Multiple Sclerosis in US Veterans of the Vietnam Era and Later Military Service: Race, Sex, and Geography

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We identified 5,345 cases of multiple sclerosis (MS) among US veterans who first entered military service between 1960 and 1994, and who were "service-connected" for MS by the Department of Veterans Affairs (VA). Two controls per case were matched on age, date of service entry, and branch of service. Available for service and VA files were demographic and military data for 4,951 cases and 9,378 controls. Versus white men, relative risk of MS was significantly higher for all women, at 2.99 for whites, 2.86 for blacks, and 3.51 for those of other races. This was a significant increase from our prior series of veterans of World War II and the Korean Conflict, where white women had a relative risk of 1.79. Risk for black men was higher now (0.67 vs 0.44), while other men remained low (0.30 vs 0.22). Residence at service entry in the northern tier of states had a relative risk of 2.02 versus the southern tier, which was significantly less than the 2.64 for the earlier series. Residence by individual state at birth and service entry for white men further supported this decreasing geographic differential. Such marked changes in geography, sex, and race in such a short interval strongly imply a primary environmental factor in the cause or precipitation of this disease.

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Multiple sclerosis (MS) is an inflammatory demyelinating disease of the central nervous system. It affects approximately 300,000 persons in the United States and up to 2 million worldwide.[1] Despite intensive research over the last century, no specific cause has been identified. Epidemiological studies have been important in this disease in focusing research efforts by identifying disease patterns, assessing risk factors, and evaluating secular trends.

The US veteran population provides an exceptional resource for such studies. In eight previous articles, we have explored the epidemiology of MS using an unusually large cohort of MS cases and preillness matched controls comprising US veterans of World War II (WWII) and the Korean Conflict (KC).[2–9] Risk factors for developing MS from these studies included female sex, white race, northern latitude, urban residence, high socioeconomic status, and Scandinavian ancestry of the populations, but not of the patients themselves.

In this report, we examine data on a newly assembled cohort of US veterans with first entry into military service between 1960 and 1994. We compare them with our earlier WWII-KC cohort, which had been assembled in a similar manner. The uniqueness of this new cohort lies in its size, racial diversity, national representation, and relative recency, with, as before, preillness matched controls from the military to represent the specific population at risk.

Subjects and Methods

The new Vietnam era (VNE) and later service case–control series was assembled in a manner similar to the WWII-KC series.[2] Starting with a list of all veterans receiving "service-connection" for MS from the Department of Veterans Affairs (VA), we identified 5,345 new cases who first entered military service between 1960 and 1994 and who were alive in 1995. The VA has established the following periods of service for "Wartime veterans:" WWII: December 7, 1941 to December 31, 1946; KC: June 27, 1950 to January 31, 1955; VNE: August 5, 1964 to May 7, 1975; and the Gulf

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War: August 2, 1990 to September 30, 2003.[10] A decision for service-connection for MS requires definitive evidence of clinical signs upon examination attributable to MS during or within 7 years after military service. Copies of all relevant medical information are in the veteran claims folder for all service connection requests. The decision was made without regard to rank, race, sex, or financial status. Roughly half of the cases (and, of course, controls) served in the VNE. Sixty-five random case records were reviewed for diagnostic accuracy (M.T.W. and J.F.K.) and 97% (binomial 95% confidence interval, 89.3–99.6%) met the Schumacher[11] and Poser[12] criteria for definite MS. All data retrieval and initial analyses were performed by the Medical Follow-up Agency-National Academy of Sciences under our direction.

A total of 10,683 controls were selected from the automated personnel files of the Defense Manpower Data Center and a 1% sample of military personnel held by the Medical Follow-up Agency-National Academy of Sciences depending on date of service entry. The controls were matched on a 2 to 1 basis for age, month and year of entry into military service, and branch of service. The VNE and later service series contains substantial numbers of women and minorities because of the changing demographics of the military (see Appendix Table 3; Appendix Tables 1–3 can be viewed online at www.interscience.wiley.com/jpages/0364-5134/suppmat).

Data from computerized military records were available for most subjects, and hard-copy military records also were abstracted and computerized to obtain additional information. The numbers of MS cases and controls analyzed were 4,951 and 9,378, respectively. Race and sex were taken directly from the computerized record, as was home of record, which is the same as residence at time of entry into service for almost all subjects.

The contiguous United States was divided into the same three geographic tiers used previously to allow for stratification by residence location. The northern tier was defined as states north of 41 degrees to 42 degrees north latitude; the southern tier as states south of 37 degrees north latitude as well as California from Fresno south. The middle tier included all other states and northern California.

