Ambient Solar UVR, Personal Exposure and Protection

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Ambient solar ultraviolet radiation (UVR) has been monitored around Australia by the Australian Radiation Laboratory (ARL) and its successor ARPANSA since the mid 1980's using a network of radiometric detectors and a spectroradiometer (SRM) for spectral measurements, based in Melbourne. In a continent the size of Australia, the levels vary markedly, basically following a latitude gradient increasing towards the equator but with local geographical and weather effects also evident. ARL also conducts personal exposure studies of various population groups in collaboration with other research centres to gather information on what fraction of the ambient UVR people receive. ARL also undertakes studies on the UVR protection provided by sunscreens, clothing, hats, sunglasses and other materials in an attempt to improve UVR protection used by the public. J Epidemiol, 1999 ; 9 : S115-S122.

Solar UVR, exposure, protection

Australia has high levels of solar UVR, due mainly to its geographical position between 10° and 43° S. During summer in the southern hemisphere, the earth's elliptical orbit brings it closer to the sun than during the northern summer, resulting in an additional 7% solar UVR intensity. This, coupled with clearer atmospheric conditions and the more significant ozone depletion observed over the Antarctic, may result in a measured ambient UVR which is 10 to 15% higher than for comparable locations in the northern hemisphere. These high UVR levels coupled with an outdoor lifestyle result in high rates of both non melanoma skin cancer (NMSC) and melanoma, with approximately 1200 deaths and 200,000 new cases of NMSC a year and a cost to the Australian community of the order of $300 Million per year. This is already a major problem and the prospects of increases in solar UVR at the earth's surface of 5 to 7 % due to long term ozone depletion can only add to the problem. This would lead to an increase in NMSC and melanoma if outdoor exposure remained constant. A programme to determine the solar UVR levels the Australian population is exposed to was implemented by ARL, along with personal exposure studies to quantify outdoor exposures and to identify and target at risk groups and provide information to public education campaigns to try to change behaviour and further reduce exposure. The goal of a reduction in the UVR exposure of the population has been actively pursued by the state Cancer Councils with their education programmes such as SunSmart. The introduction of the UVIndex may provide a significant educational opportunity to impact on people's behaviour.

MATERIALS AND METHODS

Ambient Solar UVR

The measurement network used to monitor ambient solar UVR around Australia covers all of the capital cities and a number of other major population centres and has been described in detail elsewhere. Since 1992/93, Solar Light 501 UVBiometers have been in use in all major capitals. Spectral measurements of solar UVR across the wavelength range 280 to 400nm at 1nm intervals have been made on selected clear days using a Spex 1680B double monochromator spectroradiometer system since 1986, with calibration against 1000W tungsten halogen standard lamps traceable to the CSIRO National Measurement Laboratory. An automated, weather proof system has been installed on the roof of the laboratory and will commence continuous daylight spectral mea-
measurements in all weather conditions by March 1999.

**Personal Exposures**

Polysulphone (PS) film has been employed as a dosimeter of solar UVR in personal exposure studies since 1976. The dose response of PS film has been characterised with simultaneous solar spectral measurements and PS exposures and a number of such studies in conjunction with other research organizations have been undertaken. More recently, ARL has been involved in a personal exposure study using small electronic UV detector/datalogger systems pioneered by Diffey and Saunders recording UV exposure on a minute by minute basis. This study done in conjunction with the Anti-Cancer Council of Victoria (ACCV), used an ARL modified system as used in 19 to determine the effect of behaviour on the UVR exposure.

**Protection**

Australia has standards covering protection against solar UVR by sunscreens, sunglasses, sun protective clothing, protective eyewear and shadecloth. The SunSmart campaigns run by the various state cancer councils and the Australian Cancer Society have raised awareness amongst the population to the extent that the demand for information on the UVR protection provided by items of protection is high and increasing. ARL undertakes laboratory measurements on a variety of such items to assess their UVR protection.

