

HOME WORKERS AND ULTRAVIOLET RADIATION EXPOSURE

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ABSTRACT

This paper investigates preventive measures for the reduction of the occupational ultraviolet (UV) exposure of a group of home workers by altering the time spent outdoors. Various scenarios for time spent indoors were investigated, namely, (1) 12:00 to 13:00 EST, (2) 11:00 to 12:00 EST, (3) 08:00 EST to 10:00 EST, (4) 14:00 to 16:00 EST, (5) 07:00 EST to 12:00 EST and (6) 12:00 to 17:00 EST. The annual UV occupational exposures of home workers for each of the six scenarios above in the location of Toowoomba (27.5° S, 151.9° E, elv 693 m) were estimated using a numerical model which incorporates measurements of the ambient UV exposure, and the fraction of time spent outdoors. The home workers within this study, regardless of time of year, exceeded the occupational exposure for UV during a normal working day. The relative reduction of annual occupational UV exposure to home workers due to spending time indoors as in scenarios (1) to (6) was 12%, 13%, 17%, 17%, 53% and 47% respectively.

INTRODUCTION

Excessive repeated exposure to UV is known to cause skin cancer in humans (Diffey, 1992). Human occupational exposure to ultraviolet radiation has been previously measured using polysulphone dosimeters (Diffey et al., 1996, Rosenthal et al., 1991, Melville et al., 1991, Gies et al., 1995, Holman et al., 1983). Wong et al., (1992) and Airey et al., (1997) have measured human UV occupational exposure at a location in south east Queensland.

Home workers are not usually associated with being exposed to high levels of solar ultraviolet radiation, due to the nature of the occupation being homes and indoors for part of their working day. The use of UV protective devices such as hats and sunscreens has been encouraged by government promotions but by far the best means of reducing UV exposure is varying the time spent outdoors to exclude the home workers from UV exposure. The home workers are generally indoors, but they do spend time outdoors for gardening, shopping and other home duties. A study by Kimlin et al. (1998) measured UV exposures to a group of home workers of 1 MED or higher to the shoulder per day where 1 MED (minimal erythemal dose) is defined as the minimum erythemal dose and is the amount of biologically effective UV required to produce barely perceptible erythema after an interval of 8 to 24 hours following UV exposure (Diffey, 1992) (Diffey, 1992). The home workers UV exposure can be reduced by changing the time of day when undertaking outdoor activities. This paper extends the previous research and provides a comparison of the percentage reduction of annual occupational UV exposure to a typical group of home workers for the scenarios of six different time of day spent indoors.

MATERIALS AND METHODS

Estimation of Annual Occupational UV Exposure

Human exposure to solar UV mainly depends on: the ambient UV levels, the protection employed and the anatomical distribution of individual exposure for different activities. To estimate the long term human UV exposure, the following equation (Wong et al., 1996) for UV exposure to a selected body site was used:

$$D = \sum_{k=1}^M N(h) \sum_{i=0}^{i=23} AE(i, h) \cdot FO(i, h) \cdot \frac{ER(i, h)}{PF(i, h)} \quad (1)$$

where for a selected period of exposure time, M months, the day is broken up into hourly intervals labeled by i, and the time interval, M, into monthly intervals labeled by h. AE is the ambient erythemal UV exposure (the total amount of UV falling on a horizontal plane, which was measured by ambient UV monitoring stations), FO is the activity index (the proportion of time spent outside) which is assumed to be the same pattern all year, ER is the fraction of ambient UV radiation falling on a particular anatomical location (in this study this is ignored), PF is the protection factor (reduction of UV exposure by a protection device) and N(h) is the number of days in the month (Wong et al., 1996). The number of working days used in this study is 5 days per week and the values of PF is equal to 1, so it is regarded as the 'worst case scenario'. However this is sufficient to provide an indication of the effect of varying the time of the day spent outdoors.