For comparisons between individual case–control (CC) ratios with the WWII-KC series, adjustment was made by dividing the specific CC ratio by the total CC ratio for the comparison of which this was a component. For small subsets, this approximates the standard odds ratio. This study has been approved by the VA Medical Center Washington, DC Institutional Review Board. All statistical analyses were performed using the Statistical Analysis System computer software package.[13]

Results

There were 394 MS cases and 1,305 controls with missing data and/or who were unable to be linked between Department of Defense and VA databases. These cases were eliminated from the study cohort, leaving a total of 4,951 MS cases and 9,378 controls (Table 1). As expected, the predominant racial group for MS cases was white, but there were a substantial number of blacks and "other" race persons. This last classification includes Asian and Native American veterans as the major groups.

Table 1 shows the adjusted CC ratios for MS by sex and race according to period of service. Black males in the VNE and later service cohort had a significantly higher risk for developing MS compared with the WWII-KC cohort. The other male race groups had fairly similar risk ratios between the two time periods.

All female groups in the VNE and later service cohort had a higher risk for developing MS than the WWII-KC cohort. Differences for white females and all females as a group were statistically significant. Comparison of the nonwhite groups between cohorts is

Table 1. Multiple Sclerosis in US Veterans by Sex and Race According to Period of Service

	Vietnam and later		WWII and KC[a]	
Sex and Race	No. of cases, controls	CC ratio[b] (95% CI)	No. of cases, controls	CC ratio[b] (95% CI)
Male				
White	3,758/7,426	0.96 (0.90–1.00)	4,923, 4,741	1.04 (0.98–1.10)
Black	415/1,225	0.64 (0.57–0.73)	177, 390	0.45 (0.38–0.54)
Other	35/231	0.29 (0.20–0.41)	17, 73	0.23 (0.14–0.39)
Total	4,208/8,882	0.90 (0.85–0.94)	5,117, 5,204	0.98 (0.93–1.02)
Female				
White	604/402	2.85 (2.49–3.25)	182, 98	1.86 (1.44–2.38)
Black	123/85	2.74 (2.00–3.52)	4, 3	1.33 (0.23–9.10)
Other	16/9	3.37 (1.52–7.56)	2, 0	—, (—)
Total	743/496	2.84 (2.50–3.24)	188, 101	1.86 (1.44–2.38)
Grand total	4,951/9,378	1.00 (—)	5,305, 5,305	1.00 (—)

[a]Data of Table 1 from Kurtzke and colleagues (1979)[2]
[b]Adjusted CC ratios.

WWII = World War II; KC = Korean Conflict; CI = confidence interval; CC = case–control.

limited with the low numbers in the WWII-KC series. With the differing proportions between cohorts for all subsets of race and sex, we also calculated these data as the relative risk of MS versus that for white males for each service cohort (Table 2).

Adjusted CC ratios for MS by sex, race, and tier of residence at entry into service are shown in Table 3. There is a decreasing risk for MS when proceeding from north to south in each sex-race group, and of fairly equal degree for each subset. The low number of nonwhite MS veterans in the WWII-KC cohort precluded calculating such ratios for other-race males and nonwhite females. To compare north versus south directly, we summarized these data as north to south ratios in Table 4. There is a 2 to 1 difference for the total VNE and later service cohort. This gradient was more pronounced in the WWII-KC cohort, at 2.6 to 1. Thus, although higher MS risk in the northern states than in the south persists, it is now to a significantly lesser degree.

Figure 1 shows the distribution by state and tier of residence at service entry for the WWII-KC cohort and the corresponding distribution for the new series. To avoid confounding by sex or race, data for both are limited to white males. Because of low numbers (case + control = 10 or less) in some comparisons, results for Maryland and Washington, DC and for Nevada and Utah were combined for all assessments. The latitude gradient observed in the WWII-KC series is still apparent but less pronounced. Figure 2 is a scatterplot of these adjusted CC ratios, with the *x*-axis presenting the data from the VNE and later cohort, and the *y*-axis presenting the data from WWII-KC. The Spearman's coefficient of correlation (*r*) of 0.73 is very highly significant, indicating that, whereas difference are clearly lessening, the overall distribution of MS in this country has remained similar over a 40 to 50-year period.

Table 5 presents the adjusted CC ratios for residence at birth and service entry, stratified by geographic tier and data source. The Pacific column had to be excluded for the recent cohort, because California was not divisible by birth location into its two tiers, middle and south. The north to south ratio was 2.27 birth and

Table 2. Relative Risk of Multiple Sclerosis versus White Males by Race and Sex from Adjusted Case–Control Ratios

Sex and Race	Vietnam and later	WWII and KC
Male		
White	1.00[a]	1.00[a]
Black	0.67	0.44
Other	0.30	0.22
Total	0.94	0.95
Female		
White	2.99	1.79
Black	2.86	1.28
Other	3.51	—
Total	2.96	1.79

Data from Table 1.

