
Draftee	0.48	0.25	-0.03	0.21	0.17	0.16
Volunteer	0.23	0.27	-0.22	0.22	0.04	0.17
All strata	0.37	0.15	-0.02	0.12	0.14	0.10
Vietnam service plus covariates:*						
Tactical						
Draftee	0.86	0.37	0.25	0.28	0.49	0.22
Volunteer	-0.39	0.45	0.10	0.42	-0.13	0.31
Nontactical						
Draftee	0.49	0.26	0.00	0.21	0.20	0.16
Volunteer	0.47	0.28	-0.13	0.23	0.11	0.18
All strata	0.45	0.16	0.03	0.13	0.20	0.10

*Covariates include age at discharge, race, General Technical test score and pay grade.