

NATIONAL HAZARD EXPOSURE WORKER SURVEILLANCE:

EXPOSURE TO DIRECT SUNLIGHT AND
THE PROVISION OF SUN EXPOSURE
CONTROLS IN AUSTRALIAN WORKPLACES



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National Hazard Exposure Worker Surveillance – Exposure to direct sunlight and the provision of sun exposure controls in Australian workplaces

Acknowledgement

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Foreword

The Australian Safety and Compensation Council (ASCC) (now Safe Work Australia) requested the development and fielding of the National Hazard Exposure Worker Surveillance (NHEWS) survey to determine the current nature and extent of Australian workers' exposure to selected occupational disease causing hazards. The survey also collected information from workers about the controls that were provided in workplaces to eliminate or reduce these hazards. The results of the NHEWS survey will be used to identify where workplace exposures exist that may contribute to the onset of one or more of the eight priority occupational diseases identified by the National Occupational Health and Safety Commission (NOHSC) in 2004. These diseases are; occupational cancer, respiratory diseases, noise-induced hearing loss, musculoskeletal disorders, mental disorders, cardiovascular disease, infectious and parasitic diseases and contact dermatitis.

The NHEWS survey was developed by the ASCC in collaboration with Australian OHS regulators and a panel of experts. These included Dr Tim Driscoll, Associate Professor Anthony LaMontagne, Associate Professor Wendy Macdonald, Dr Rosemary Nixon, Professor Malcolm Sim and Dr Warwick Williams. The NHEWS survey was the first national survey on exposure to workplace hazards in Australia.

In 2008, Sweeney Research was commissioned to conduct the NHEWS survey using computer assisted telephone interviews (CATI). The data, collected from 4500 workers, forms a national data set of occupational exposures across all Australian industries. The survey was conducted in two stages. The first stage (n=1900) focussed on the five national priority industries as determined by NOHSC in 2003 and 2005. These industries were selected to focus the work under the National Strategy 2002-2012 relating to reducing high incidence and high severity risks. The priority industries are Manufacturing, Transport and storage, Construction, Health and community services and Agriculture, forestry and fishing. The second stage (n = 2600) placed no restrictions on industry.

An initial report on the results of the NHEWS survey can be found on the Safe Work Australia website¹. It contains a descriptive overview of the prevalence of exposure to the nine studied occupational hazards within industries and the provision of the various hazard control measures.

This report focuses on the exposure of Australian workers to direct sunlight and the control measures that are provided in workplaces that eliminate, reduce or control worker exposure to direct sunlight. The aims of this report are as follows: to describe patterns of exposure to direct sunlight in conjunction with patterns of direct sunlight control provision with respect to industry, occupation and other relevant demographic and employment variables, and; to make recommendations, where possible, for the development of OHS and workers' compensation policy.

¹ <http://www.safeworkaustralia.gov.au/swa/AboutUs/Publications/2008ResearchReports.htm>

Table of contents

Foreword	i
Executive summary	1
Introduction	3
2.1 Background	3
2.1.1 Ultraviolet radiation and skin cancer	3
2.1.2 Skin cancer and occupational exposure to UV radiation in Australia	3
2.1.3 The NHEWS Survey	4
2.2 Objectives	4
2.3 NHEWS Methodology	5
2.4 Analysis	5
2.4.1 Outcome variables	5
2.4.2 Predictor variables	6
2.4.3 Analysis Plan	7
2.4.4 Interpreting Odds Ratios and Relative Risk Ratios	8
2.4.5 Logistic Regression Diagnostics	8
2.4.6 Limitations	8
Detailed findings	10
3.1 Analysis 1: Exposure to Direct Sunlight	10
3.1.1 Summary of Australian workers' exposure to direct sunlight	10
3.1.2 Demographic and employment factors that affect exposure to high levels of sunlight	11
3.2 Analysis 2: Access to Risk Controls	13
3.2.1 Summary of the provision of sun protective risk controls	13
3.2.2 How do demographic and employment factors and sun exposure levels affect the provision of individual sun exposure controls?	14
3.2.3 How do demographic and employment factors and sun exposure level affect the provision of primary and secondary sun exposure controls?	18
Discussion	21
References	24
Appendix A: Analysis Output	26
List of Figures	32
List of Tables	32

Executive summary

The National Hazard Exposure Worker Surveillance (NHEWS) survey commissioned by Safe Work Australia was designed to examine the current nature and extent of Australian workers' exposure to selected occupational disease-causing hazards, including direct sunlight. The quantitative research study was conducted between January and July 2008 and comprised 4500 telephone interviews with workers in all Australian industries.

