HHS Public Access

Author manuscript

J Am Acad Dermatol. Author manuscript; available in PMC 2020 June 01.

Published in final edited form as:

J Am Acad Dermatol. 2018 June ; 78(6): 1185–1192. doi:10.1016/j.jaad.2017.11.062.

Skin cancer in the military: A systematic review of melanoma and nonmelanoma skin cancer incidence, prevention, and screening among active duty and veteran personnel

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Abstract

Background—Occupational sun exposure is a well-studied risk factor for skin cancer development, but more work is needed to assess melanoma and nonmelanoma skin cancer risk among US military personnel to improve education and screening efforts in this population.

Objective—To conduct an extensive review of skin cancer risks for US military personnel to inform preventive education, diagnosis, and treatment efforts to better protect these individuals from future skin cancer development.

Methods—A systematic review of published studies on the subject of melanoma and nonmelanoma skin cancer in military personnel was conducted.

Results—A total of 9 studies describing skin cancer incidence in the US military were identified, with 4 studies specific to melanoma. The study findings reveal an increased risk for melanoma associated with service in the military or prisoner of war status. Service in tropical environments was associated with an increased incidence of both melanoma and nonmelanoma skin cancer among World War II soldiers. Two studies found that increased melanoma risk was also branch dependent, with the highest rates among the United States Air Force. Several of the reviewed studies implicated increased sun exposure during military service and lack of sufficient sun protection as the causes of higher rates of skin cancer among US military and veteran populations as compared with among the nonmilitary population in the United States.

Limitations—The reviewed articles have variable results; a prospective randomized controlled trial would be helpful to develop interventions that mitigate skin cancer risk in the US military.

Conclusion—This review identifies an abundance of evidence for an increased risk for skin cancer development among US active duty and veteran populations.

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Conflicts of interest: None disclosed.

Keywords

basal cell carcinoma; melanoma; military; nonmelanoma; occupational sun exposure; prevention; screening skin cancer; squamous cell carcinoma; veterans

Skin cancer is diagnosed in 1 in 5 Americans postal or construction workers[4–7] and US military during their lifetime, accounting for more than personnel. According to the US Department of 10,000 deaths in the United States annually.[1,2] Veterans Affairs, more than 3 million soldiers were This increasing incidence[3] raises concerns for those deployed from 2001 to 2014 for the Operation with significant occupational sun exposure, such as Enduring Freedom (OEF)/Operation Iraqi Freedom (OIF) missions in Afghanistan and Iraq. These soldiers operated at more equatorial latitudes (338N) than the mean latitude of the US population (388N). Previous operations in equatorial climates, such as those of the Southwest Asia and the Western Pacific during World War II, have also been associated with increased rates of melanoma and nonmelanoma skin cancer among US veterans.[8,9]

The ultraviolet (UV) exposure and skin cancer risks to American military personnel represent a very specific health care challenge, especially in the deployment setting. Soldiers work in an environment that may inhibit routine sun protection. Less than 30% of surveyed soldiers reported regular sunscreen use during deployment, and skin was unprotected 70% of the time or more.[10] This problem is multifactorial, stemming from inadequate sunscreen access, insufficient emphasis on sun protection, harsh weather conditions, and immediate safety concerns prioritized over preventive care. In addition, 85% of the military population is male,[11] and male sex is associated with lower sunscreen use.[12]

Many demographic aspects of the US military are already known to be associated with higher melanoma incidence and poorer prognosis. These include male sex, older age, and white race, which portend both biologic and behavioral risks.[3,13–16] The veteran population is on average older, with 65 years for veterans compared with 41 years in the general population,[15] and is more commonly white (78% of male veterans versus 61% of male nonveterans).[15] This pattern of increased risk also extends to basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). To date, studies have not explicitly identified additional intrinsic characteristics of American military service that may increase skin cancer risk outside of those factors previously described. However, exposure to chemicals associated with melanoma, such as polychlorinated biphenyls found in older military equipment (including navy vessels), may account for additional risk factors in this population.[17–19] Pilot exposures to jet exhaust and ionizing radiation may also be part of the military experience that contributes to the risk for melanoma not explained by previously well-described risk factors, but further studies are needed to explain these troubling trends.

