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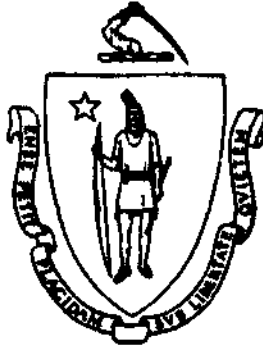
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Mortality among Vietnam veterans in Massachusetts, 1972-1983

*The Commonwealth of Massachusetts
Michael S. Dukakis, Governor
Office of the Commissioner of Veterans' Services
Agent Orange Program*

January 18, 1985

FOREWORD

The Office of the Commissioner of Veterans' Services was provided funding by the 1983 Massachusetts Legislature for the purpose of conducting "medical and scientific testing related to Agent Orange."

In January of 1984, the Agent Orange Program of the Office of the Commissioner of Veterans' Services was implemented to survey programmatic, medical and scientific options. The Agent Orange Program instituted an Agent Orange Medical Scientific Advisory Board to provide technical recommendations, oversight and review of proposal and implemented medical and scientific programs and studies.

As recommended by the Agent Orange Program and the Agent Orange Medical and Scientific Advisory Board, the attached study, "Mortality Among Vietnam Veterans in Massachusetts, 1972-1983" compiled by Michael Kogan, M.A., and Richard Clapp, M.P.H., was contacted as the first step in the Commonwealth's attempt to find some answers to the complex questions surrounding the issue of Agent Orange. This mortality study provides a stable foundation for our continued ongoing efforts to provide scientific, technical, verifiable data regarding the effects of Agent Orange where none has been previously available.

As highlighted in the study summary, "Deaths due to motor vehicle accidents, suicides and kidney cancer were significantly elevated among Vietnam Veterans compared to non-veteran males for the study period 1972-1983." As further stated, "Elevated risk of death due to motor vehicle accidents and suicide lends support to the hypothesis that Vietnam Veterans have had a greater incidence of traumatic death since the end of the conflict than other non-veteran males."

This office is designing, preparing and directing this mortality study equally emphasizing the preparation of an administrative and program response to all study findings. Relative to the significant findings of elevated death due to cancer and traumatic-stress related death, I feel strongly that the Office of the Commissioner of Veterans' Services response to the study focus primarily on the incidence of traumatic-stress related death among Vietnam veterans. Further study and research regarding cancer incidence and cancer death among Vietnam Veterans will be aggressively pursued by this office.

In an attempt to appropriately respond to the traumatic-stress related deaths highlighted by the study, it is necessary to assess the needs of those living Vietnam Veterans who display stressed behavior. For this reason, the Office of the Commissioner of Veterans' Services through the Agent Orange Program has engaged McLean Hospital to provide a behavioral study of Vietnam Veterans. The purpose of the study is to examine the possible behavioral consequences of exposure to Agent Orange and to determine whether this exposure is responsible for any of the symptoms that are often referred to as Post-Traumatic-Stress-Disorder.

The Office of the Commissioner of Veterans' Services feels most strongly that the priority in dealing with the Vietnam Veterans is in researching, defining and treating Post-Traumatic-Stress. It is my fear that Post-Traumatic-Stress-Disorder is the root of a host of problems facing not only the Vietnam Veteran but also their families, spouses, children, neighbors and employers.

ACKNOWLEDGMENTS

The Massachusetts Agent Orange Program, directed by Chris Gregory, was substantially responsible for assembling a blue ribbon Medical/Scientific Advisory Board. The credentials of the board members are consistent with the highest standards of medical services found in the Boston area.

Because of his sincere and unrelenting drive to seek the answers to the health predicament caused by Agent Orange, State Representative Thomas Valley, a Vietnam Veteran himself, provided the board with his own personal experience as well as the need for public awareness of the perils of exposure to Agent Orange.

This study would not have been possible without the wisdom and commitment of the General Court of Massachusetts, and, in particular, the dedicated efforts of State Senator Francis D. Doris, Chairman of the Special Commission on the Concerns of the Vietnam Veteran. The Senator's sympathetic efforts have been the bench mark for legislative support.

The support of the Department of Public Health and its personnel under the direction of Commissioner Bailus Walker was significant. Dr. Walker's commitment to public issues is consistent with his concern for the potential for harm to humans exposed to Agent Orange.

Many staff members of the Office of the Commissioner of Veterans' Services worked diligently in the publication of the mortality study and developed a program to generate public awareness. They are: Joe Bangert, Research Assistant for the Agent Orange Program; Martin Burke, Public Information Specialist; Linda Wiggins, Administrative Assistant, for the long and arduous hours of secretarial duties; the sound counsel of Maryann Argento, and last, but not least, Dennis O'Brien, for whatever else needed to be done.

The Office of the Commissioner of Veterans' Services will continue to work to uncover the complexities of exposure to Agent Orange and its harmful effects upon Veterans of Vietnam and their families in the areas of behavior, birth defects and mortality. Expanded mortality studies to address any new hypotheses brought by this study will be forthcoming.