Sun exposure has been identified as the cause of around 99% of non-melanoma skin cancers and 95% of melanoma in Australia (Armstrong 2004; Armstrong & Krickler 1993). Outdoor workers generally receive five to 10 times more ultraviolet (UV) exposure per year than indoor workers (ARPANSA 2003). It is estimated that around 200 melanomas and 34 000 non melanoma skin cancers per year are caused by occupational exposures in Australia (Fritschi & Driscoll 2006). Occupational health and safety (OHS) legislation states that employers and employees have responsibilities to reduce risk of injury and risks to health, which includes reducing sun exposure.

The NHEWS survey is the first national research study on workplace ultraviolet radiation exposure from direct sunlight across all Australian industries.

Exposure to high levels of direct sunlight

Workers who were exposed to high levels of direct sunlight (more than 4 hours per day) in the week prior to the survey showed a number of demographic and employment differences to workers with no, low or medium exposure.

The odds of being exposed to a high level of direct sunlight were:

- higher in northern Australian states (QLD, NT, WA) than workers in southern states (NSW, ACT, SA, VIC, TAS)
- higher for male workers compared to female workers
- generally higher for smaller-sized workplaces, and
- higher for workers in the Agriculture, forestry and fishing, Construction, and Cultural, recreational and personal services industries when compared with the Manufacturing industry.

Provision of individual sun exposure control measures

The provision of sun protective risk controls (i.e. sunscreen, protective clothing, hats, sunglasses and being able to reorganise work outside peak UV hours) among those exposed to direct sunlight was affected by worker employment and demographic characteristics.

For those workers exposed to sunlight, the odds of any form of sun protection being provided were:

- lower among workers with a university level education, workers in the Property and business services industry and in the Health and community services industry
- greater among owner operators and contractors when compared with those who worked for an employer, and
- increased for workers exposed to sunlight for more than one hour per day.

Workers were more likely to be provided with sunglasses if they were exposed to direct sunlight for more than one hour per day.

Workers with their own business had greater odds of having access to protective clothing, hats, sunglasses and having their work rescheduled outside of peak UV times.

The number of employees in the organisation was significantly associated with all secondary risk control measures. In general, the larger the workplace, the greater the odds of workers being provided with sunscreen, protective clothing, hats, or sunglasses.

Government administration and defence and the Construction industry were consistently associated with greater odds of providing workers with sunscreen, protective clothing and hats. In contrast, Health and community services and Education were the industries where workers were less likely to have access to sunglasses, protective clothing and hats.

Provision of primary and secondary sun exposure controls

Employment and demographic factors and the level of sun exposure also affected the provision of primary and secondary sun exposure controls (primary controls = reorganise work outside peak UV hours; secondary controls = sunscreen, protective clothing, hats and sunglasses) to workers exposed to direct sunlight.

- Owner operators were more likely to have access to some form of sun protective controls and less likely to have secondary controls only when compared with those who work for an employer.
- Workers in the Construction and the Government administration and defence industries had significantly lower odds of being provided with no controls compared to being provided with primary and/or primary and secondary controls.
- Compared with female workers, male workers were more likely to have access to secondary controls only when compared to their access to primary and/or both primary and secondary controls.
- Workers with a medium level sun exposure (>1 hour but ≤4 hours per day) were significantly more likely to have access to some form of sun protective control than workers with low sun exposure (<1 hour per day). Workers with high sun exposure (>4 hours per day) showed a similar, but not statistically significant, pattern.