An extensive review of skin cancer risks for the US military is needed to optimize preventive education, diagnosis, and treatment efforts, which are a priority of the American Academy of Dermatology.[20] Unlike other groups with occupational sun exposure, US veterans make up a potentially vulnerable population that faces more health-related problems, higher mortality rates, lower-quality medical care, and decreased quality of life.[21] Moreover, skin cancer screening targeted toward at-risk populations may be a more practical method of skin

cancer prevention than blanket screening of the general population. A study at the Palo Alto Veterans Administration (VA) using this approach within the veteran population demonstrated that targeted screening of individuals who are older than 50 years with Fitzpatrick skin types I to III yielded higher rates of skin cancer detection.[22] Dermatologists have an opportunity to mitigate skin cancer risk and improve treatment in this population.[3]

This review addresses knowledge gaps related to skin cancer risks in the military population by identifying what data currently exist, exploring hypotheses, and identifying research needs for this topic going forward.

METHODOLOGY

A literature review was conducted by using all combinations of the following search terms: *skin cancer, cutaneous malignancy, basal cell carcinoma, squamous cell carcinoma, melanoma, military, soldiers, and veterans.* Qualitative review was used to identify studies relevant to the topic of skin cancer incidence in military personnel. Literature published during and before December 2016 were included in this review.

REVIEW OF LITERATURE

Melanoma

A summary of the reviewed studies on melanoma among active duty or veteran members of the military is shown in Table I.[8,23–25] A study conducted in 1984 compared the incidence of melanoma in servicemen who were of draft age during World War II.[8] The study found that 34% of these servicemen had lived in the tropics, compared with only 6% of controls. A retrospective study in 2000 also revealed a nonsignificant trend toward increased melanoma mortality among subjects who were prisoners of war in the tropics.[23] A 2010 retrospective tumor registry review from the Department of Defense and the National Cancer Institute found that among people who were 45 years or older, those with military service had significantly increased melanoma incidence compared with the general population.[24] This disparity in melanoma incidence was age dependent, with the oldest group of servicemen having the highest incidence relative to the general population. The melanoma incidence rates for whites in the military versus in the general population were 33.62 versus 27.49 among 45- to 49year-olds, 49.76 versus 32.18 among 50- to 54-yearolds, and most impressively, 178.48 versus 39.17 among 55- to 59-year-olds. Furthermore, increased melanoma risk was branch dependent, with the highest rates among the United States Air Force (USAF), a trend that carried across sex. Men in the USAF had a melanoma incidence rate of 7.59 compared with 6.25 for men in the army, whereas women in the USAF had a rate of 8.98 compared with 5.46 for women in the army.[24] More recently, a 2014 retrospective study confirmed the latter finding, with the highest incidence rate of melanoma occurring in USAF members (17.80 versus 9.53 in army personnel).[25] This difference is perhaps due to increased exposure to ionizing radiation, exposure to aviation-related chemicals, and disrupted sleep patterns.[26] Although an occupational subanalysis specific to each military branch has not been conducted, it is plausible that the increased rates observed among USAF personnel can in part be attributed to the increased melanoma incidence observed among civilian pilots and cabin crews.[27]

Nonmelanoma skin cancers and skin cancer risk factors

Nonmelanoma skin cancers represent a significant burden for both the civilian and military populations (Table II).[9,10,28–31] One study at a combat support hospital in Iraq has helped to characterize skin cancer prevalence in these patients, with skin cancer accounting for 8% of dermatology clinic visits over a 6-month period.[29] On the basis of a retrospective chart review of 370 World War II soldiers, about two-thirds of servicemen in whom BCC and SCC had been diagnosed were deployed in the Pacific, despite the number and characteristics of soldiers deployed to the Pacific and European theatres being approximately equal.[9]

