Ultraviolet radiation exposure and melanoma in Australian naval personnel

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Abstract

In the tropics of Australia, the Royal Australian Navy operates two permanent bases and conducts a large number of operations. Despite an overall incidence of melanoma not significantly different to that of the general Australian population (Standardised Incident Ratio, SIR = 149, p>0.05), older members of the RAN (SIR = 236, aged >29 years) and those holding duties in engine spaces while at sea (SIR = 412 compared to the remainder of the Navy) have an increased incidence of melanoma after indirect age standardisation, suggesting a risk factor associated with Service.

Introduction

The Royal Australian Navy has two permanent operational bases in the tropics of Australia, at Cairns and Darwin, and conducts many exercises and operations in tropical waters.

Previously, Defence Force personnel serving in tropical latitudes have been found to be significantly over-represented in a skin cancer case group of men at draft age during 1941-451. The latitudinal distribution of skin cancers has been well known for some time[2], including both melanotic and non-melanotic skin cancer[3]. Queensland has the highest rate of skin cancer in the world[4,5], probably due to a combined effect of greater exposure and a large population of Caucasian people living in the region[6,7].

Outdoor occupations other than in the maritime environment have been associated with an increased risk of developing melanoma such as farmers[8,9]; however, this is not a consistent association[10], especially when controlled for other risks for cancer such as smoking and age[11]. Links between melanoma and outdoor occupations are not well established[12].

Considering the environmental exposure of Naval personnel, the incidence of melanomatous skin cancer for sailors has been evaluated, including closer scrutiny of higher risk groups.

Methods

Rates of melanoma in the Navy were initially ascertained from the ICD9 (172, Melanomatous skin cancers) coded database (MEDREX) employed by the (then) Directorate of Naval Health Services, Canberra. All cases were confirmed by a manual search of Service Medical Documents. Inclusion as a case required histological confirmation of the case by an independent histopathologist. The reported date of a confirmed diagnosis was used for chronological placement of cases. Period of Service has been calculated from the date of enlistment recorded on the Entry Medical Examination contained in Service Medical Documents. Only those personnel enlisted in the Royal Australian Navy as sailors on full time Service during the defined period, from 31 December 1986 to 1 January 1992, were included. All cases initially intended to be included as cases following the confirmation of histopathological diagnosis were retained as cases throughout analysis.

Information regarding the Royal Australian Navy population (numbers of personnel by age and employment categories) during the incident period of years were provided by the Directorate of Personnel -Navy. From these lists, population person-years data were derived. Ordinal data were created based on standard five yearly groupings from the yearly categories provided. This permitted indirect age standardisation[13] and comparison of the Navy rates of melanoma to those recorded by the Australian Institute of Health and Welfare and the Australasian Association of Cancer Registries as of the general population of Australia. This most recent available data was used under the a priori assumption that rates would not vary significantly in the years immediately following, over which the Navy rates were generated.

Indirect age standardisation was applied as the Navy population is notably skewed towards excluding children and the elderly. This was considered to cause variable bias based on the evidence available regarding the general incidence of melanoma. Age is a significant and enduring risk factor towards melanoma and therefore requires control. The indirect method of standardisation was considered the most appropriate given the incidence of the disease being observed.

From age standardised categories, expected rates of melanoma were found for the Navy group from Australian population rates and compared to observed rates for the Navy using the Poisson distribution[14]. A similar method was used for those age groups greater than 29 years. Superficial analysis of the Navy rates of melanoma revealed an apparent preponderance of cases from the employment categories largely holding duties in the engine spaces when deployed to sea. The group is referred to as "Stokers" and includes personnel from the categories (at that time) of Marine Hull Engineering Sailors, Marine Propulsion Engineering Sailors, and Electrical Propulsion Engineering Sailors. The method of analysis was then further used for the categories of employment based on primary duties in the engine spaces and a consequent low occupational ultraviolet exposure. Standardised incident ratios (SIR) were calculated.

Results

Between the years of 1987 and 1991 inclusive, a total of 62010 person years were recorded. From this period, 14 cases of melanoma were reported and confirmed on histological examination of excision specimens. Based on indirect age standardisation of the Australian rates of melanoma, between nine and ten cases were expected.

From the power generated from the number of person years observed, it is not possible to discern a statistical difference ($p>0.05$) between the incidence of melanoma in the Navy and the general population of Australia. The Standardised Incident Ratio of sailors is 149.1 relative to the Australian population.

Calculation of the power associated with the investigation of the melanoma rate from the Navy with that of the Australian population suggested a low (< 0.10) probability of a ß error (Z ß = 3.19).

From the age groups of Navy members older than 29 years, a significantly greater number of cases of melanoma were apparent compared to the general population of Australia as ten cases were observed while four (4.23) cases were expected (SIR = 236, 95% confidence intervals = 4.795, 18.390, p = 0.0233).

Within the Navy, the population of "Stokers" included 13519 person years of observation. The Stokers experienced a significantly greater number with seven cases of melanoma reported in this period; however, fewer than three cases (2.08) were expected after indirect age standardisation from the Australian population (C.I.95% = 2.814, 14.423, p=0.011). This indicates a Standardised Incident Ratio for Stokers of 336.5 compared to the Australian population.

For those Stokers aged greater than 29 years, four cases were recorded while no more than one (0.91) case was expected from indirect age standardisation of the Australian population data, resulting in a SIR of 439 (C.I.95% = 1.090, 10.242, p=0.028).

The group of Stokers was compared to the rest of the Navy without age standardisation as it was considered that the distribution of ages would be comparable. No more than two (1.95) cases of melanoma were expected in the group of Stokers based on the rates for the rest of the Navy, whereas seven cases were recorded. Again using Poisson probability, this was found to be a significant difference between the groups (C.I.95% = 2.814, 14.423, p=0.008). The (non-standardised) Incident Ratio of Stokers for melanoma on the background of the other serving sailors was 359.