Policy and intervention implications

This research highlights some key relationships between occupational exposure to UV radiation through direct sunlight and employment and demographic factors of workers. This information will be valuable for guiding policy development and future interventions to limit exposure to this occupational hazard. Education of workers about the risks of overexposure to UV radiation and how to work safely in the sun is required to support policy. Specifically, regulators and interventions should target the following groups as immediate priorities:

- industries with high levels of occupational exposure to direct sunlight (Agriculture, forestry and fishing and Construction in particular)
- smaller sized workplaces as opposed to workplaces with more than 200 employees, and
- workers in northern Australia where occupational exposure to UV radiation for long durations is more common and the UV radiation is more intense and harmful.

Introduction

2.1 Background

2.1.1 Ultraviolet radiation and skin cancer

Sun exposure has been identified as the cause of around 99% of non-melanoma skin cancers and 95% of melanoma in Australia (Armstrong 2004; Armstrong & Krickler 1993). In particular, cumulative sun exposure has been shown to be linked to squamous cell carcinoma, and intense, intermittent sun exposure is associated with melanoma and basal cell carcinoma (Livingston et al. 2007). Exposure to ultraviolet (UV) radiation from the sun has also been linked to serious eye damage, including cataracts, cancer of the conjunctiva, pterygium, solar keratopathy, and ocular melanoma (CCA & ERA 2008).

Australia has the highest rate of skin cancer in the world. Over 1700 Australians die from skin cancer every year (ABS 2007). In 2001, skin cancer cost the health system approximately \$300 million, the highest cost of all cancers (AIHW 2005). However, the human and financial cost of skin cancer can be reduced, because skin cancer is highly preventable. Furthermore, investment in prevention programs, such as SunSmart, is extremely cost effective with a \$2.32 net saving for every dollar spent (Shih et al. 2009).

Sun exposure also has beneficial health effects. In particular, exposure to sunlight stimulates the production of vitamin D, which is required to maintain musculoskeletal health and is important for maintaining bone density (Papadimitropoulos et al. 2002; Trivedi et al. 2003). It has also been linked to possible beneficial treatment or prevention effects for a number of diseases. Therefore, a balance is required between avoiding an increase in the risk of skin cancer by excessive sun exposure and achieving enough sun exposure to maintain adequate vitamin D levels. Most people probably achieve adequate vitamin D levels through the UVB exposure they receive during typical day-to-day outdoor activities. For example, it has been estimated that fair skinned people can achieve adequate vitamin D levels (50-75 nmol/L) in summer by exposing the face, arms and hands or the equivalent area of skin to a few minutes of sunlight on either side of the peak UV periods on most days of the week (CCA 2007).

2.1.2 Skin cancer and occupational exposure to UV radiation in Australia

Outdoor workers are at a higher than average risk of skin cancer and other health issues related to excess UV radiation due to their exposure to high levels of direct sunlight over long periods of time (Armstrong 2004). It is estimated that around 200 melanomas and 34 000 non-melanoma skin cancers per year are caused by occupational exposures in Australia (Fritschi & Driscoll 2006).

Occupational health and safety (OHS) legislation states that both employers and employees have responsibilities to reduce risk of injury and risks to health. Reducing sun exposure while at work protects outdoor workers from sun-related injuries and can prevent most skin cancers. Skin cancer is firmly established as a compensable disease, with sun exposure the most common cause of compensated cancer claims during the three years from 2001 to 2003 (22%), followed by asbestos (21%) (Fritschi & Driscoll 2006). In fact, in the five years from 1999 to 2004, the rate of compensated skin cancer claims (per million employees) more than doubled (ASCC 2006). This increased recognition of skin cancer as an OHS issue was boosted in 2003 by two landmark legal cases settled in favour of workers with occupational skin cancer (Australia Post and Boral) (Somerville 2003).

Workplace education interventions that promote behaviours and environments conducive to working safely in the sun have shown encouraging results, but to date insufficient

evidence of the effectiveness of these interventions has been collected (Glanz et al. 2007).