**MORTALITY AMONG VIETNAM VETERANS
IN MASSACHUSETTS, 1972-1983**

**MICHAEL D. KOGAN, M.A.
RICHARD W. CLAPP, M.P.H.**

January 18, 1985

**Massachusetts Office of Commissioner of Veterans Services
Agent Orange Program**

**Massachusetts Department of Public Health
Division of Health Statistics and Research**

Summary

The patterns of death among Vietnam veterans, other veterans who did not serve in Vietnam, and non-veteran males from Massachusetts were studied by compiling death certificate information. Veteran status was based on whether or not the decedent's name appeared on a list of Massachusetts veterans who served from 1958-1973 and received a bonus. This bonus list was supplied by the Office of the Commissioner of Veterans Services. Only those with an honorable discharge were eligible for the bonus. Persons whose name on the death certificate matched that on the bonus list were identified as Vietnam veterans if they received a \$300 bonus, or as non-Vietnam veterans if they received a \$200 bonus. If there was no match, the decedent was presumed to be a non-veteran. Analyses of the mortality patterns of Vietnam veterans compared to non-Vietnam veterans and to other males who died during the time period (1972-1983) of the study were conducted.

Deaths due to motor vehicle accidents, suicides, and kidney cancer were significantly elevated among Vietnam veterans compared to non-veteran males for the study period 1972-1983. Deaths due to stroke and connective tissue cancer were significantly elevated among Vietnam veterans compared to both non-Vietnam veterans and non-veteran males. Deaths due to circulatory system diseases, other than stroke, were lower among the Vietnam veterans compared to non-Vietnam veterans. Elevated risk of death due to motor vehicle accidents and suicide lends support to the hypothesis that Vietnam veterans have had a greater incidence of traumatic death since the end of the conflict than other non-veteran males. The excess cancers of connective tissue and kidney are based on only nine deaths from each type. More years of follow-up would be

Introduction

The Agent Orange Program in the Office of the Commissioner of Veterans Services (OCVS) requested that a mortality study be conducted comparing the causes of death among Vietnam veterans to those of non-Vietnam veterans and non-veteran Massachusetts residents. This study was motivated by a concern that Vietnam veterans may be at increased risk of dying from violent, preventable causes, such as motor vehicle accidents, homicide, and suicide.

The list of Massachusetts veterans whose mortality experience was evaluated was supplied on computer tape by the OCVS. In August 1984, the study was initiated using mortality information from the statewide data base collected by the Massachusetts Department of Public Health, Division of Health Statistics and Research. Using computer-record linkage techniques and manual matching, the study group and two comparison groups were assembled. The proportionate mortality and mortality odds ratio were chosen as the methods for comparing the mortality experience among the three groups because information on the number of years since Vietnam service was not available for the Vietnam veterans on the OCVS computer tape. In addition, the ages of the veterans were not available. This study is a first step in analyzing Vietnam veterans' experience of one particular health outcome (mortality). Therefore, it can be used only to draw very general conclusions and to develop hypotheses for further studies.

necessary to adequately assess these findings, and further investigation, using other sources of information, is recommended.

These results are based on the limited information available from death certificates. Information on such potential confounding factors as smoking and drinking habits, and complete histories of occupational exposures, was unavailable and therefore could not be controlled for in the analysis. Nevertheless, the results justify intensified efforts to reduce deaths due to stress-related or self-destructive behavior among Vietnam veterans.

Methods

The mortality experience of Vietnam veterans was compared to that of Vietnam-Era veterans who did not serve in Vietnam and to the general Massachusetts white male population during the period 1972-83.

A computerized file of Massachusetts mortality data is available from the Division of Health Statistics and Research of the Massachusetts Department of Public Health (MDPH). The mortality data for Vietnam and non-Vietnam veterans was obtained by linking the statewide computerized mortality files with the computerized list of veterans who applied for a military service bonus, available from the Massachusetts Office of Veterans Services. Eligibility for the bonus was based on the following criteria: (1) veterans must have served for at least six months between July 1, 1958 and April 1, 1973; (2) they must have been Massachusetts residents for at least six months immediately prior to entering the service; (3) they must have applied for the bonus; and (4) they must have been honorably discharged. Veterans received a bonus of \$300 if they went to Vietnam, or \$200 if they did not. It has been estimated that 95% of all eligible Massachusetts residents received the bonus.(1)

The mortality and veterans files were linked by matching social security numbers for the years 1972-76 and 1980-83. For the years 1977-79, social security numbers were not entered on the MDPH computerized files, although they continued to be recorded on death certificates. For these three years, the computer files were linked by matching names. The resulting output was then verified by hand-checking social security numbers on death certificates with those from the veterans file.

The computer linkage provided information on age at death, sex, race, cause of death, year of death, and Vietnam service. Cause of death was classified according to the appropriate revisions of the International Classification of Diseases and converted to the Ninth Revision Codes.(2) Systematic validation procedures were used to assess the accuracy of the computerized information on cause of death and veteran status, compared to the information from the veterans bonus applications and the death certificates. The cause of death codes on the mortality file were found to be more than 99% accurate when compared to death certificates, as were the veteran status codes on the veterans file.

Because white males accounted for about 98% of the veteran decedents, cause of death data for non-whites or female veterans would be very sparse. This report, therefore, is restricted to an analysis of white male mortality patterns, although information on other groups may be pursued in further studies.¹

The number of deaths from specific causes among Vietnam veterans was compared with the expected number of deaths based upon the actual mortality experience of both non-Vietnam veterans and all other males in Massachusetts. Veteran deaths were not included in the Massachusetts white male comparison group. These numbers were derived from calculations of time-cause-specific proportionate mortality within 10-year age groups. The ratios of observed to

¹Appendix A lists the non-white deaths by age at death, cause of death and year of death.

expected numbers of deaths were summarized using the standardized proportionate mortality ratio (sPMR).(3) The statistical significance of the differences was assessed using the Mantel-Haenszel Chi test with one degree of freedom.(4) For cases in which the observed number of deaths was greater than five, but the expected number of deaths was less than five, the Poisson distribution was used to determine statistical significance. sPMRs were calculated for both the entire study period (1972-83) and the last six or eight years of the study period, depending upon which time frame offered sufficient numbers for statistical stability. Also, the last half of the study period was analyzed separately because any significant effect in the last six or eight years might have been diluted by looking at the whole study period only.

