EXPOSURE TO UVR: RISK QUANTIFICATION FOR NON-MELANOMA SKIN CANCER

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ABSTRACT

Solar UVR has an acknowledged role in both non-melanoma skin cancer (NMSC) and malignant melanoma (MM). Episodic exposure to UVR, sufficient to cause erythema, has been shown to be a major risk factor for MM. For NMSC and for skin damage the lifetime cumulative solar UVR exposure is of more importance. A software package has been developed to assist in estimating a person's lifetime exposure.

INTRODUCTION

Long-term UVR exposure of the skin is generally accepted as the most important cause of NMSC. Much of our knowledge on the influence of solar UVR is derived from epidemiological studies of skin cancer. Such studies are greatly strengthened when the actual exposure of the subjects can be quantified. This is difficult and most studies use surrogates such as latitude, sunlight hours, or ambient UVR measurements for personal exposure. Within a given population the actual exposure will depend on many factors including place of residence, occupation, recreational activities, annual vacation, outdoor behaviour and most importantly the personal protective measures practised (1). This information together with a global solar UVR database are used in a windows-based software program which has been developed to generate monthly UVR exposure data for different anatomical sites over a person's lifetime.

For a given genetic susceptibility, the two most important factors in determining the relative risk of NMSC from solar UVR exposure are age and environmental UVR exposure. In the program, *UVRISK*, thegenerated UVR exposure data, is used in a simple power law relationship to calculate the cumulative NMSC risk. The program is used as an aid in the determination of pensions for chronic skin damage sustained as a result of armed forces overseas service. The lifetime exposure and risk is given for several different scenarios involving change in place of residence, employment and outdoor behaviour. The benefits of behaviour modification are clearly demonstrated.

EXPERIMENTAL METHOD AND RESULTS

Personal solar UVR exposure

The mid-month ambient UVR for a given location has been calculated by use of a modified Bjorn (2) model. The computed spectral power distribution has been weighted by the CIE (3) reference action spectra for erythema to give the effective irradiance. The data are then expressed in terms of minimal erythemal doses (MEDs) where one MED is 200 J m^{-2} of effective irradiance (4). Data have been calculated in 5° bands from 75°S to 75°N. The effect of long-term average cloud cover has been included and the results verified for Australia. Anatomical distribution and personal protection data are from published studies. The exposure calculation is performed for anatomical sites including face(cheek), hand(dorsum), back (shoulder), arm(upper) and leg. The effective dose to the skin for the given month and body site according to the following:

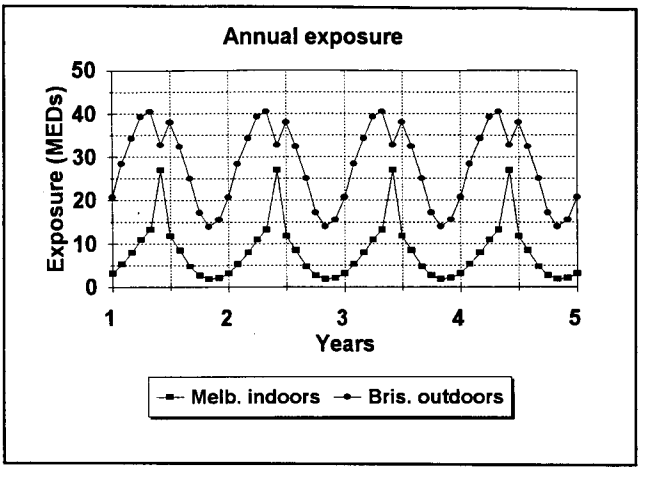
$$PAE(a,m) = \sum_{n=1}^{n=8} MAE\,(m,L_n) \cdot AF \cdot SF_n \cdot OF_n \cdot CF_n \cdot ESF_n \cdot W_n$$

where PAE(a,m), (personal ambient

exposure (in MEDs) for a specified anatomical site, a and month number, m); n (specified activity); m (month of the year); MAE(m,L_n),(daily ambient exposure for the middle of the month m in location L and activity n); AF, (body anatomical factor); SF_n, (site factor for activity n), OF_n (outdoor factor for activity n); CF_n(clothing factor for activity n); ESF_n(environment shade factor for activity n) and W_n(number of days in the month that the activity was performed). The cumulative personal ambient exposure for a specified anatomical site up to the evaluation age of T (months) i.e. $MED_{cum}(a,T)$ is determined by summing over T months.

Figure 1 shows the calculated annual exposure for two scenarios.