Australian research into UV radiation exposure of outdoor workers has predominantly been conducted in Queensland and has involved a variety of different outdoor workers including gardeners, lifesavers, construction workers, school teachers and indoor workers. Recent research has been conducted using personal dosimeters that provide an accurate measure of the UV radiation exposure for an individual. One study compared outdoor workers and home workers in Queensland over the course of a year, and indicated that outdoor workers received 35% greater exposure than home workers (Parisi et al. 2000). Similar research in Perth found that outdoor workers (gardeners, roof carpenters and bricklayers) received six to eight times greater levels of UV radiation exposure than teachers (Holman et al. 1983).

A more recent large study specific to construction workers conducted in Queensland involving 493 participants across 19 different occupations indicated that during spring, 90% of the participants received UV radiation exposure greater than the recommended limit (Gies & Wright 2003). Pavers and tilers were identified as the occupational groups within the construction industry with the highest exposure. Another Queensland study investigated the exposure levels of three groups of predominantly outdoor workers - physical education teachers, lifesavers and gardeners (Gies et al. 1995). Of the three groups, physical education teachers received the highest UV radiation exposure. Lifesavers' lower readings were due to spending much of their work time on an elevated chair with shade cover. Nevertheless, all three groups had UV radiation exposure in excess of occupational guidelines for the measurement time in November.

2.1.3 The NHEWS Survey

Safe Work Australia, previously the Australian Safety and Compensation Council (ASCC), develops national OHS and workers' compensation policy. To inform its decision making, the ASCC requested the development and fielding of the National Hazard Exposure Worker Surveillance (NHEWS) survey to determine the current nature and extent of Australian workers' exposure to selected occupational disease-causing hazards.

The survey also collected information from exposed workers about the controls that were used to eliminate or reduce exposures to these hazards. The results from the NHEWS survey will be used to estimate where workplace exposures exist that may contribute to the onset of one or more of the priority occupational diseases. These include: occupational cancer, respiratory diseases, noise induced hearing loss, musculoskeletal disorders, mental disorders, cardiovascular disease, infectious and parasitic diseases, and contact dermatitis. The specific occupational hazards investigated in the NHEWS survey included: direct sunlight; loud noise; vibrating tools, equipment or vehicles; dust; gases, vapours, smoke or fumes; biological materials; wet work; chemical substances; biomechanical; and psychosocial hazards. A preliminary descriptive report on the survey results was published in 2008 and can be accessed from the Safe Work Australia website.

This report presents the research findings from a detailed analysis of the data related to Australian workers exposure to direct sunlight and the measures provided in the workplace that control workers exposure to direct sunlight.

2.2 Objectives

The key objectives of the analyses were to estimate the prevalence of workplace sun exposure, and identify and describe the population at risk of exposure. A further objective was to examine access to risk controls that prevent health problems associated with

excessive sun exposure. This information will support policy development, prevention actions and interventions.

2.3 NHEWS Methodology

The NHEWS survey collected data from 4500 people in paid employment, and who worked in the last week, i.e. the week preceding data collection. Respondents were interviewed at random using the computer assisted telephone interview (CATI) technique.

The survey was conducted in two waves. The first wave (January to March 2008) interviewed 1900 workers in the five national priority industries: Transport and storage; Health and community services; Construction; Manufacturing; and Agriculture, forestry and fishing. The second wave (May to July 2008) interviewed 2600 workers in both priority and non-priority industries. The data from both waves were combined for analysis, giving a total sample of 4500 interviews with results accurate within +/-1.5%, at the 95% confidence level at a national level.

To ensure a representative sample and to disproportionately sample by industry, quotas by gender within industry within state was set for Wave 1 of the NHEWS survey. Quotas by gender for non priority industries were applied for Wave 2 of the survey.

More information about the NHEWS survey methodology can be found on the Safe Work Australia website.

2.4 Analysis

2.4.1 Outcome variables

The outcome variables used for this analysis were:

- exposure to high levels of direct sunlight, and
- five risk controls, comprising of sunscreen, protective clothing, hats, sunglasses, and having work reorganised outside of peak UV times.

Exposure to direct sunlight generally refers to people who work outside in direct sunlight. However, the definition used in the NHEWS survey also includes transport workers and office workers if the sun shone directly on them even though they were indoors or were inside a vehicle. Exposure to direct sunlight was assessed by the NHEWS survey using the following question:

“On a typical day at work last week, how long did you work in direct sunlight, with or without protective lotions or clothing?”