For causes of death for which the sPMR was statistically significant, the standardized mortality odds ratio (sMOR) was also calculated according to the method described by Miettinen.(5) The sMOR was used to confirm the results of, and to correct for biases inherent in, the sPMR method. The sMOR compares the odds for the exposed population--the number of deaths from the cause of interest compared with the number of deaths from selected reference (auxiliary) causes--with the expected odds derived from a comparison (nonexposed) population.(6) The sMOR approach is essentially equivalent to the case-control approach, in which cases are all deaths from the disease of interest, controls are all deaths from the auxiliary causes, and the exposure of interest is Vietnam service. (7)

The sMOR analysis was carried out using all circulatory disease, except rheumatic heart disease (ICDA 390-459), as the auxiliary cause. All cir-

culatory disease was chosen on the assumption that it was unrelated to the exposure of interest (Vietnam service). There were sufficient numbers of deaths due to this auxiliary cause that statistically stable results could be calculated.

Although accidents and violent deaths comprised the largest cause of death category (e800-e999), they were not chosen as the auxiliary causes of death because they had previously been found to be higher for Vietnam veterans compared to other males. Including these causes of death would have introduced bias into the SMOR analysis. The differences between the two ratios of observed and expected deaths were assessed by using the Mantel-Haenszel Chi test with one degree of freedom.

The standardized mortality ratio (SMR) is another method for calculating the ratio of observed to expected deaths. It is sometimes viewed as a preferable method to the sPMR or the sMOR because the SMR is calculated by taking the ratio of the mortality rate in the exposed group to the mortality rate in the nonexposed group for a comparable follow-up period.(3) However, in this study it was not possible to calculate SMRs because neither the calendar years of Vietnam service nor the ages of the veterans were recorded on the veterans file. Date of birth was available for approximately 67% of the veterans on the veterans file. This information was added to the original veterans file by the Massachusetts Registry of Motor Vehicles, which matched the veterans files with a computerized list of Massachusetts driver's license holders in 1983. An estimated death rate using only those veterans where a date of birth was listed would have been subject to selection bias, because it would have

excluded veterans who died, moved out of state, or did not hold a driver's license. Therefore, age-specific mortality rates for the veterans could not be calculated from the information available on the computerized files.

Results

The numbers of deaths that occurred during the study period (1972-83) among both Vietnam veterans and non-Vietnam veterans are presented, by age group and calendar year, in Tables 1 and 2. The distribution of deaths suggests that Vietnam veterans, as a group, are probably younger than the non-Vietnam veterans. Tables 3 and 4 present the results of the standardized proportionate mortality ratio (sPMR) analysis comparing Vietnam veterans to non-Vietnam veterans and to all other non-veteran Massachusetts white males for specified causes of death. The sPMRs and their chi values are included in the tables, and p-values are given for all statistically significant findings ($p < .05$). Uncommon causes of death for Vietnam veterans are not presented because statistically stable comparisons could not be made. A minimum of seven observed Vietnam veteran deaths was used as a criterion for calculating an sPMR. Two methods of accounting for suicide deaths are used. The first method includes only those deaths that were recorded as suicides on death certificates. However, it has been estimated that the actual suicide rate is three times the reported rate.(8) Therefore, a second calculation, known as an "estimated suicide rate," was used which includes all poisonings (ICDA codes e850-e869, e980-e982), recorded suicides (ICDA codes e950-e958), and unknown causes of death (ICDA code 799.9).(9) The analyses presented were carried out on 766 deaths from specific causes out of the total 840 deaths in the Vietnam veterans group.

TABLE 1
DISTRIBUTION OF DEATHS BY AGE AND CALENDAR YEAR
FOR WHITE MALE VIETNAM VETERANS, 1972-1983

AGE AT DEATH	YEAR OF DEATH												
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	TOTAL
20-29	49	40	48	48	41	22	18	17	8	1	2	0	294
30-39	6	6	8	14	8	18	22	34	57	57	52	53	335
40-49	8	8	9	15	12	4	4	9	6	13	10	8	106
50-59	1	2	5	3	4	2	8	8	11	7	12	16	79
60+	1	0	1	1	1	3	1	2	0	3	4	9	26
TOTAL	65	56	71	81	66	49	53	70	82	81	80	86	840

TABLE 2
DISTRIBUTION OF DEATHS BY AGE AND CALENDAR YEAR
FOR WHITE MALE NON-VIETNAM VETERANS, 1972-1983

AGE AT DEATH	YEAR OF DEATH												
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	TOTAL
20-29	52	52	42	51	60	24	14	17	20	17	7	6	362
30-39	37	68	73	83	94	52	70	59	77	66	64	67	810
40-49	19	24	24	36	40	31	26	49	75	95	105	112	636
50-59	26	22	40	39	34	30	29	37	43	38	36	46	420
60+	3	14	12	16	15	3	11	22	36	40	55	60	287
TOTAL	137	180	191	225	243	140	150	184	251	256	267	291	2515