[a]Index group.

WWII = World War II; KC = Korean Conflict.

Table 3. Multiple Sclerosis in US Veterans by Tier of Residence within the Contiguous US at Entry into Service by Sex and Race

	North Tier		Middle Tier		South Tier	
Sex and Race	No. of cases, controls	CC ratio (adjusted)	No. of cases, controls	CC ratio (adjusted)	No. of cases, controls	CC ratio (adjusted)
Vietnam and later						
Male						
White	1,385/2,007	1.29	1,486/2,844	0.97	796/2,276	0.65
Black	67/138	0.91	178/417	0.80	164/647	0.47
Other	7/30	0.43	10/35	0.53	14/95	0.27
Female						
White	205/114	3.35	219/146	2.80	142/120	2.21
Black	27/12	4.19	52/38	2.55	39/33	2.20
Other	8/0	—	4/2	3.73	4/7	1.07
Total	1,699/2,301	1.38	1,949/3,482	1.04	1,159/3,178	0.68
World War II and Korean Conflict[a]						
Male						
White	2,195/1,544	1.43	2,059/2,022	1.03	668/1,161	0.58
Black	28/46	0.61	88/150	0.59	61/194	0.32
Female						
White	97/35	2.79	65/38	1.72	20/25	0.81
Total[b]	2,323/1,647	1.42	2,213/2,269	0.98	762/1,425	0.54

[a]Data from Table 2 in Kurtzke and colleagues (1979)[2]

[b]Includes black female, and other race men and women.

CC = case–control.

Table 4. Multiple Sclerosis in US Veterans

Sex and Race	Vietnam and Later (ratio north:south)	WWII and KC (ratio north: south)
Males		
White	1.97	2.47
Black	1.92	1.94
Other	1.58	—
Females		
White	1.52	3.46
Black	1.90	—
Other	—	—
Total	2.02	2.64[a]

Ratios of residence within northern tier of the contiguous US versus southern tier from adjusted case-control ratios by sex and race. Data from Table 3.

[a]Includes black women, and other race men and women.

WWII = World War II; KC = Korean Conflict.

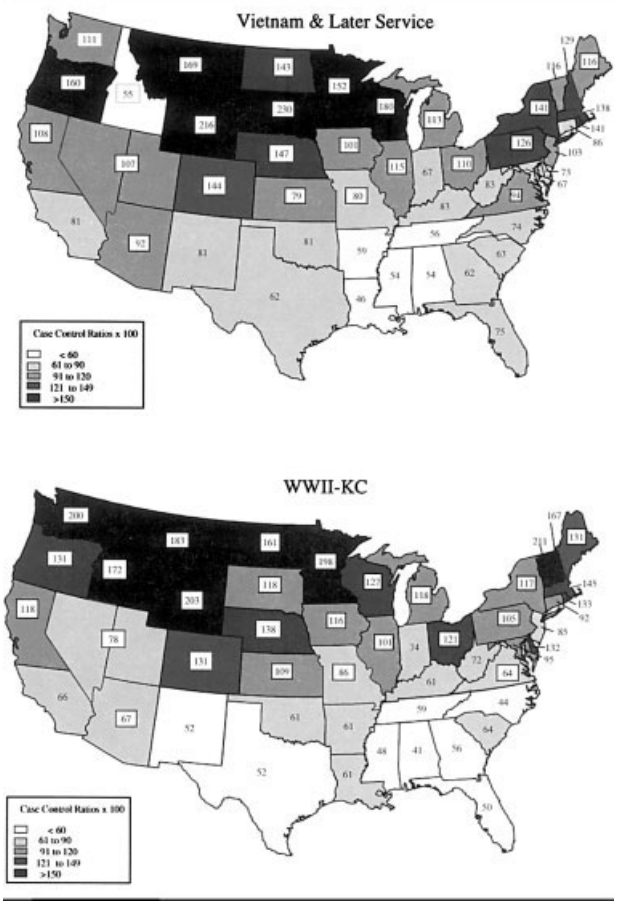

Fig 1. Adjusted case–control ratios (×100) for white male veterans service-connected for multiple sclerosis (MS), according to state and tier of residence within the coterminous United States at entry into active duty (EAD): (top) *Vietnam-era and later service cohort;* (bottom) *World War II–Korean Conflict cohort. Data in Appendix Table 1.*