Several of the reviewed studies describe increased sun exposure during deployment, as well as insufficient sun protection. A 2015 study using a cross-sectional survey of 356 USAF personnel found that 67% of their career involved direct sun exposure. Furthermore, less than 11% of respondents used sunscreen when working in the sun.[31] Another 2015 study of 212 veterans returning from OEF/OIF missions that was conducted at our center found that 84% of respondents worked in a desert climate, 77% spent 4 or more hours per day working in bright sun, and 64% spent more than 75% of their days working in bright sun. However, only 13% of respondents reported routine sunscreen use and less than 30% had routine access to sunscreen while working. Recreational activity during deployment, such as sports and other outdoor activities, may also be an additional source of sun exposure not experienced at home.[32] Only 23% of veterans reported that the US military made them aware of skin cancer risks.[10] A qualitative survey in 2016 conducted with focus groups of male veterans indicated they overwhelmingly agreed with the need for increased education on skin care, and that current efforts to prevent skin cancer in the military were insufficient.[30] Although acute psychosocial stressors and threats to life are understandably of higher immediate importance than sun protection, skin cancer prevention and screening efforts can still be prioritized when active conflict is not present. In addition to work exposures during deployment, recreational activities during deployment may also differ from those at home. Through the Morale, Welfare, and Recreation military program established in 2001, soldiers participate in organized sports and other outdoor activities such as camping, rock climbing, and fishing that could also represent additional exposures to UV light.[33]

DISCUSSION

Occupational risk

Though the military risks for skin cancer development have a unique context, considering broader occupational development of skin cancer is prescient. Several occupations have been linked to increased skin cancer risk, with higher rates observed among engineers, construction workers, farmers, lifeguards, mountain guides, and postal workers.[4–7] Workplace education efforts and employer provision of personal protective equipment, including sunscreen, hats, and sunglasses, could minimize occupational sun exposure and subsequent skin cancer development.[33] Outdoor work has been associated with increased incidence of BCCs and SCCs in particular.[34,35]

Although melanoma is also associated with sun exposure, it has been suggested that intense periods of exposure to UV radiation increase the risk for development of melanoma to a greater extent than does chronic cumulative UV radiation exposure.[36] This concept is known as the intermittent exposure hypothesis, according to which individuals may be susceptible to melanoma because of a lack of adaptive mechanisms to UVradiation that individuals with more chronic exposure may acquire.[37] Therefore, although occupations in certain climates, such as military service overseas, may involve only a few years of work or even periodic service rotations in these climates, such intermittent periods of exposure notably raise melanoma risk. This in part puts the military workers in a separate category from others in occupations in which the sun exposure is daily and consistent. The military work, by definition, is inconsistent and unpredictable, particularly in the context of deployments. Almost half of those deployed during OEF/OIF were deployed multiple times, and the average length of deployment varied significantly by branch, from 4.5 months in the USAF to 9.4 months in the army.[38] Although considerable data exist for skin cancer risk in the aforementioned outdoor worker populations, US military personnel are often overlooked in skin cancer prevention and research efforts. As found in previous work at the Nashville Tennessee Valley Post Deployment Clinic, an overwhelming majority of veterans reported inadequate access to sun protective equipment despite spending more than 4 hours a day of their missions in bright sun.[10] However, existing literature evaluating skin cancer risk among outdoor workers and piloting of preventive protocols such as provision of protective equipment do not extend to the military population.[39] This literature review demonstrates a need to extend these efforts to both active duty and veteran members of the military.

Risk reduction and patient education

Many readily accessible strategies for exposure reduction may be applicable to the military context, but with consideration of additional unique challenges, for example, the lower feasibility of avoiding UV exposure in the setting of highly reflective surfaces such as sand, [40] the inability to avoid peak sunlight hours during missions, or the need to wear lighter-colored clothing (which is less UV protective).[41] Patient education is another risk reduction strategy that has been shown to reduce melanoma mortality in the general population.[42–46] On the basis of our previous work,[10] veterans report a lack of skin cancer education, and emphasizing selfeskin examination is one such opportunity for this population.