TABLE 3
OBSERVED AND EXPECTED NUMBERS, STANDARDIZED PROPORTIONATE MORTALITY RATIOS
AND CHI VALUES COMPARING VIETNAM VETERANS TO NON-VIETNAM VETERANS
BY SPECIFIC CAUSES OF DEATH FOR PERIODS 1972-83 AND 1976-83 OR 1978-83*

CAUSE OF DEATH (ICDA CODES, 9th REV.)	ANALYSIS PERIOD	OBSERVED DEATHS	EXPECTED DEATHS	SPMR	CHI VALUES
ALL CAUSES		840			
ALL NEOPLASMS (140-239)	1972-83	129	136.15	95	-.52
153-154)	1972-83	8	7.07	113	.34
LUNG, BRONCHUS (162)	1972-83	25	25.49	98	-.10
	1976-83	21	22.44	94	-.30
CONNECTIVE TISSUE (171)	1972-83	9	1.02	880	7.89 (p<.0001)
KIDNEY CANCER (189)	1972-83	9	4.91	183	1.84
CIRCULATORY SYSTEM (EX- CEPT CEREBROVASCULAR)	1972-83	139	158.54	88	-1.55
(390-429, 439-459)	1978-83	85	106.54	80	-2.08 (p=.03)
CEREBROVASCULAR DISEASE	1972-83	28	25.17	111	.56
(430-438)	1978-83	19	11.56	164	2.19 (p=.02)
CIRRHOSIS OF LIVER	1972-83	29	30.81	94	-.33
(571)	1976-83	24	19.03	126	1.15
ALL EXTERNAL CAUSES	1972-83	428	396.09	108	1.60
(e800-e999)	1978-83	202	181.51	111	1.52
MOTOR VEHICLE ACCIDENTS	1972-83	169	153.17	110	1.27
(e810-e825)	1978-83	74	61.38	121	1.61
RECORDED SUICIDES	1972-83	102	109.92	93	-.75
(e950-e958)	1978-83	55	55.65	99	-.09
ESTIMATED SUICIDES***					
(799.9, e850-e869, e950-e958, e980-e982)	1972-83	163	144.75	113	1.51
	1978-83	94	76.01	124	2.06 (p=.03)
HOMICIDE (e960-e969)	1972-83	31	38.73	80	-1.24
	1976-83	20	18.82	106	.27

*SEE PAGE 6 FOR FURTHER EXPLANATION OF STUDY PERIOD ANALYSIS.

**SIGNIFICANCE BASED ON POISSON DISTRIBUTION.

***ESTIMATED SUICIDES BASED ON UNKNOWN CAUSES OF DEATH, RECORDED SUICIDES,
AND POISONINGS.(9)

TABLE 4
OBSERVED AND EXPECTED NUMBERS, STANDARDIZED PROPORTIONATE MORTALITY RATIOS
AND CHI VALUES COMPARING VIETNAM VETERANS TO THE MASSACHUSETTS WHITE
MALE POPULATION BY CAUSE OF DEATH FOR PERIODS 1972-83 AND 1976-83 OR 1978-83*

CAUSE OF DEATH (ICDA CODES, 9th REV.)	ANALYSIS PERIOD	OBSERVED DEATHS	EXPECTED DEATHS	SPMR	CHI VALUES
ALL CAUSES		840			
ALL NEOPLASMS (140-239)	1972-83	129	115.69	112	1.24
	1976-83	102	87.57	116	1.54
COLO-RECTAL (153-154)	1972-83	8	9.38	85	-.45
LUNG, BRONCHUS (162)	1972-83	25	24.44	102	.11
	1976-83	21	19.79	106	.27
CONNECTIVE TISSUE (171)	1972-83	9	1.90	473	5.14 (p=.0001)**
KIDNEY CANCER (189)	1972-83	9	2.55	353	4.04 (p=.001)**
CIRCULATORY SYSTEM (EX- CEPT CEREBROVASCULAR) (390-429, 439-459)	1972-83	139	159.98	87	-1.66
	1978-83	85	104.43	81	-1.90
CEREBROVASCULAR DISEASE (430-438)	1972-83	28	20.25	138	1.72
	1978-83	19	10.95	174	2.43 (p=.015)
CIRRHOSIS OF LIVER (571)	1972-83	29	32.07	90	-.54
	1976-83	24	23.61	102	.08
ALL EXTERNAL CAUSES (e800-e999)	1972-83	428	377.66	113	2.59 (p=.010)
	1978-83	202	166.11	122	2.78 (p=.005)
MOTOR VEHICLE ACCIDENTS (e810-e825)	1972-83	169	133.26	127	3.10 (p<.003)
	1978-83	67	50.98	131	2.24 (p=.025)
RECORDED SUICIDES (e950-e958)	1972-83	102	86.16	118	1.71
	1978-83	55	41.80	132	2.04 (p=.041)
ESTIMATED SUICIDES*** (799.9, e850-e869, e950-e958, e980-e982)	1972-83	163	116.21	140	4.34 (p<.001)
	1978-83	94	59.56	158	4.46 (p<.001)
HOMICIDE (e960-e969)	1972-83	31	46.71	66	-2.30 (p=.021)
	1976-83	20	28.09	71	-1.52

*SEE PAGE 6 FOR FURTHER EXPLANATION OF STUDY PERIOD ANALYSIS.