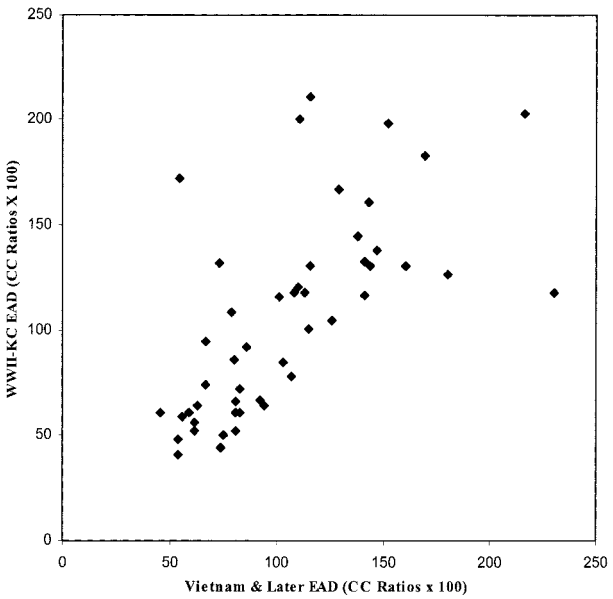

Fig 2. Scatterplot of adjusted case–control ratios (×100) for white male veterans service-connected for multiple sclerosis (MS) of Vietnam-era and later service by state of entry into active duty (EAD) versus white males of World War II–Korean Conflict (WWII-KC) by EAD; California is divided into its two parts as in Figure 1. Spearman's r = *0.73. Data in Appendix Table 1.*

2.07 at entry for the new cohort, in which the ratio had been 1.97 at entry with the Pacific column included. The complete tier data for the WWII-KC cohort showed north to south ratios of 2.50 at birth and 2.46 at entry into active duty.[4] The correlation between the adjusted CC ratios by state for the new cohort at birth and entry into active duty was very strong (Spearman's *r* of 0.84) (Fig. 3). This also serves to support the inference that geographic movement between birth and service entry in either cohort was not primarily responsible for the north to south gradients in risk, or for their significant decrease in the recent cohort.

Discussion

This relatively modern era US veteran cohort has produced what we believe to be important information on the changing distribution of MS by race, sex, and geography. The north to south gradient persists but is much less pronounced than for our earlier WWII-KC cohort. There has been a notably increased risk for developing MS in white females compared with the previous cohort. In the VNE and later cohort, the relative risks for black and other race females were also significantly higher than for white males and appeared similar to that for white females.

The rarity of MS among certain racial groups such as the native Siberians, North American Indians, and

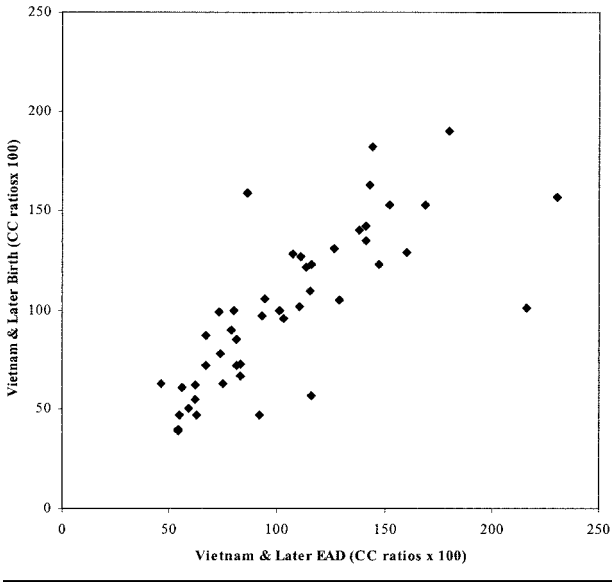

Fig 3. Scatter plot of adjusted case-control ratios (×100) for white male veterans service-connected for MS of Vietnam-era and later service by state of entry into active duty (EAD) vs. state of birth. Spearman r = 0.84. Data in Appendix Table 2.

Japanese is held as evidence for a strong influence of genetics on the disease. Yet, many of these groups have not recently been studied intensively. Note our own findings for all nonwhite women veterans. The specific races of our "other race" females are not yet available, but the expectation is that they will be mostly Asian. Two recent reports found MS to be present among ethnic groups felt earlier to be resistant to developing MS. Mirsattari and colleagues[14] presented a population based study of aboriginals in Manitoba, Canada, where an MS prevalence rate of 40 per 100,000 was found.[14] Seven aboriginals with MS were identified in the study, most with an aggressive disease course and predominance of neuromyelitis optica. Grønlie and colleagues found an increasing incidence of MS over the past 30 years in northernmost Norway.[15] The counties that were surveyed were those where most of the Sami people (Lapps) lived, six of whom had diagnoses of MS in the 1993 prevalence survey for a crude rate of 73 per 100,000.

