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Melanoma incidence rates among whites in the U.S. military

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Abstract

Background—The U.S. Military and general populations may differ in the exposure to sunlight and other risk factors for melanoma, and therefore the incidence rates of melanoma may be different in these two populations. However, few studies have compared melanoma incidence rates and trends over time between the military and the general population.

Methods—Melanoma incidence rates from 1990 to 2004 among white active-duty military personnel and the general U.S. population were compared using data from the Department of Defense (DoD)'s Automated Central Tumor Registry (ACTUR) and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program.

Results—Age-adjusted melanoma rates overall were significantly lower in the military than in the general population; the incidence rate ratio (IRR) was 0.75 for men and 0.56 for women. Age-specific rates, however, were significantly lower among younger individuals aged <45 years but significantly higher among those aged 45 years or older (p-values<0.05). Melanoma incidence rose from 1990–1994 to 2000–2004 in both populations, with the most rapid increase (40%) among younger men in the military. Melanoma incidence rates also varied by branch of military service; rates were highest in the Air Force.

Conclusions—These results suggest that melanoma incidence rate patterns differ between the military and the general population.

Impact—Further studies of risk factors for melanoma in the military are needed to explain these findings.

Keywords

Melanoma; incidence rates; Active duty; military; SEER program

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Introduction

Over the past 30 years, melanoma incidence has risen in the U.S., most likely related to increased sun exposure (1). Ultraviolet (UV) radiation from the sun is the major known risk factor for melanoma (2–5); individuals with high sun exposure, especially those who tend to burn easily (i.e., light skin tones), have an elevated risk (4–7). Other well-established risk factors include dysplastic nevi, moles, family history of melanoma, and immunosuppressive medications (4, 5). More speculative risk factors include exposure to polychlorinated biphenyls (PCB) and pesticides (8, 9).

Melanoma rates vary by age, gender, race/ethnicity and socioeconomic status. Unlike other cancers which mainly affect older adults, melanoma also affects young and middle-aged individuals (4, 10). The median age at diagnosis is 57 years, and the median age at death is 67 years (4, 10). Men are about 50% more likely to develop melanoma than women, and whites are more than 10 times more likely to develop the disease than blacks or Asians (4, 11). In addition, individuals with higher socioeconomic status have a higher risk of melanoma than those with lower socioeconomic status (12, 13), possibly due to the greater opportunity for recreational sun exposure (5).

Melanoma is of particular interest to the U.S. military because active duty personnel are often required to be outside for prolonged periods (therefore more exposure to sunlight) and may be exposed to other potential risk factors (e.g., polychlorinated biphenyls and pesticides) (14–16). Two previous studies conducted within the Navy (14) and the Air Force (17) suggested that the incidence rates were not significantly different from those in the U.S. general population. However, it is unclear if the incidence rates for the military as a whole or for the other service branches differ significantly from those in the general population, or if the temporal trends in incidence differ between the two populations.

We hypothesized that the incidence rates might differ between the military and the general population due to different extent of exposures to sunlight and other potential risk factors. This study compared melanoma incidence rates from 1990 to 2004 among active-duty military personnel using the Department of Defense (DoD)-wide data from the military's Automated Central Tumor Registry (ACTUR) and among the general U.S. population using data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program.

Methods

ACTUR was established in 1986 as the DoD's main cancer data collection and clinical tracking system. The registry captures data on DoD active-duty personnel, military retirees and their dependents with cancer diagnosed or treated at military medical facilities. The registry collects information on the tumor (e.g., site, histology and stage) and individual (e.g., gender, race and age at diagnosis). For the current study, data prior to 1990 were not included to minimize the possibility of incomplete reporting during the initial years of the program. In ACTUR, cases diagnosed from 1990–1991 were categorized using the first edition of the International Classification of Diseases for Oncology (ICD-O) (18), from

1992–2000 according to the second edition (ICD-O-2) (19), and after 2000 according to the third edition (ICD-O-3) (20). All cases diagnosed before 2001 were converted to ICD-O-3 according to guidelines that are also used by the SEER program. All malignant melanomas of the skin with ICD-O-3 site codes “C440-C449” and histology codes “8720–8790” were included in the analysis.