**SIGNIFICANCE BASED ON POISSON DISTRIBUTION.

***ESTIMATED SUICIDES BASED ON UNKNOWN CAUSES OF DEATH, RECORDED SUICIDES,
AND POISONINGS. (9)

Table 3 focuses on the proportionate mortality experience of Vietnam veterans compared to non-Vietnam veterans. Although the proportion of deaths from all neoplasms was not unusual, the sPMR for connective and other soft-tissue neoplasms was significantly elevated (sPMR=880). All of the nine connective tissue neoplasms were sarcomas of five different types. This finding for this cause of death had the most significant p-value in the study.

There was significantly less circulatory system disease among Vietnam veterans for the six years from 1978-1983 (sPMR=80) compared to non-Vietnam veterans. Conversely, cerebrovascular disease among Vietnam veterans was significantly elevated during the same time period (sPMR=164). The sPMR for estimated suicides was significantly higher than expected for the final six years of the study period (sPMR=124).

Table 4 displays the proportionate mortality ratios of Vietnam veterans compared to the non-veteran Massachusetts white male population. Once again, there were no significant differences in the proportion of all neoplasms. However, the sPMR for connective and other soft-tissue neoplasms was significantly elevated (sPMR=473), as was the sPMR for kidney cancer (sPMR=353).

The patterns for causes of death found in Table 4 are similar to those in Table 3. There was a greater than expected proportion of cerebrovascular disease among Vietnam veterans compared to the state's white male population as a whole during the second half of the study period (sPMR=174). All major categories of violent death were significantly elevated for Vietnam veterans, with the exception of homicides (sPMR=66). These categories included motor

vehicle accidents (sPMR=127), estimated suicides (sPMR=140), and all external causes (sPMR=113). Recorded suicides were elevated for the final six years of the study period (sPMR=132).

The standardized mortality odds ratio (sMOR) was computed for each cause of death for which the sPMR was statistically significant. The sMOR results are presented in Table 5. The sMOR for circulatory system disease was not computed because circulatory disease was used as the auxiliary cause of death for the sMOR analysis. The sMOR findings differed from the sPMR findings in only two instances. Homicide was not found to be significantly lower for Vietnam veterans compared to the state's white males (sMOR=.82), and estimated suicide was not significantly elevated when compared to non-Vietnam veterans (sMOR=1.46). Table 6 summarizes the causes of death for which the findings were significant using both analytic methods.

TABLE 5
STANDARDIZED MORTALITY ODDS RATIOS AND CHI VALUES
COMPARING VIETNAM VETERANS TO EITHER NON-VIETNAM VETERANS OR
THE MASSACHUSETTS WHITE MALE POPULATION BY SPECIFIC CAUSES OF DEATH
FOR 1972-83 AND 1976-83 OR 1978-83*

CAUSE OF DEATH (ICDA CODES, 9th REV.)	ANALYSIS PERIOD	COMPARISON GROUP	SMOR	CHI VALUES
CONNECTIVE TISSUE CANCER (171)	1972-83	NON-VIETNAM VETERANS	5.16	4.18(p<.001)
	1972-83	MASSACHUSETTS WHITE MALES	5.87	4.98(p<.001)
KIDNEY CANCER (189)	1972-83	MASSACHUSETTS WHITE MALES	4.04	4.27(p<.001)
ALL EXTERNAL CAUSES (e800-e999)	1972-83	MASSACHUSETTS WHITE MALES	1.44	2.52(p=.012)
	1978-83	MASSACHUSETTS WHITE MALES	1.29	1.96(p=.05)
MOTOR VEHICLE ACCIDENTS (e810-e825)	1972-83	MASSACHUSETTS WHITE MALES	1.65	3.85(p<.001)
	1978-83	MASSACHUSETTS WHITE MALES	1.39	3.10(p=.002)
RECORDED SUICIDES (e950-e958)	1972-83	MASSACHUSETTS WHITE MALES	1.46	2.09(p=.037)
	1978-83	MASSACHUSETTS WHITE MALES	1.40	1.50
ESTIMATED SUICIDES** (799.9, e850-e869, e950-e958, e980-e982)	1972-83	NON-VIETNAM VETERANS	1.46	1.53
	1978-83	NON-VIETNAM VETERANS	1.46	1.06
	1972-83	MASSACHUSETTS WHITE MALES	1.73	3.11(p=.002)
	1978-83	MASSACHUSETTS WHITE MALES	1.69	2.43(p=.015)
HOMICIDES (e960-e969)	1972-83	MASSACHUSETTS WHITE MALES	.82	-1.62
	1976-83	MASSACHUSETTS WHITE MALES	.78	-.75

*SEE PAGE 6 FOR FURTHER EXPLANATION OF STUDY PERIOD ANALYSIS.