**RESULTS AND DISCUSSION**

**Ambient Solar UVR.**

Measurements of ambient biologically effective solar UVR (UVReff) from a number of countries increase with decreasing latitude (Figure 1). With ozone depletion of the order of 3% per decade at mid-latitudes, it is unlikely that long-term ozone depletion effects on the measured UV levels will be observed for some years due to cloud cover variations. The latitude gradient of solar UVR is clearly evident in Figure 1, as is the fact that Australia has very high levels, between 4000 to 8000 Minimum Erythemal Doses (MEDs - 1 MED is 200 J/m² effective weighted with the erythemal response of the CIE) per year. The levels of non melanoma skin cancer (NMSC) are also very high and the variation with latitude is shown in Figure 1.

The introduction of the UVIndex, implemented in Australia during the summer of 1995/96, allows people to become familiar with the levels of solar UVR associated with different weather at different times of the year. The TV/news reports now give the daily UV index and show the variation of UVR with time of day at the end of each day as well as giving the UVIndex predictions for the next day as computed by the Australian Bureau of Meteorology.

The UVIndex is the maximum value of biologically effective solar UVR during the day, rather than the value at solar noon, and forecasts are generally accurate for clear sky conditions. Figure 2 shows the effect of clouds on the solar UVR

![UVR Latitude Gradient](image)

**Figure 1.** Measured annual biologically effective solar UVR in MEDs/yr for a number of northern and southern hemisphere sites. Also shown are the non-melanoma skin cancer rates for Australia.
levels for Melbourne for consecutive days in March. March 2 was cloudy, but with a break in the clouds near noon, while March 1 was clear all day. Both days had similar measured UVIndices (8.5 vs 9.1) yet the measured daily total solar UVR was significantly different (10.8 MEDs vs 24.4 MEDs). Daily total UVR is a better measure of the overall levels of ambient solar UVR while UVIndex is more useful as an indicator of the maximum potential hazard. Figure 3 shows the typical daily variation of solar UVR and a comparison between UVIndex and MEDs. At solar noon, 5 MEDs per hour (sufficient UVR to induce mild erythema in sensitive skin in 12 minutes) correspond to a UVIndex of 11.2. Measured UVIndices for six

![Figure 2](image2.png)

**Figure 2.** The variation of solar UVR measured in Melbourne for two days in March, showing the effects of cloud cover on UVIndex and daily total UVR.

![Figure 3](image3.png)

**Figure 3.** The daily variation of effective UVR for a typical summer day in MEDs/hr (left scale) compared with the UVIndex (right scale).
Australian capital cities for 1997/98 are shown in Figure 4 for comparison.

**Personal Exposure to Solar UVR**

While knowledge of the ambient levels of solar UVR is vital in studies related to skin cancer and melanoma incidence, an important aspect is personal exposure. Personal exposure of the general population to solar UVR is a complex relationship between activity, behaviour, location (both geographical and local) and ambient UVR levels. Personal exposure studies provide information on various aspects of this interaction and a number of such studies using a variety of subject groups have been undertaken over the past 20 years. Not all results agree but some generalizations can be made. These are summarized below:

- Males have higher UVR exposures than females.

Figure 4. Measured UVIndices for 1997/98 for 6 Australian capital cities.
receiving between 50 and 100% more UVR, because they generally spend more time outdoors.

- Measured UVR exposures are proportional to ambient UVR for similar subject groups. Schoolchildren in the UK received 5 to 6% of daily total ambient while in Australia they received 5 to 10% and 4 to 8% respectively. Each of 3 locations in Queensland showed boys had exposures proportional to ambient as did girls, although these proportions were different.

- UVR exposures of large groups of subjects are non uniformly distributed, generally following log normal distributions.

- Some subjects have consistently high or consistently low exposures in comparison to the mean, from a tenth to ten times the mean. Population groups are not homogeneous as regards UVR exposure.