Those unable to answer for a typical day at work were asked to report the number of hours exposed in a typical week. The typical weekly exposure was converted to an average daily exposure based on the number of days the respondent worked in the previous week. All analyses were based on a daily exposure level. This enabled easier analysis and interpretation, and as the time of exposure was not collected in the survey this averaging did not greatly influence the outcomes. Table 1 shows that 34% of workers were exposed to some level of direct sunlight at work in the previous week.

Table 1. Definition of the categorical exposure variable used in all analyses.

Category	No exposure	Low exposure	Medium exposure	High exposure
Description	No exposure	1 hour or less of exposure	More than 1 hour & less than half the standard working day	Exposure for more than half the standard working day
Daily hours exposed to direct sunlight	0	≤1	>1 & ≤4	>4
n (%)	2949 (66)	534 (12)	480 (10)	537 (12)

An option for analysis was to create an exposure variable that was based on both the number of hours exposed and location (northern vs. southern states). Upon preliminary analysis it was revealed that the state grouping did have a significant relationship with exposure when included as an independent predictor, and hence it was determined that this additional classification of exposure would not provide any further detailed information, particularly when time of exposure was not recorded.

If workers had been exposed to direct sunlight, the questionnaire followed up with a question relating to access to risk controls. The wording of the control measure question varied slightly depending on whether or not the person worked for an employer or whether the person was self employed.

‘Do you’ / ‘Does your employer’ do any of the following to prevent health problems caused by exposure to direct sunlight or sunburn?

A pre-coded list of responses was read out to the respondents and multiple responses to the question were accepted. The question specifically referred to sun protective measures that workers had access to or were provided with, it did not ask whether or not they used them.

2.4.2 Predictor variables

Exploratory analysis was undertaken to identify a set of predictors that could be used consistently in all analyses. This enabled an easier comparison and interpretation of effects between models. In choosing the predictors we aimed to strike a balance between predictors that had subject matter relevance (e.g., state group) and predictors that appeared to consistently and independently predict the outcomes (e.g., industry, work type). Some variables were collapsed to ease interpretation and to achieve adequate cell sizes (refer to Table 2). The final set of common predictor variables are shown in Table 2 and the final column gives the specification of variables used for the analyses.

To analyse sun exposure it is informative to have some location information as UV radiation levels are inversely related to latitude. As latitude was not included in the survey, a proxy variable was created, a two category variable, representing northern and southern states. There are obvious limitations with this proxy, as larger states such as Western Australia cover many degrees of latitude.

Table 2. Frequency distributions of selected demographic and employment variables and the collapsed variables used in the analyses

Demographic Variable	Values (full)	n (%)	Values (reduced)
State Group	Southern states (NSW, ACT, SA, VIC, TAS)	2750 (65.63)	
	Northern states (QLD, NT, WA)	1440 (34.37)	
Gender	Female	1847 (44.08)	
	Male	2343 (55.92)	
Highest education qualification	Year 12 not completed	618 (14.75)	High school
	Year 12 completed	396 (9.45)	
	Trade certificate / TAFE	1865 (44.51)	Trade certificate / TAFE
	Bachelor degree	868 (20.72)	University
	Postgraduate	305 (7.28)	
Work type	For an employer	3348 (79.90)	For an employer
	Own business (unique code)	310 (7.40)	Own business (unique code + employ/doesn't employ others)
	Own business that employs others	183 (4.37)	
	Own business that doesn't employ	157 (3.75)	
	Contractor	191 (4.56)	Contractor
Workplace size (Number of employees)	Less than 5	942 (22.48)	
	5 to 19	880 (21.00)	
	20 to 199	1402 (33.46)	
	200 or more employees	939 (22.41)	
Industry *	Manufacturing	714 (17.04)	
	Transport & storage	391 (9.33)	
	Construction	655 (15.63)	
	Agriculture, forestry & fishing	317 (7.57)	
	Health & community services	956 (22.82)	
	Wholesale & retail trade	237 (5.66)	
	Property & business services	262 (6.25)	
	Govt admin & defence	243 (5.80)	
	Education	320 (7.64)	
	Cultural, recreational & personal services	95 (2.27)	

Notes: For some of the variables, the sum of categories does not equal 100% due to missing data.