To confirm that the age distribution of Stokers was not significantly different the rest of the Navy with respect to these calculations, a sensitivity analysis was conducted by repeating the procedure with age standardisation on the age profile of the remainder of the Navy. A significant difference remains between the cases expected among the Stokers and that recorded (cases expected = 1.72, observed cases and confidence intervals as above, p=0.004). The standardised incident ratio with this procedure is calculated to be 412.

The Navy personnel other than Stokers were found to have a Standardised Incident Ratio (with respect to the Australian population) of 111. This is not of significance. Calculation of power for this comparison was not deemed necessary given the previous results.

Discussion

In recent years, the Royal Australian Navy has maintained an active role in the tropics around Australia with deployments, exercises and two permanent Naval bases in the area. Recognition of the risks confronted from increased solar ultraviolet exposure has prompted active promotion of sun protection measures.

This investigation has been to assess the rate of melanoma among the members of the Royal Australian Navy. As the population of the Navy is quite obviously skewed in terms of age, standardisation is necessary for valid comment. Despite an increased standardised incident ratio for Naval personnel on crude rates, the difference found between the Navy rates of melanoma and those of the general Australian population, after age standardisation, is not significant.

Is Naval Service associated with increased risk of melanoma?

The power generated from the Navy population sample as a part of the Australian population control indicate that the numbers in the Navy are sufficient to observe a reasonable increase in melanoma rate if it were to be present. From this crude analysis, it is assumed that enlistment in the Royal Australian Navy is not associated with increased risk of melanoma.

Clearly, it is possible that the increased risk observed in the group with greater age (>29 years) is completely related to the well-known risk factor of age; however, the SIR is greater compared to the Australian population. Age is a surrogate measure for duration of service, albeit a rather loose indicator and laden with potential biases. Nevertheless, the greater SIR of sailors older than 29 years indicates that their Naval Service can not be excluded as being associated with this higher risk.

Biases in Navy selection

The Navy is selective in the enlistment of personnel. Enlisting generally healthy individuals may cause a bias towards the null for the overall rates of melanoma for serving personnel.Considering the greater risk associated with more prolonged service after age standardisation of the data, a bias towards the null would tend to mask a greater rate of melanoma associated with Naval Service, some aspect of it, or an occupational group within the population of sailors. Other selection biases may be operating such as ethnicity[15] with selection for those more prone to melanoma. While this is likely to be a bias away from the null, increasing the apparent risk from Naval Service, it is not possible to determine the extent to which it is influence results.

A serious potential confounding bias is the possibility of differential ultraviolet radiation exposure in childhood between the Australian public and those recruited for Navy, or between members of the Stoker group and the remainder of the Navy. This proposes that an apparent modulating effect of adult occupational ultraviolet radiation exposure may indeed be due to an incidental inverse association of childhood ultraviolet radiation exposure[16-18], and adult occupational ultraviolet radiation exposure such that the childhood exposure is the only truly causative association with the outcome of skin cancer and melanoma.

Adequate control of this potential confounding is logistically difficult as an assessment of childhood ultraviolet radiation exposure requires retrospective assessment with the concurrent recall and interpretative biases. The assumption made in this instance is that the groups of comparison have a normally distributed childhood exposure approximating equivalence. This may or may not be a valid assumption. It could be argued that the preponderance of Caucasian Naval personnel reflects an apparent bias in childhood exposure to solar ultraviolet light exposure. Nevertheless, within Navy, there is no apparent selection bias towards being a Stoker related to childhood ultraviolet exposure.

Stokers

"Stokers" are those members serving in categories whose duties at sea are predominantly below decks in the engine spaces, having a low occupational ultraviolet radiation exposure. A notable elevation of risk was found for this group, most distinct when compared to the risk of melanoma for the remainder of the Navy (SIR 412, p<0.01).

These research findings are supportive of other research indicating a lack of direct association melanoma risk[19] and cumulative ultraviolet radiation exposure as well as a possible protective role from occupational exposure to ultraviolet radiation[20]. There are several possible confounding associations potentially influencing this relationship, including concurrent exposures to artificial light sources and solvents in the workplace.

While the literature reviewed indicates a possible association of artificial light sources (Arc welders, sun lamps, sterilisers, printing equipment and fluorescent lights), it is at best a weak association[21-25]. When considered collectively the hypothesis can be discounted[26]. Further, Stokers are not routinely exposed highly to these sources in the course of their duties.

Duties in engine spaces when deployed to sea are rather ubiquitously associated with occupational exposure to solvents and this exposure could be considered greater than that of Naval members in general. Accounting for solvent exposure is a difficult problem in terms of research design; however, the literature reviewed observing the effect of occupational exposure to solvents in the petroleum and oil industries[27-29] and from industries using PCB[30,31] on the rate of melanoma, did not support confounding from this source.

These conventional potential confounding influences have been concluded to be unrelated to the observed association.

Conclusions

This research has not supported an increased risk of melanoma for sailors arising from ultraviolet radiation exposure. Nevertheless, within the Naval population, some cumulative exposure with Service may be increasing risk of melanoma as those sailors over the age of 29 years have an increased risk of melanoma compared to the Australian population. Closer investigation suggests that within the Navy, the risk of melanoma is also greater among those whose primary duties at sea are in engine spaces, protected from natural ultraviolet radiation. In conclusion, occupational ultraviolet radiation exposure does not seem to be related to increased melanoma risk within the Royal Australian Navy; however, some other factor in Service may be related.

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