Ambient UV Irradiances

The ambient erythemal UV levels in Toowoomba (27.5° S, 151.9° E, elv. 693m) were monitored continuously by a UV monitoring station (Monitor Sensors, 7-9 Industry Drive, Caboolture, Qld, Australia). The monitoring station was calibrated seasonally against the erythemal spectral irradiance by employing the erythemal action spectrum (CIE, 1987) and the spectral irradiance recorded by a spectroradiometer as described previously in (Wong et al., 1995). The average ambient erythemal UV exposure in Toowoomba at each six minute interval of the day was recorded by the monitoring station and averaged for each hour every month. These values were then used as the average hourly exposure for each hour of the day to produce the average hourly exposure for each month.

Activity Index

The activity index (FO) is the probability of exposure of a population group as a fraction of the time of day split into hourly intervals. The activity index for summer, winter and spring was obtained for this group of home workers via a questionnaire that subjects' completed over five consecutive days starting from the 13 February 1997, 21 July 97 and 10 October 97 respectively. The subjects were asked through a questionnaire to indicate on a bar graph the times they were indoors or undercover in the shade. The time spent outdoors but in the shade was weighted by a factor of 0.5 in a similar manner to Airey et al., (1997).

The five day activity index collected through the course of this experiment does not take into account weekend activities. The calculations performed are in order to calculate occupational exposure of home workers at a sub tropical location of Toowoomba in south east Queensland. The number of days, N(h), in equation (1) was taken as the number of working days in each

month. The activity index for each hour was averaged over the five days of each questionnaire period. The activity index was linearly interpolated between the questionnaire periods to provide an activity index at intermediate points. The exposure ratio, ER, is defined as the fraction of ambient UV radiation reaching a particular body site. For this study, the value of ER was taken to be 1, which represents the vertex of the head in an upright body position.

Reduction of non melanoma skin cancer risk

The ratio of the contributions to risk of developing basal cell carcinomas (BCC) and squamous cell carcinomas (SCC) is governed by a power law relationship, as shown in equation 2 (Wong et al., 1996):

$$\left(\frac{UV_i}{UV_j} \right)^k \quad (2)$$

where UV_i is the personal erythemal annual UV exposure after protective strategies have been used, UV_j is the personal annual erythemal UV exposure without any protective strategies and k is the factor for SCC (2.5) and BCC (1.4) (Diffey, 1992). As the home workers do not adhere to a strict timetable for outdoor activities, such as gardening, various scenarios for the time spent indoors were investigated, namely, (1) 12:00 to 13:00 Australian Eastern Standard Time (EST), (2) 11:00 to 12:00 EST, (3) 08:00 EST to 10:00 EST, (4) 14:00 to 16:00 EST, (5) 07:00 EST to 12:00 EST and (6) 12:00 to 17:00 EST. By investigating the effect of time of day when outdoor activities are undertaken by home workers, the change in UV exposure can be investigated. It was assumed in this study that during periods of no UV exposure (as indicated by the activity index), the subjects were indoors or in a location where they were not exposed to solar radiation. No other UV protective devices such as hats and sunscreen were assumed to be used in this study.

RESULTS

Activity Index

Figure 1 shows, as an example, the average activity index for the home workers during 1997. The home workers indicated that for a large proportion of the day, they were exposed to small, infrequent levels of solar UV. This is to be expected, as the home workers were not outside in the sun for defined periods of the day when compared to say, a group of outdoor workers.