This study was restricted to active-duty personnel who were diagnosed with melanoma of the skin between 1990 and 2004. Dependents and retirees were excluded because we could not determine the population at risk for these groups. Furthermore, dependents and retirees are more likely to seek care outside of military treatment facilities, leading to incomplete ACTUR data. The number of non-white active-duty personnel with melanoma was small (n= 30); therefore this study was restricted to whites. Also, due to the ages of the active-duty personnel, our analyses were restricted to persons who were aged 20 to 59 years at diagnosis. Data consolidation procedures were undertaken to reconcile duplicate records for the same patient so that only one summary record existed for each primary tumor. Guidelines from the North America Association of Central Cancer Registries (NAACCR) (21), SEER (22) and some state cancer registries (23) were used to identify multiple primaries and to select the best information when discrepancies existed between records for the same tumor. Population counts were obtained from the Defense Manpower Data Center, which maintains demographic and military data for service personnel.

Melanoma rates in the general U.S. population were calculated using data from nine population-based SEER program cancer registries (SEER-9): the states of Connecticut, Iowa, New Mexico, Utah, Hawaii and Detroit, San Francisco-Oakland, Atlanta and Seattle-Puget Sound, which together represent approximately 10% of the total U.S. population (24).

Age-standardized incidence rates (per 100,000 person-years) and 95% confidence intervals (CIs) were calculated, stratified by gender, age at diagnosis, diagnosis year, and military service branch. To give more weight to the age groups with a large number of active-duty members and thereby minimize variability, the age distribution of the military population, combined from 1990 to 2004, was used as the standard population. In the trend analysis, years of diagnoses were grouped into three categories (1990–1994, 1995–1999 and 2000–2004). Incidence rates were calculated when there were at least 10 cases in a given stratum. Incidence rate ratios (IRR) and 95% CIs were calculated to compare rates between the military and the general population, as well as rates over time stratified by gender and age at diagnosis. All analyses were conducted using SEER*Stat (version 6.6.1) and SAS software (version 9.1), and the two sided significance level was set at $p<0.05$.

Results

Age-adjusted incidence rates of melanoma overall were significantly lower in the military than in the general population among both men (IRR = 0.75, 95% CI = 0.71–0.80) and women (IRR = 0.56, 95% CI = 0.48–0.64, Table 1). This finding was age-dependent with a reversal of the IRR around age 45 years. That is, the IRRs were <1.0 through age 40–44 years after which IRRs were >1.0, with the IRRs rising monotonically from 0.38 among those aged 20–24 to 4.56 among those aged 55–59. Compared to the rates in the general

population, rates were significantly lower in the military among younger individuals (<45 years) but were significantly higher in the military among older individuals (≥45 years).

From 1990–1994 to 2000–2004, melanoma incidence among men rose significantly more in the military than in the general population (36% vs. 7%; Table 2). During the same time period, rates increased significantly among young men aged 20–44 years in both the military and general populations by 40% and 7%, respectively, and among older men aged 45–59 years by 19% and 12%, respectively, although the latter increase among the military was non-significant. Among women, melanoma incidence rates increased non-significantly between 1990–1994 and 2000–2004 by 22% in the military and significantly in the general population by 36%. Age stratified analyses of trends among women were not conducted because there were very few melanoma cases among women aged 45–59 years (n=13) in the military.

Melanoma incidence varied by military service branch (Table 3). Compared to men in the Army, those in the Air Force, Navy and Marines had higher rates, although only the rate among men in the Air Force (IRR=1.22, 95% CI=1.05–1.40) was significantly elevated. Compared to women in the Army, those in the Air Force (IRR=1.56, 95% CI=1.03–2.33) and the Navy (IRR=1.64, 95% CI=1.14–2.39) had significantly elevated rates. There were insufficient numbers of women with melanoma in the Marines and Coast Guard to calculate stable rate estimates.