Another important component to addressing skin cancer risk is that of early detection through regular screening. Given the low rates of skin cancer awareness reported by veterans,[10] prioritizing annual skin cancer screening during medical mission physical examinations could lead to a reduction in mortality. Early dermatologist involvement may also be helpful. A chart review of veterans referred to the dermatology department of a Minneapolis VA hospital in 2016 indicated that about 37% of melanomas were detected incidentally by the dermatologist and were not the reason for the initial dermatology consult. [47] Moreover, in the same study, melanomas identified incidentally by dermatologists were smaller than those identified by other physicians. It is also important that VA physicians in the United States be trained to identify past military service as a risk factor that warrants more frequent skin examinations. Studies have shown that increased patient perception of the benefits of sun protection correlates with increased compliance.[12] Developed countries

have experienced improved melanoma outcomes with the combination of increased screening of high-risk patients and public awareness.[48] Given the barriers that many veterans face in accessing VA resources, a strategic public health screening effort would first target veterans with the greatest risk factors for skin cancer, as delineated by this review (such as whites older than 55 years of age who have served at equatorial latitudes or those with a history of service in the USAF).

Future research

Additional studies are needed to determine the efficacy of implementing US military branch programs that educate soldiers on sun protection and provide protective sun equipment on missions. Veterans themselves appear to be receptive toward efforts to increase awareness and skin cancer protection.[30] Furthermore, sex considerations that inform compliance must be taken into account. It has been postulated that the higher incidence and death rates of melanoma among older men may be due in part to decreased use of sun protection, decreased social influences to avoid premature skin aging, and increased time spent outdoors.[49,50] In addition, the majority of melanomas are self-discovered, and women are much more likely to discover their own lesions than are men (66% versus 42%).[46] Among married couples, wives are much more likely to detect melanoma on their spouses than vice versa,[51] suggesting that marriage has a protective effect on melanoma for men. However, veterans are also more likely to be divorced[52] and hence less likely to benefit from this protective spousal effect. More research is needed to determine how melanoma incidence and prognosis differ on the basis of sex in the US veteran population specifically.

CONCLUSION

A growing body of evidence in the scientific literature suggests that members of the US military are exposed to significant risk factors for melanoma and nonmelanoma skin cancers. Although the link to intermittent and intense UV is well established within the military cohort, there appears to be a more complex picture surrounding military personnel because of male sexespecific epidemiologic factors, population selection, and occupational hazards such as radiation and stress. This review highlights knowledge and practice gaps in this area and provides an opportunity for improvement in the skin cancer prevention strategies implemented with our servicemen and servicewomen, as well as for new areas of research. The implementation of programs that mitigate risk associated with equatorial latitude service, male sex, white race, lack of protective equipment, and inadequate patient education and screening protocols could shrink the gap in incidence of skin cancer observed between US military personnel and US civilians.

Acknowledgments

Funding sources: None.

Abbreviations used

OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom

USAF	United States Air Force
UV	ultraviolet
VA	Veterans Administration

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CAPSULE SUMMARY

- Outdoor occupations are correlated with skin cancer development.
- US military personnel have higher rates of skin cancer than civilians, and they report low rates of skin cancer awareness and dermatologic care.
- Skin cancer prevention and screening for active duty and veteran military must be improved to address this practice gap.

Table I.