**ESTIMATED SUICIDES BASED ON UNKNOWN CAUSES OF DEATH, RECORDED SUICIDES, AND POISONINGS.(9)

TABLE 6
SUMMARY TABLE FOR STATISTICALLY SIGNIFICANT CAUSES OF DEATH FOR PERIODS
1972-83 AND 1976-83 OR 1978-83*
STANDARDIZED MORTALITY ODDS RATIOS AND STANDARDIZED PROPORTIONATE
MORTALITY RATIOS COMPARING VIETNAM VETERANS TO EITHER NON-VIETNAM VETERANS
OR THE MASSACHUSETTS WHITE MALE POPULATION

CAUSE OF DEATH (ICDA CODES, 9th REV.)	ANALYSIS PERIOD	COMPARISON GROUP	SMOR (x100)	SPMR
CONNECTIVE TISSUE CANCER (171)	1972-83	NON-VIETNAM VETERANS	516	880
	1972-83	MASSACHUSETTS WHITE MALES	587	473
KIDNEY CANCER (189)	1972-83	MASSACHUSETTS WHITE MALES	404	353
CIRCULATORY SYSTEM (EXCEPT CEREBROVASCULAR)**(390-429, 439-459)	1972-83	NON-VIETNAM VETERANS		88
	1978-83	NON-VIETNAM VETERANS		80
CEREBROVASCULAR DISEASES**(430-438)	1972-83	NON-VIETNAM VETERANS		111
	1976-83	NON-VIETNAM VETERANS		164
	1972-83	MASSACHUSETTS WHITE MALES		138
	1976-83	MASSACHUSETTS WHITE MALES		174
ALL EXTERNAL CAUSES (e800-e999)	1972-83	MASSACHUSETTS WHITE MALES	144	113
	1978-83	MASSACHUSETTS WHITE MALES	129	122
MOTOR VEHICLE ACCIDENTS (e810-e999)	1972-83	MASSACHUSETTS WHITE MALES	165	127
	1978-83	MASSACHUSETTS WHITE MALES	139	131
RECORDED SUICIDES (e950-e958)	1972-83	MASSACHUSETTS WHITE MALES	146	118
	1978-83	MASSACHUSETTS WHITE MALES	140	132
ESTIMATED SUICIDES*** (799.9, e850-e869, e950-e958, e980-e982)	1972-83	MASSACHUSETTS WHITE MALES	173	140
	1978-83	MASSACHUSETTS WHITE MALES	169	158

*SEE PAGE 6 FOR FURTHER EXPLANATION OF STUDY PERIOD ANALYSIS.

**SMORs NOT CALCULATED FOR CIRCULATORY DISEASE SINCE IT WAS USED AS AUXILIARY CAUSE.

***ESTIMATED SUICIDES BASED ON UNKNOWN CAUSES OF DEATH, RECORDED SUICIDES AND POISONING.(9)

Discussion

This study was carried out using death certificates as the source of the health outcome information. There are inherent problems in relying on such information. Other studies have assessed the accuracy of death certificate information by comparing the stated cause of death on the death certificate to either clinical data or autopsy findings.(10,11) The accuracy of death certificates has generally been about 90%. Death certificates seem to be approximately 85-90% reliable for the general diagnosis of malignant neoplasms, although there may be underreporting of malignant neoplasms of about 10%.(11) This study did not attempt to confirm cause of death using hospital or other records. However, the effect of misclassifying cause of death due to inaccuracies on the death certificate would most likely be one of diluting the magnitude of the effects seen in the comparisons.

Further problems with death certificate studies involve lack of knowledge about other factors related to the cause of death. For example, there is no information on death certificates concerning potential confounding factors such as smoking, alcohol consumption, and dietary habits. In addition, death certificate studies may be biased due to differential access to good quality medical care. In this study, Vietnam veterans may not have had as good access to medical care as the non-veteran white males to whom they were compared. On the other hand, the non-veteran comparison group includes some individuals who were unable to serve in the military because of health problems. This potential bias, referred to as the "healthy veteran effect," would tend to dilute the magnitude of the associations between veterans and non-veterans.(12)

The method of identifying deceased veterans by computer file-linking represents a potential source of bias. The primary linking method (social security number) has been found in other mortality studies to be more than 90% accurate in identifying deaths in a study population.(13) However, some studies have found a 20% false negative rate (missing deaths) when matching was done using names, as it was in this study for the years 1977-79.(14) Nevertheless, there is no reason to suspect that there is any systematic bias between the study group and the non-Vietnam veteran comparison group. However, misclassified social security numbers, names, or veterans who died out of state would only reduce the magnitude of the excess mortality seen in the Vietnam veterans compared to the Massachusetts male population.

Another potential source of bias is that only honorably discharged veterans were included in the study population. It is not known if Vietnam veterans were more likely to have been dishonorably discharged than non-Vietnam veterans. Once again, this potential bias would tend to dilute the magnitude of the associations between Vietnam service and specific causes of death.

The standardized proportionate mortality ratio (sPMR) as a method of analysis has been criticized by various authors.(3,5,15) The major criticisms of the sPMR approach concern the summary nature of the statistic. Because the sPMR for all causes must equal 100, the statistic cannot give any information about the total force of mortality.(15) Secondly, the sPMRs for two or more causes are interdependent, since the sum of the expected numbers must equal the sum of the observed numbers.(3) Therefore, any sPMR greater than the null

may be an underestimate if more than one specific cause of death is estimated. It has also been pointed out that sPMRs tend to be more easily interpreted for uncommon causes of death, because they are less dependent upon how common are the other causes, relative to the cause of interest.(3,5)

The sMOR has certain advantages relative to the sPMR. When the auxiliary cause(s) of death is unrelated to the exposure, the mortality odds ratio is interpretable as the observed-to-expected ratio. When standardized for age and time, the mortality odds ratio becomes the standardized mortality odds ratio and the observed-to-expected ratio becomes the standardized mortality ratio. In contrast, the sPMR can be quantitatively interpreted as the standardized mortality ratio only when the sum of the mortality rate(s) of interest and the rate for the auxiliary cause(s) of death is the same for both the exposed and nonexposed.(6)

In this study, the sPMR analysis identified specific causes of death for which there were significant differences between Vietnam veterans and the comparison groups. The sMOR analysis was used to confirm these findings. The results of the study are strengthened by the fact that the sMOR analysis, using a specific auxiliary cause, differed from the sPMR analysis in only two instances.