Figure 1. *Calculated annual exposure for Melbourne (37.8°S) indoor worker with 50% outdoor recreational exposure and for Brisbane (27.5°S) outdoor worker with similar recreational activities. At 40 years of age the Brisbane worker has had 3.4 times the effective UVR exposure of the Melbourne worker.*



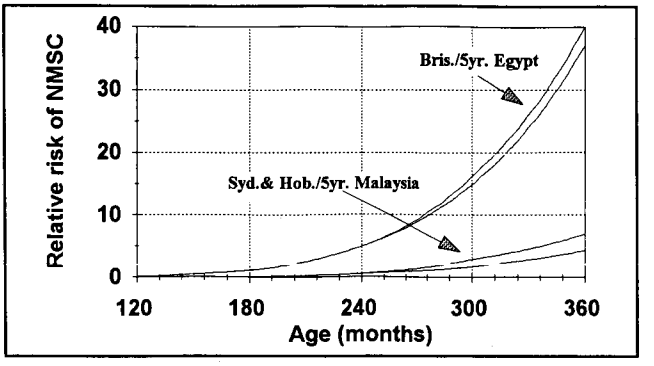
The risk of NMSC from solar UVR exposure

It has been shown that, for a group of subjects with a given genetic susceptibility, the two most important factors in determining the relative risk are age and environmental UVR exposure. A simple power law relationship { $Risk \propto (MED_{cum})^{\beta-1} (age)^{\alpha}$ } expresses the cumulative risk in terms of these factors (5) where α is a numerical constant associated with the age dependence of the cumulative incidence and β is a biological amplification factor. This relationship applies to the situation where the annual exposure received by an individual remains constant throughout life. Generally exposure does not remain constant - children often receive greater exposure than adults, adults can change their city of residence and their occupation. In order to take this into account this risk equation is modified (6) to estimate the risk of NMSC at age, T, for a given body site as:

$$Risk \propto [MED_{cum}(a)]^{\beta-1} \sum_{t=0}^{T} [MED_{ann}(a) \text{ at age } (T-t)]\, t^{\alpha-\beta}$$ where $MED_{cum}(a)$ is the cumulative effective UVR dose to the skin and $MED_{ann}(a)$ is the annual effective UVR dose to the skin, both being for a given body site. We assume (7) values of α=5 and β =2 as the result of combining the data for SCC and BCC and taking into account that BCCs are about four times more prevalent than SCCs.

Figure 2. shows the increased risk arising from 5 years of overseas service. For Egypt the increased risk of 8% arises from poor protection in a desert environment. For Malaysia (~4°S) the low latitude and poor protection accounts for an increased risk of 60%.

Figure 2. *Effect of overseas service on a veteran. Results show an increase in risk as a result of serving for 5 years in Malaysia or Egypt. Increase is due partly to the higher UVR environment but more importantly to the poor protection practices while serving.*



Protection and behaviour modification

Figure 3 shows that even for an outdoor worker large changes in both exposure dose and risk can be attained with the adoption of even modest behaviour and protection changes.

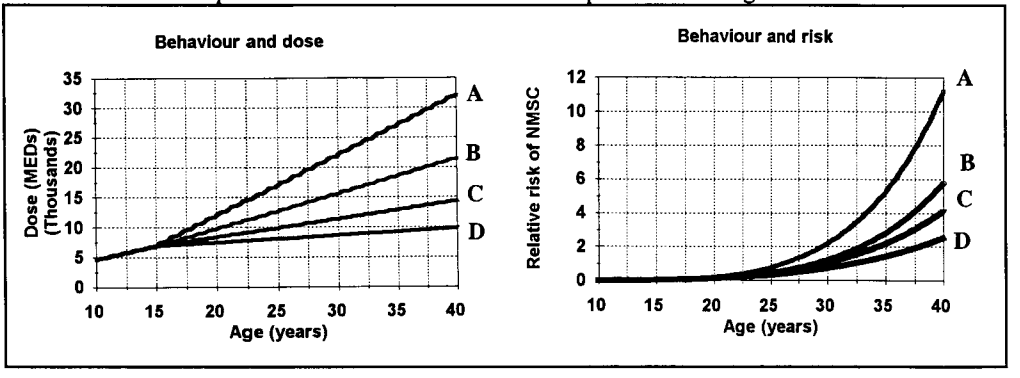


Figure 3. Effect of behaviour change on personal dose and risk of NMSC. A - 100% outdoor worker, unprotected during work and recreation; B - 50% outdoor worker, unprotected; C - as for B but SPF 5 protection during work; D - as for B but SPF 5 protection during work and recreation.

CONCLUSION

The program described has proven to be both user friendly and efficient in evaluating exposure doses and risk of NMSC. Changes in protection and behaviour are readily assessed. Further verification is planned.

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