Discussion

To the best of our knowledge, this is the first study comparing DoD-wide incidence rates of melanoma among active-duty personnel and those in the general population. Our results showed significant differences in melanoma incidence rates among whites in the U.S. military and general populations from 1990 to 2004. The overall age-adjusted incidence rates were lower in the military than the general population for both men and women. However, in the military age-specific rates were significantly lower among younger individuals but significantly higher among older individuals. Melanoma incidence rates rose from 1990–1994 to 2000–2004 in both populations; the greatest relative increase occurred among younger men in the military. Melanoma incidence rates also varied by service branch; personnel in the Air Force, Navy and Marines had higher incidence rates than did Army personnel.

There are several potential limitations to this study. First, the ACTUR and SEER databases may differ in the completeness of case ascertainment. Although cancer reporting to ACTUR is required by the DoD, some small military treatment facilities might not have reported cancer patients. The extent of underreporting in the military is unknown. Despite the possible underreporting in the military, the higher melanoma incidence rates among older (≥45 years) military personnel suggests that underreporting cannot fully explain the observed differences between the two populations. Potential differential extents of underreporting over time between ACTUR and SEER cannot be excluded and therefore might have affected our results on incidence trends. However, a larger increase among younger men in the military but similar increases for older men and women suggests that the

incidence trend results may not be explained exclusively by differential temporal changes in underreporting between the two datasets. Second, the data consolidation procedures might differ between ACTUR and SEER; no shared standards for case consolidation currently exist. However, our data consolidation procedures were developed based on guidelines from the NAACCR (21), SEER (22) and some state cancer registries (23); therefore, data consolidation differences between ACTUR and SEER may not be substantial enough to account for the large differences and the variations in patterns observed.

Prior to the current study, few studies had investigated melanoma incidence in the U.S. military. Garland and colleagues found that the incidence rates among white men between 1974 and 1984 were not significantly different between the Navy and the U.S. general populations (14). A study among Air Force personnel, using ACTUR data from 1989 to 2002, also found no significant difference (17). In contrast, our findings indicated that the incidence rates of melanoma might be different between the military and the general population. Multiple factors might account for the inconsistent findings, including differences in study period, inclusion of only certain military branches and data consolidation practices.

Several factors might explain why melanoma incidence rates among younger individuals are lower in the military than the general population. First, military personnel are members of a selected population that tends to be healthier than the U.S. general population (25). Second, military personnel have a high level of access to healthcare and are required to undergo routine physicals that often include skin examinations, which might lead to earlier diagnosis and treatment of precancerous skin lesions, lowering the occurrence of melanoma (26). The differential in frequency and completeness of the health examinations among individuals in the military and general population may be greater among the young because they tend to be healthier and therefore, if not required to do so, are less likely to undergo routine physicals. Third, military personnel may have better access to cancer prevention and health promotion information through educational programs and materials. For example, the U.S. Army Center for Health Promotion and Preventive Medicine (ACHPPM) and the Army Medical Department develop and disseminate information on ways to minimize sun exposure and correctly select and apply sunscreen (27, 28). The Air Force, Navy and Marines also have similar programs to distribute health information (29, 30). It is possible that individuals in the military have more knowledge about the preventive procedures and are more likely to use them when they expect intensive exposure to sunlight. Studies have shown that melanoma caused by intense episodes of burning sun exposure is usually diagnosed at a relatively young age (5, 31). Therefore the use of preventive sunlight exposure procedures may have resulted in the reduced melanoma incidence among the young in the military.

Melanoma diagnosed among older individuals may be related to chronic UV exposures. Studies have shown that melanoma related to chronic UV exposure is more likely to be diagnosed in older individuals (5, 31). Therefore, the higher rates of melanoma in the military among older individuals might reflect higher cumulative exposures than their counterparts in the general population. For the younger group, due to a relatively long latent period for cancer occurrence (32), the length of their military service might not be long enough for chronic sunlight exposure to have an effect. Furthermore, older military

personnel are more likely to have been exposed to PCBs and other chemicals that may be related to melanoma (15, 16). For example, many of the Navy's older vessels constructed between 1946 and 1977 are contaminated with PCBs, and some of the older ships are still in use (15). Older crews and shipyard workers may therefore be more likely to have been exposed.