In order to interpret the meaning of the findings in this study, it is necessary to keep two other factors in mind. First, the study group of Vietnam veterans was assembled from a list of those who received a bonus after they had presented proof of Vietnam service and honorable discharge. No

information about length of service (beyond the six month required minimum), precise location of service, or specific exposures to toxic substances, such as Agent Orange, was available from these records. Furthermore, no correction was made for possible social class differences between the Vietnam veterans and the two comparison groups. However, the Vietnam veterans findings for three causes of death which are highly correlated with social class--lung cancer, colo-rectal cancer, and cirrhosis of the liver--did not, in this instance, differ significantly from those of the comparison groups.

Three significant findings presented in Table 6, specifically suicides, estimated suicides, and motor vehicle accidents, are all similar in that the causal factor may be a behavioral one. It may be that social stress, which could not be directly measured in this study, was higher for Vietnam veterans compared to non-Vietnam veterans and other non-veteran white males. Depression is a major risk factor for suicide (8), and previous studies of Vietnam veterans have documented post-traumatic stress disorder and associated depression, as well as elevated rates of suicide, among those who served in combat.(16,17,18) It is certainly plausible that the findings in this study may be due, at least in part, to increased stress experienced by Vietnam veterans.

No significant differences were found between Vietnam veterans and the two comparison groups with respect to death due to malignant neoplasms as a whole (ICDA 140-239). The significant elevation of connective tissue cancer was based on only nine deaths; all of these were sarcomas of five different types. Table 7 lists the nine cases by histological type. Previous studies

have reported that soft-tissue sarcomas were associated with exposure to phenoxycetic acids such as 2,4-D and 2,4,5-T, the components of Agent Orange.(19,20) For all of the cases with the possible exception of case 9, occupational exposure as obtained from the death certificate did not seem to be significant. A more recent study of upstate New York Vietnam veterans reported no excess of soft-tissue sarcomas diagnosed through 1980.(21) The present study was not based on either adequate numbers of deaths or adequate exposure information to help resolve this important issue. Nevertheless, the highly significant excess of this rare malignancy in Vietnam veterans is important new information. The latency period for soft-tissue sarcoma in adults is probably sufficiently long that several more years of observation will be necessary before any conclusive findings can be made.

TABLE 7
 CASE-SPECIFIC INFORMATION FOR CONNECTIVE TISSUE CANCER DEATHS
 AMONG VIETNAM VETERANS BY HISTOLOGIC TYPE AND OCCUPATION

CASE	AGE AT DEATH	YEAR INDUCTED	YEAR DISCHARGED	YEAR OF DEATH	HISTOLOGIC TYPE	OCCUPATION ON DEATH CERTIF.
1	30	1969	1971	1975	FIBROSARCOMA	DATA PROCESSING
2	28	1967	1970	1976	SYNOVIAL SARCOMA	MANAGER
3	30	1965	1967	1976	LIPOSARCOMA	MENTAL HEALTH ASSISTANT
4	32	1967	1972	1977	FIBROSARCOMA	MANAGER
5	30	1964	1967	1977	FIBROSARCOMA	ENGINEER'S AIDE
6	32	1970	1971	1978	FIBROSARCOMA	CIVIL ENGINEER
7	32	1970	1971	1982	EPITHELIOID SARCOMA	GRAPHICS
8	29	1971	1974	1982	SARCOMA, NOS	FIREFIGHTER
9	39	1961	1966	1983	HEMANGIOPERI-CYTOMA	PICKER

Kidney cancer is less rare than soft-tissue sarcomas and was found to be significantly elevated in Vietnam veterans compared to non-veteran white males. Possible confounding due to cigarette smoking, analgesic use or other known risk factors among veterans should be considered, but information on those risk factors was unavailable in this study. Further studies may also shed light on this finding.

Finally, the significantly lower number of deaths among Vietnam veterans due to circulatory system disease (excluding stroke) for the time period 1978-83 may be a reflection of the "healthy veteran effect."⁽¹²⁾

Conclusions

The findings in this study support the hypothesis that white male Vietnam veterans are at greater risk of death due to self-inflicted or stress-related conditions than the non-veteran white male population in Massachusetts. The results would support an effort to reduce early or untimely deaths among Vietnam veterans due to suicide or motor vehicle accidents, which are largely preventable. Although the numbers of cancer deaths are small, the finding of excess deaths due to connective tissue sarcoma and kidney cancer warrants further study using the cancer incidence records from the Massachusetts Cancer Registry, and, if available, information on possible exposures to Agent Orange, as reflected in detailed military service histories, as well as histories of other exposures to potential carcinogens.