Studies of melanoma among military personnel

Study	Study population	Design	No. of subjects/No. of controls	Control strategy	Major findings	Reported limitations
Brown et al (1984)[8]	Men of draft age (18–31 y) during World War II (1941–1945) in the Melanoma Cooperative Group at NYU SOM database	Case-control	89/5	Age-matched male NYU dermatology patients with cutaneous problems, excluding malignant melanoma	34% of patients with melanoma lived in tropics vs 6% of control subjects	N/A
Page et al (2000)[23]	White male former World War II POWs	Cohort	5524/3713	White male non-POW World War II veterans	No significant differences in melanoma rates	- Low sample size with low melanoma mortality risk of 2 per 1000 veterans - Survivor bias
Zhou et al (2010)[24]	White active duty military personnel (ACTUR) with diagnosis of melanoma from 1990 to 2004	Cohort	1545/33612	General US population (SEER-9 registries) with diagnosis of melanoma from 1990 to 2004	- Higher melanoma rates among military personnel >45 y old - Highest melanoma incidence in Air Force branch	- Limited case reporting to ACTUR and SEER databases - Data consolidation differences between ACTUR and SEER - Military selection bias for young, healthy people
Lea et al (2014)[25]	Active duty military (ACTUR and MDR) 18–56 y of age with diagnosis of melanoma from 2001 to 2007	Cohort	1105/46082	General US population (SEER-17 registries) with diagnosis of melanoma from 2001 to 2007	- Melanoma incidence rate was 62% greater in active military personnel - Highest melanoma incidence among Air Force branch	- Limited case reporting to ACTUR, MDR, and SEER databases - Limited interpretation of nonwhite patients because of small sample size - Potential increased detection of melanoma through military screening

ACTUR, Active Central Tumor Registry; *MDR*, Medical Device Reporting; *N/A*, not available; *NYU SOM*, New York University School of Medicine; *POW*, prisoner of war; *SEER*, Surveillance, Epidemiology, and End Results.

J Am Acad Dermatol. Author manuscript; available in PMC 2020 June 01.

Table II.

Studies of skin cancer and risk factors among military personnel

Study	Study population	Design	Study size (N)	Major findings	Reported limitations
Ramani et al (1993)[9]	World War II veterans who served in the Pacific or Europe and were referred for Mohs micrographic surgery at the University of Southern California	Retrospective chart review	370	66% of patients with BCC and 68% of patients with SCC previously stationed in the Pacific	N/A
Henning et al (2010)[29]	Patients with dermatology visits at 86th Combat Support Hospital in Ibn Sina, Iraq, between January 15, 2008 and July 15, 2008	Retrospective chart review	2696	8% of total visits were for skin cancer: BCC (n = 70), SCC (n = 68), mycosis fungoides (n = 1), bowenoid papulosis (n = 1), melanoma (n = 9)	- Referral bias may result in underestimation of skin cancer incidence - Diagnoses not subject to inter observer correlation - Increased surveillance and average patient age may result in increased skin cancer estimates
Parker et al (2015)[31]	Air Force Maintenance squadrons at Travis Air Force Base in California (AFMT)	Cross-sectional survey	356	- 67% of respondents' careers involved direct sun exposure - 88% were aware that sunscreen can prevent skin cancer, but less than 11% used it most of the time	- Unable to compare UV exposure duration with that in other studies - Conclusions based on survey responses - Limited generalizability
Powers et al (2015)[10]	Veterans returning from OEF/OIF missions seen at Nashville Tennessee Valley Post Deployment Clinic	Cross-sectional survey	212	- 77% spent ≥4 h/d working in bright sun - <30% had routine access to sunscreen - 23% said that US military made them very aware of skin cancer risks	- Recall bias - Regional study limited to mostly 1 military branch - 80% of responses involved recall after a ≥1-y period
McGrath et al (2016)[30]	Veterans with skin cancer treatment at Audie Murphy Veterans Hospital and University of Texas Health Science Center-San Antonio	Cross-sectional survey	41	- Participants reported inadequate education about skin cancer - Participants requested predeployment education and increased protective equipment availability	- Sample size - Qualitative report of responses

AFMT, Airway facilities management team; *BCC*, basal cell carcinoma; *N/A*, not available; *OEF*, Operation Enduring Freedom; *OIF*, Operation Iraqi Freedom; *SCC*, squamous cell carcinoma; *UV*, ultraviolet.