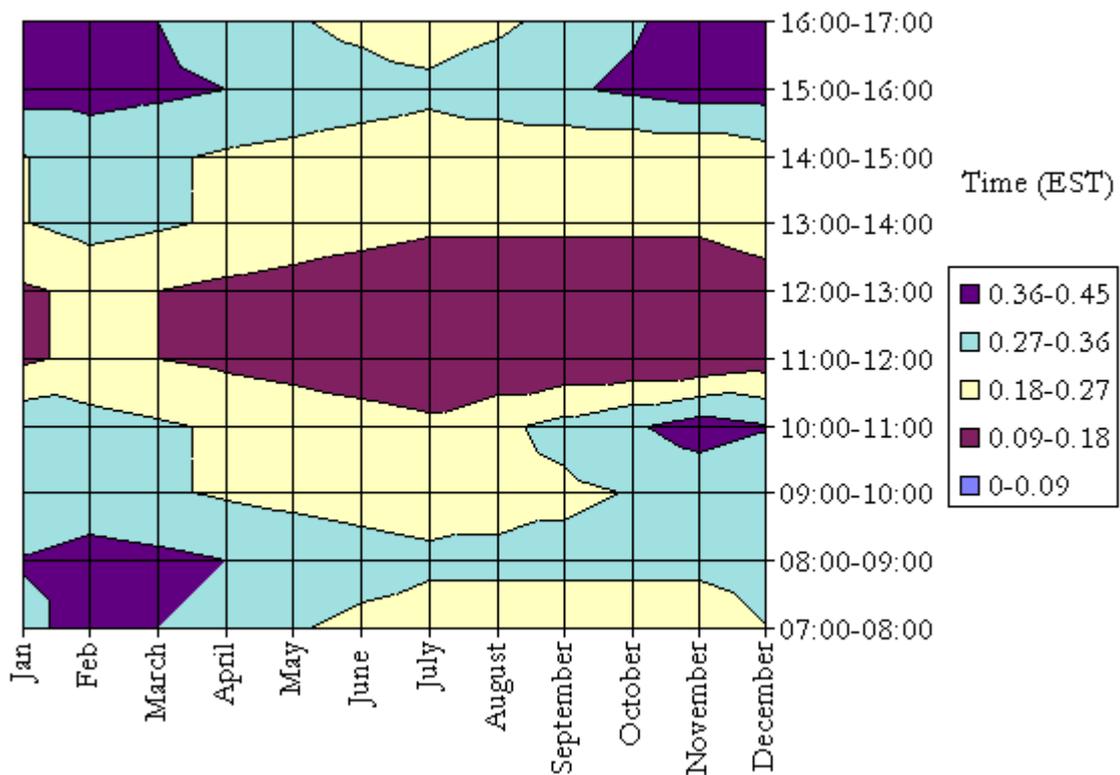


Figure 1 - Activity Index for home workers in Toowoomba during 1997

Annual UV Exposure

Figure 2 shows the estimated year long occupational exposure to the vertex of the head (in MED) for the Toowoomba home workers for each month in hourly intervals. The highest exposure period for this group was in the summer months (November through to February), but they still received a high exposure, in excess of 0.25 MED in one hour in winter. The average estimated exposure to the vertex of the head between 12:00 and 13:00 EST during summer (February) was 4.9 times higher when compared to that in winter (July). The effect of any protective devices, such as hats and sunscreens has been neglected in this study. Consequently, the presented results are regarded as the 'worst case scenario'.