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APPENDIX A

NON-WHITE VETERAN DEATHS BY YEAR OF DEATH, VETERAN STATUS, CAUSE OF DEATH AND AGE AT DEATH			
YEAR OF DEATH	VETERAN STATUS	CAUSE OF DEATH (ICDA CODES, 9th REV.)	AGE AT DEATH
1972	Vietnam	Motor vehicle collision (e812.0)	31
	Vietnam	Suicide by hanging (e953.0)	28
	Non-Vietnam	Metastatic cancer without specification (199.0)	33
	Non-Vietnam	Disease of aortic valve (395.9)	45
	Non-Vietnam	Acute myocardial infarction (410)	43
	Non-Vietnam	Cardiomyopathy (425)	43
	Non-Vietnam	Fall out of building (e882)	47
	Non-Vietnam	Homicide by knife (e966)	32
1973	Vietnam	Lymphosarcoma (200.1)	22
	Vietnam	Accidental drowning (e910.9)	24
	Non-Vietnam	Rectal cancer (154.1)	31
	Non-Vietnam	Myocardial insufficiency (428)	21
	Non-Vietnam	Cirrhosis of liver, unspecified (571.9)	57
	Non-Vietnam	Suicide by firearms (e955.4)	32
	Non-Vietnam	Homicide by firearms (e965.4)	25
	Non-Vietnam	Homicide by firearms (e965.4)	27
1974	Vietnam	Legal intervention by firearms (e970)	27
	Non-Vietnam	Sigmoid colon cancer (153.3)	53
	Non-Vietnam	Brain cancer (191)	36
	Non-Vietnam	Acute myocardial infarction (410)	56
	Non-Vietnam	Motor vehicle traffic accident (e815.0)	41
	Non-Vietnam	Watercraft accident (e830.0)	27
1975	Vietnam	Motor vehicle collision (e812.0)	29
	Vietnam	Motor vehicle collision (e812.0)	24
	Non-Vietnam	Acute myocardial infarction (410)	41
	Non-Vietnam	Noncollision traffic accident (e816.0)	31
	Non-Vietnam	Accident by electric current (e925.9)	36
	Non-Vietnam	Homicide by firearms (e965.4)	31
1976	Non-Vietnam	Stomach cancer (151.9)	33
	Non-Vietnam	Stomach cancer (151.9)	56
	Non-Vietnam	Disease of mitral valve, rheumatic (394.0)	29
	Non-Vietnam	Acute myocardial infarction (410)	40
1977	Vietnam	Accidental poisoning, opiates (853.0)	25
	Non-Vietnam	Bronchus and lung cancer (162.9)	53
	Non-Vietnam	Essential hypertension (401)	52
	Non-Vietnam	Atherosclerotic heart disease (414.0)	42
	Non-Vietnam	Subarachnoid hemorrhage (430)	37
1978	Vietnam	Chronic nephritis (582)	29
	Vietnam	Unknown and unspecified cause of death (799.9)	27
	Vietnam	Homicide by knife (e966)	27
	Non-Vietnam	Bronchus and lung cancer (162.9)	32

APPENDIX A (continued)

NON-WHITE VETERAN DEATHS BY YEAR OF DEATH, VETERAN STATUS, CAUSE OF DEATH AND AGE AT DEATH			
YEAR OF DEATH	VETERAN STATUS	CAUSE OF DEATH (ICDA CODES, 9th REV.)	AGE AT DEATH
1979	Vietnam	Volume depletion (276.5)	52
	Vietnam	Ischemic heart disease (414.9)	53
	Non-Vietnam	Chronic monocytic leukemia (206.1)	40
	Non-Vietnam	Pneumonitis due to inhalation of food (507.0)	54
	Non-Vietnam	Passenger in motor vehicle collision (e812.1)	36
1980	Vietnam	Colon cancer (153.9)	42
	Vietnam	Intracerebral hemorrhage (431)	36
	Vietnam	Motor vehicle collision (e812.0)	36
	Non-Vietnam	Bronchus and lung cancer (162.9)	45
	Non-Vietnam	Diabetes mellitus (250.0)	66
	Non-Vietnam	Epilepsy (345.9)	46
	Non-Vietnam	Acute myocardial infarction (410)	45
	Non-Vietnam	Chronic renal failure (585)	53
1981	Vietnam	Rectal cancer (154.1)	53
	Vietnam	Acute edema of lung (518.4)	38
	Vietnam	Motor vehicle collision (e812.0)	32
	Non-Vietnam	Palate cancer (145.5)	43
	Non-Vietnam	Larynx cancer (161.9)	57
	Non-Vietnam	Bronchus and lung cancer (162.9)	56
	Non-Vietnam	Bronchus and lung cancer (162.9)	63
	Non-Vietnam	Alcohol dependence syndrome (303)	38
	Non-Vietnam	Acute myocardial infarction (410)	52
	Non-Vietnam	Intracerebral hemorrhage (431)	37
	Non-Vietnam	Accidental drowning (e910.1)	27
	Non-Vietnam	Suicide due to firearms (e955.4)	28
	1982	Vietnam	Atherosclerotic heart disease (414.0)
Vietnam		Alcohol cirrhosis of the liver (571.2)	38
Vietnam		Drowning, undetermined if accidental (e984)	33
Non-Vietnam		Bronchus and lung cancer (162.9)	64
Non-Vietnam		Volume depletion (276.5)	45
Non-Vietnam		Atherosclerotic heart disease (414.0)	36
Non-Vietnam		Cardiomyopathy (425)	64
Non-Vietnam		Acute edema of lung (518.4)	32
1983	Vietnam	Cardiomyopathy (425)	33
	Vietnam	Myocarditis (429)	35
	Non-Vietnam	Acute myocardial infarction (410)	49
	Non-Vietnam	Acute myocardial infarction (410)	52
	Non-Vietnam	Cerebral infarction (434.9)	52
	Non-Vietnam	Suicide by firearms (e955.4)	32
Non-Vietnam	Homicide by firearms (e965.4)	40	