MS has been described as distributed throughout the world within three zones of high, medium, and low frequency.[16] High-frequency areas, with prevalence rates of 30 and above per 100,000 population currently include most of Europe into the former Soviet Union, Israel, Canada, and the entire United States, plus New Zealand and southeastern Australia. This also seems to include the easternmost part of Russia. Evidence has indicated the existence of geographic gradients within North America,[16,17] Australia,[18] and Europe.[19,20] Although time trend analyses have shown many of these gradients to persist,[15,21,22] diffusion of these gradients over one or two generations also has been reported,[17] a pace too rapid for genetic influences to be effective. There is now little difference between north versus south in Europe, and, as noted, the difference in the United States is decreasing even though half our new cohort is from the Vietnam era (1964–1975) not long after the WWII-Korean Conflict periods.

Some have argued against the existence of recent latitude gradients for MS. Robertson and colleagues[23] and Forbes and colleagues[24] have stated that latitude gradients in the United Kingdom may be an artifact of methodological differences. Savettieri and colleageus[25] have concluded with 20 years of prevalence data that Sicily now is a high-risk region for MS, but it was not so reported in earlier data. This high rate,

Table 5. Multiple Sclerosis in US White Male Veterans

	Birth			Entry into Service		
Tier	Case	Control	Adjusted CC	Case	Control	Adjusted CC
Vietnam and later[a]						
North	1,098	1,505	1.36	1,201	1,721	1.36
Middle	1,287	2,324	1.03	1,346	2,593	1.01
South	491	1,527	0.60	655	1,941	0.66
Total	2,876	5,356	1.00	3,202	6,255	1.00
Ratio		North: south = 2.27			North: south = 2.07	
WWII & Korean Conflict[b]						
North	2,111	1,498	1.35	2,120	1,487	1.37
Middle	2,074	2,023	0.99	2,017	1,981	0.98
South	616	1,092	0.54	664	1,145	0.56
Total	4,801	4,613	1.00	4,801	4,613	1.00
Ratio		North: south = 2.50			North: south = 2.46	

Ratios of residence of birth and at entry into service, by tier of residence in the contiguous US.

[a]Data of Appendix Table 2, excludes Pacific column: entry into active duty north:south ratio with Pacific column is 1.97.
[b]Data of Kurtzke and colleagues (1985)[4]; entry into active duty north: south ratio without Pacific column is 2.49 (Appendix Table 1).

they argue, is in contrast with the gradient hypothesis; they believe the high frequencies observed on the island are related to the genetic makeup of the populace. Geography, however, is a marker of the environmental influences that we would argue are playing a major role in initiating this disease. It is our impression that, at least in the Occident, there is a clear diffusion of this disease over time, with a decrease or disappearance of previously identified geographic variations.[26]

MS, then, is predominantly endemic among white populations of Europe and its former colonies such as Canada, the United States, Australia, and New Zealand. Whether or not this is related in whole or in part to the geographic distribution of the races and variations in racial susceptibility, or to diagnostic practices, survey methods, and reporting procedures has been questioned repeatedly. The admixture of race within the United States may be argued to be a confounder that could weaken our conclusions. There has been evidence for increasing genetic admixture of nonwhites and whites over the past few decades.[27,28]Harrison and Bennett reported there were 150,000 interracial married couples in the United States in 1960.[29] This number increased to 1 million in the 1990. Therefore, there may have been some effect of racial admixture between white, black, and other races in our cohort, but it was likely minimal because of the time frame (1960–1994) of collection of our MS cases. Most subjects in our cohort were born before 1970. Although one could argue as to what the racial terms really mean, these categories were applied equally across cases and controls.

We believe that our conclusions are independent, and potential confounders have largely been dealt with by our case–control matching and stratification of results. For the north to south gradient, the consistent gradient effect across all race and sex subgroups makes bias an unlikely explanation for the diffusion of the gradient over time. Moreover, there are sufficient comparable data to conclude that there has been a striking geographic variation in the risk of MS in North America and Europe, even though some of the details may be tenuous.[21,30]

This report has shown that MS risk has changed in the US veteran population, and thus presumably in all Americans, over a single generation. The risk for developing MS has significantly increased for white women, and now all women regardless of race, have significantly higher risk of MS than do white males in this country. This change is too rapid for genetic or hormonal influences and again supports the need to look further at the interaction of both the macroclimate (environment) as well as the microclimate (genetics) to solve the enigma which is MS.

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