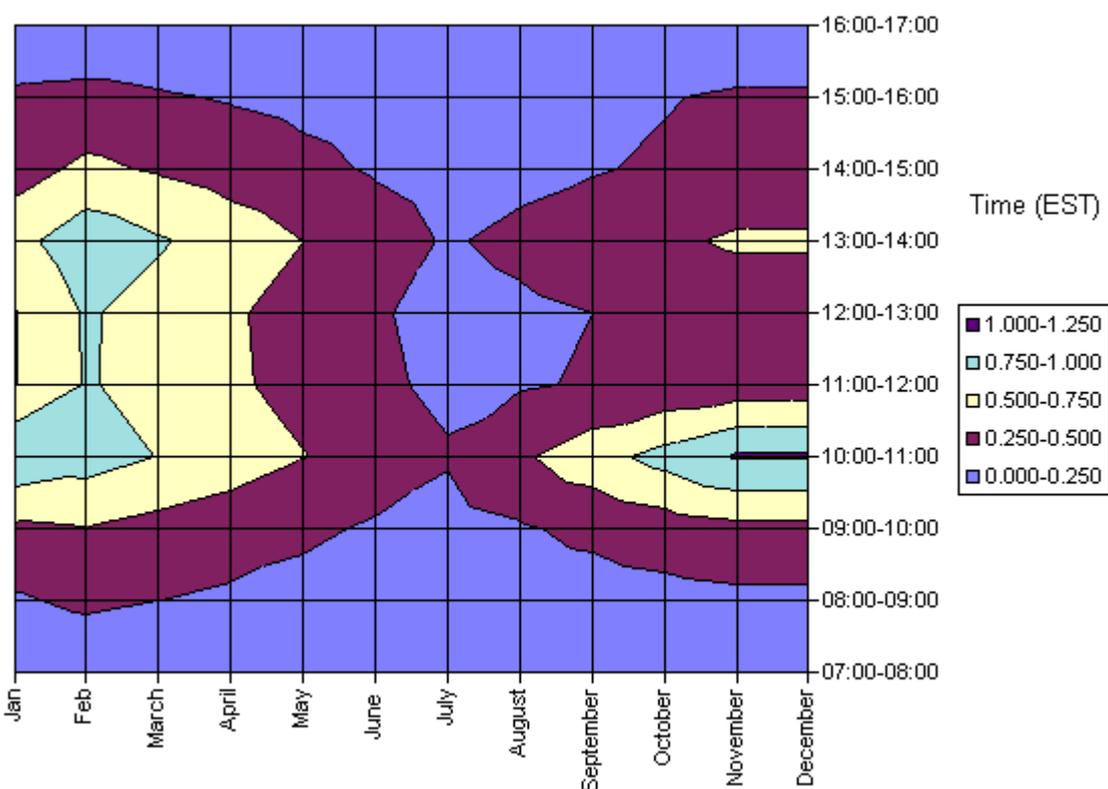


Figure 2 - Annual UV exposure (MED) to the vertex of the head for the Toowoomba home workers.

Reduction of UV Exposure

The reduction of occupational UV exposure of home workers (using equation 1) due to the six time spent indoors scenarios described previously is shown in Table 1. The time spent indoors of 12:00 to 13:00 EST is effective (12%) for the reduction in the annual occupational UV exposure and also the reduction of the contribution to the risk of BCC (17%) and SCC (28%) compared to the annual exposure employing the average activity index. In comparison, a meal break between 11:00 and 12:00 EST has a reduction of annual occupational UV exposure (13%) and risk of BCC (17%) and SCC (29%). The greatest reduction of the UV exposure of home workers was staying indoors between 7:00 to 12:00 EST and 12:00 to 17:00 EST compared to the annual exposure using the average activity index. The reduction in year long exposure was 53% and 47% respectively, with a reduction in SCC and BCC of 85%, 80% and 65% and 59% respectively.

Table 1 - Reduction in occupational UV exposure reduction in the contribution to the risk of BCC and SCC due to various times spent indoors compared to the annual UV exposure

Time spent indoors (EST)	Reduction in UV exposure (%)	Reduction in Risk of SCC (%)	Reduction in Risk of BCC (%)
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12:00 - 13:00	12	28	17
11:00 - 12:00	13	29	17
08:00 - 10:00	17	37	23
14:00 - 16:00	17	37	23
07:00 - 12:00	53	85	65
12:00 - 17:00	47	80	59

DISCUSSION

The year long occupational exposure was estimated for a group of home workers at Toowoomba in south east Queensland. Significant reductions in the annual occupational UV exposure and consequently the risk of developing BCC and SCC of these home workers can be achieved through altering the time of day they undertake outdoor activities such as gardening and shopping. The results gained in this project will vary significantly between groups of home workers who are not engaging in activities outdoors with a predominately upright position, however, they show that with only minimal changes, the UV exposure and skin cancer risks can be significantly reduced. The results gained indicate that this group of the population in south east Queensland is at a high risk of developing skin cancer unless preventative strategies are used

Acknowledgements

One of the authors (MK), would like to thank Queensland Health for financial support for this project in the form of a postgraduate training grant.

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