Melanoma incidence rates increased from 1990–1994 to 2000–2004 in both populations. The rising incidence of melanoma observed both in the general population and in the military is likely a result of increased exposure to UV radiation (33). A more rapid increase in incidence was observed among younger men in the military. It is not clear why younger men in the military had the greatest increase in melanoma incidence.

Our study found that melanoma incidence rates were higher in the Air Force, Navy and Marines compared to the Army. Buja et al. conducted a meta-analysis of cancer incidence among male military and civilian pilots and found that both types of pilots have a higher risk of melanoma (34). One possibility is that airline pilots are more likely to be exposed to cosmic ionizing radiation and chemicals (e.g., fuel, jet engine exhaust, and cabin air pollutants) (34). The majority of Air Force personnel, however, are not pilots, so there may be other unrecognized risk factors. Navy personnel may also be exposed to PCBs to a greater extent. As mentioned before, PCBs were identified on surfaces, in component materials and equipment of older vessels (15) and have been associated with increased melanoma risk (8). Further research on risk factors of melanoma incidence among different service branches in the military is needed to explain these differences.

Although the exposure to sunlight may be one of the major factors accounting for the incidence differences between the military and general populations, the actual association between the two may be complex, particularly in the context of the relationship between sunlight and vitamin D. Sunlight exposure facilitates the synthesis of vitamin D (35), which has been shown to be protective for melanoma (36, 37) although evidence has been inconsistent (38, 39). The interrelationship among sunlight exposure, vitamin D and melanoma may be complicated, being affected by multiple factors such as the type of UV radiation (B vs. A) (40, 41), vitamin D intake (37) and vitamin D receptor gene polymorphisms (42, 43) and signaling pathways (44). Our study is a descriptive epidemiological investigation, which cannot determine the actual role of sunlight exposure particularly in terms of the military-general population differences in incidence by age and time. Further epidemiological and basic research is needed to addresses this complex issue.

In conclusion, this study found differences in melanoma incidence rates between the military and the general population that were age dependent. Further research on melanoma incidence and risk factors in the military is warranted to confirm and explain these differences.

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Table 1

Incidence rates of melanoma among Whites age 20–59 years in the U.S. active-duty military and U.S. general populations by gender and age at diagnosis, 1990–2004.

	Military[1]		General population[2]		
	Count	Rate[4] (95% CI[5])	Count	Rate[4] (95% CI[5])	IRR[3] (95% CI[5])
Gender					
Men	1342	6.96 (6.59, 7.34)	16791	9.17 (8.95, 9.40)	0.75 (0.71, 0.80)
Women	203	7.73 (6.70, 8.88)	16821	13.86 (13.56, 14.18)	0.56 (0.48, 0.64)
Age at diagnosis					
20–24	164	2.17 (1.85, 2.53)	1137	5.68 (5.35, 6.02)	0.38 (0.33, 0.46)
25–29	224	4.45 (3.89, 5.08)	2090	9.55 (9.14, 9.97)	0.47 (0.41, 0.54)
30–34	272	7.04 (6.23, 7.93)	3218	13.17 (12.72, 13.63)	0.53 (0.47, 0.61)
35–39	329	10.38 (9.29, 11.57)	4335	17.25 (16.74, 17.77)	0.60 (0.54, 0.68)
40–44	293	18.90 (16.80, 21.19)	5508	22.58 (21.99, 23.18)	0.84 (0.75, 0.95)
45–49	170	33.62 (28.76, 39.07)	5923	27.49 (26.79, 28.20)	1.22 (1.06, 1.44)
50–54	58	49.76 (37.78, 64.33)	5793	32.18 (31.35, 33.02)	1.55 (1.21, 2.07)
55–59	35	178.48 (124.32, 248.22)	5608	39.17 (38.15, 40.21)	4.56 (3.35, 6.70)

[1] Automated Central Tumor Registry (ACTUR).