- For most subjects, UVR exposures vary between 5 to 15% of daily total ambient UVR. The exception is outdoor workers where exposures can reach 20 to 30% of ambient.

- UVR exposures vary between 20 to 30% of maximum potential exposure. Recent studies in Maryborough and Melbourne also gave figures of 25-27% and 21% respectively.

- Recreational exposures can account for the major fraction of total exposure. The effect behaviour and activity can have on the UVR exposures of two subjects participating in outdoor activities (picnicking and walking) is shown in Figure 5. The picnicker in the shade of a tree has a low and almost constant exposure while the walker who is predominately in the open has a larger exposure which is proportional to ambient. The potential dose to the walker is large, yet full use of personal protection would reduce this dose substantially (to 10 to 50% of what it might have been).

Protection against Solar UVR

Behavioural changes

Education campaigns on the hazards of sun exposure designed to change people's behaviour have started to have measurable effects. This is true (and observable) with use of personal protection. The application of an SPF 15+ or greater sunscreen to all the exposed areas of skin as well as wearing a hat, good quality sunglasses and well-designed clothing provides significant protection (50 to 90% reduction in exposure). Sun avoidance (minimizing time outdoors near solar noon, and use of available shade) is also encouraged and applies to recreation as well as work. Reduction of an individual's total UVR exposure at work is of little value if appropriate behaviour is not adopted during recreational activities.

Legislative and Environmental changes

Modifying the environment, in particular providing shade and UVR protective structures for areas that in the past were in complete sun (in schools, playgrounds and outdoor recreation areas) can also help reduce human exposure. Organisations such as schools and employers are considered responsible for providing a non-hazardous environment for their students or employees. A number of policy documents have been released.

Figure 5. The variation of UVR exposure with time for two subjects undertaking outdoor activities, picnicking and walking.
in Australia covering the provision of shade. Legislation can also be used to aid in protection against solar UVR. In many states of Australia, primary schools are adopting the rule that students without hats are barred from playing in the schoolgrounds at recess and lunch times. Employers of outdoor workers must provide their employees with sun protective items and the employees are required to use these.

**Protection.**

The increased interest in UVR protection applies not only to sunscreens, sunglasses and industrial eyewear, clothing and hats, but also to materials, shadecloth, roofing and construction plastics, car windscreens, side windows, autoglass and tints and even tents. These topics are summarized elsewhere.

**Sunglasses**

Sunglasses complying with AS 1067 will provide considerable protection. Compliance with the standard became mandatory in 1988, and in the 10 years since, the UVR protective properties of sunglasses has improved significantly, while sunglasses which fail the standard or which have poor UVR protective properties have been almost completely eliminated from the market place.

**Sunscreens**

The Australian Sunscreen Standard was recently revised and raised the maximum allowed Sun Protection Factor (SPF) claim from 15+ to 30+. The standard sets in vitro test methods for the determination of UVA transmittance of sunscreens. Education campaigns emphasizing correct application are required, since surveys indicate that sunscreens are applied at a claim from 15+ to 30+. The standard sets in vitro test methods for the determination of UVA transmittance of sunscreens. Education campaigns attempting to widen their use. Successful educational campaigns mean there is now a demand for commercial products which provide UVR protection. ARL publishes a free guide which lists products (and the companies that produce them) that provide protection against solar UVR.

Education campaigns and changing the behaviour of the population offers the biggest potential for reducing exposure and the health effects due to solar UVR. Changing people's behaviour both when outdoors and to using personal UVR protection can prove difficult to achieve, as a visit to any Australian beach in summer will demonstrate. Improved forms of protection against solar UVR as well as better strategies to implement their use can also help. Education campaigns targeting the groups most at risk and identifying clearly the factors which have important effects on solar UVR exposure of the population requires input from many different areas of research.

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**REFERENCES**

2. Global Solar UV Index. International Commission on
Non-Ionizing Radiation Protection. ICNIRP-1/95.