[2] Surveillance, Epidemiology, and End Results (SEER-9).

[3] Incidence rate ratio comparing rates in the military to the rates in the general population.

[4] Age-adjusted (active duty military 1990–2004) and age-specific rates per 100,000 person-years.

[5] Confidence interval.

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Table 2

Incidence rates of melanoma among Whites age 20–59 years in the U.S. active-duty military and U.S. general populations by gender, age at diagnosis and year of diagnosis.

	1990–1994		1995–1999		2000–2004		
	Count	**Rate[3] (95% CI[4])**	**Count**	**Rate[3] (95% CI[4])**	**Count**	**Rate[3] (95% CI[4])**	**IRR[5] (95% CI[4])**
Men							
Military[1]	398	5.41 (4.89, 5.97)	509	8.44 (7.72, 9.21)	435	7.37 (6.69, 8.10)	1.36 (1.18, 1.56)
General population[2]	4664	8.88 (8.51, 9.27)	5666	9.10 (8.71, 9.50)	6461	9.52 (9.12, 9.93)	1.07 (1.01, 1.14)
Age 20–44							
Military[1]	325	4.47 (3.99, 4.98)	422	7.23 (6.56, 7.96)	345	6.27 (5.62, 6.97)	1.40 (1.20, 1.64)
General population[2]	2240	8.29 (7.91, 8.69)	2318	8.39 (7.99, 8.80)	2371	8.85 (8.43, 9.27)	1.07 (1.00, 1.14)
Age 45–59							
Military[1]	73	36.67 (28.72, 46.18)	87	48.33 (38.69, 59.66)	90	43.60 (35.03, 53.62)	1.19 (0.86, 1.64)
General population[2]	2424	28.28 (26.79, 29.82)	3348	32.39 (30.95, 33.88)	4090	31.67 (30.32, 33.06)	1.12 (1.05, 1.20)
Women							
Military[1]	55	6.64 (4.94, 8.76)	76	8.84 (6.96, 11.08)	72	8.09 (6.31, 10.21)	1.22 (0.84, 1.78)
General population[2]	4432	11.85 (11.38, 12.35)	5668	13.71 (13.19, 14.25)	6721	16.11 (15.52, 16.71)	1.36 (1.29, 1.44)

[1] Automated Central Tumor Registry (ACTUR).

[2] Surveillance, Epidemiology, and End Results (SEER-9).

[3] Age-adjusted (active duty military 1990–2004) rates per 100,000 person-years.

[4] Confidence interval.

[5] Incidence rate ratio in comparison to the 1990–1994 rate.

Table 3

Incidence rates of melanoma among Whites age 20–59 years in the U. S. active-duty military population by service branch and gender, Automated Central Tumor Registry 1990–2004.

	Men			Women		
	Count	**Rate[1] (95% CI[2])**	**IRR[3] (95% CI[2])**	**Count**	**Rate[1] (95% CI[2])**	**IRR[3] (95% CI[2])**
Army	398	6.25 (5.65, 6.89)	Reference	50	5.46 (4.05, 7.23)	Reference
Navy	372	6.99 (6.29, 7.74)	1.12 (0.97, 1.29)	57	8.51 (6.43, 11.06)	1.56 (1.03, 2.33)
Air Force	417	7.59 (6.87, 8.38)	1.22 (1.05, 1.40)	82	8.98 (7.13, 11.15)	1.64 (1.14, 2.39)
Marines	116	7.57 (6.19, 9.19)	1.21 (0.96, 1.51)	8	*	*
Coast Guard	31	5.47 (3.69, 7.80)	0.87 (0.57, 1.27)	2	*	*

[1] Age-adjusted (active duty military 1990–2004) rates per 100,000 person-years. Rates were not calculated when counts were <10

[2] Confidence interval.

[3] Incidence rate ratio.