* Industries with a small sample size (n<50: Electricity/gas/water supply; Communication services; and Mining) or low levels of exposure (<15% of sample exposed to direct sunlight: Accommodation, cafes & restaurants; and Finance and insurance) were removed from the analyses (total sample included = 4190).

The variables excluded from the analyses were: age, income, speaking another language at home, occupation, occupational skill, total hours worked and working on weekends. These variables did not consistently have an independent association with the outcome variables.

2.4.3 Analysis Plan

Logistic regression was used to determine the effects of demographic and employment factors on the outcomes. Logistic regression describes the relationship between a dichotomous response variable and a set of explanatory variables. The analyses of exposure levels to direct sunlight included all workers (n=4190), whereas analyses relating to the provision of risk control measures focused only on those who were exposed to direct sunlight (n=1551).

Multinomial logistic regression was also used to describe the relationship of dependent variables with multiple levels, such as exposure levels (no, low, medium and high) and access to protective controls.

The models treated predictor variables as categorical. The joint Wald test was used to ascertain whether the parameters comprising each categorical variable were jointly equal to zero (the null hypothesis).

2.4.4 Interpreting Odds Ratios and Relative Risk Ratios

Logistic regression applies maximum likelihood estimation after transforming the probability of an event with a logit transformation. The outcome is binary (yes or no) and the predictors can be categorical, continuous or a mixture of both. Logistic regression estimates can be used to calculate the odds of the outcome occurring with respect to each predictor. The derived estimates of the effect of each predictor are statistically independent of other predictors in the model.

The odds ratio is the exponentiated version of the logistic regression coefficient. An odds ratio of 1 corresponds to an explanatory variable that does not affect the dependent variable. For categorical variables, the odds ratio is compared with an omitted reference category. For continuous variables, the odds ratio represents the factor by which the odds change for each one-unit change in the variable.

The relative risk ratio is used in multinomial logistic regression; for a unit change in the predictor variable, the relative risk ratio of an outcome relative to the reference group is expected to change by a factor of the respective parameter estimate given that the variables in the model are held consistent.

2.4.5 Logistic Regression Diagnostics

To assess model performance and adequacy, a number of diagnostic procedures were performed for each model. These were:

- Pseudo R^2 , a rough estimate of variance explained by the model, and the C statistic, which compares model fit to a model that includes an intercept only.
- Hosmer and Lemeshow chi-square test of goodness of fit was used to test the overall fit of each binary logistic regression model. A finding of non-significance corresponds to concluding the model adequately fits the data.
- Pearson residuals, defined to be the standardised difference between the observed frequency and the predicted frequency, were graphed against the independent variables of each model. The plots were examined for any trends that might suggest a need to modify the model (e.g. funnelling).

No serious model violations were detected. Predictive power was low in some of the analyses related to the provision of risk controls, as revealed through fairly low pseudo R^2 statistics. This may be due to the risk controls being relatively common across all employment and demographic factors and therefore the model explains very little of the variation. All other diagnostics were satisfactory.

2.4.6 Limitations

The survey relies on workers' self-reported perception of their exposure to hazards. In addition, only the hours exposed to direct sunlight were recorded, there was no record of the time of day the exposure occurred. As UV radiation varies throughout the day, peaking at solar noon, the time of exposure would have a large effect on UV radiation dose received. The use of personal dosimeters in future studies would provide an accurate measure of exposure, recording time frame and intensity (Gies et al. 1995). Personal

dosimeters are preferred to self-reported exposure because they can be worn while a person works, providing an accurate measure of the UV radiation exposure for the wearer across a specific time frame.

As state comparisons were not to be made in this analysis, the state group variable, northern states and southern states, does provide some information but does not allow for detailed information for the different geographic locations. Accurate scientific measurement of UV radiation via personal dosimetry would provide the most effective and useful data.

The survey does not have a sufficient sample size to provide information on sun exposure by all industries and occupations. Larger sample sizes will be required to monitor trends in exposure.

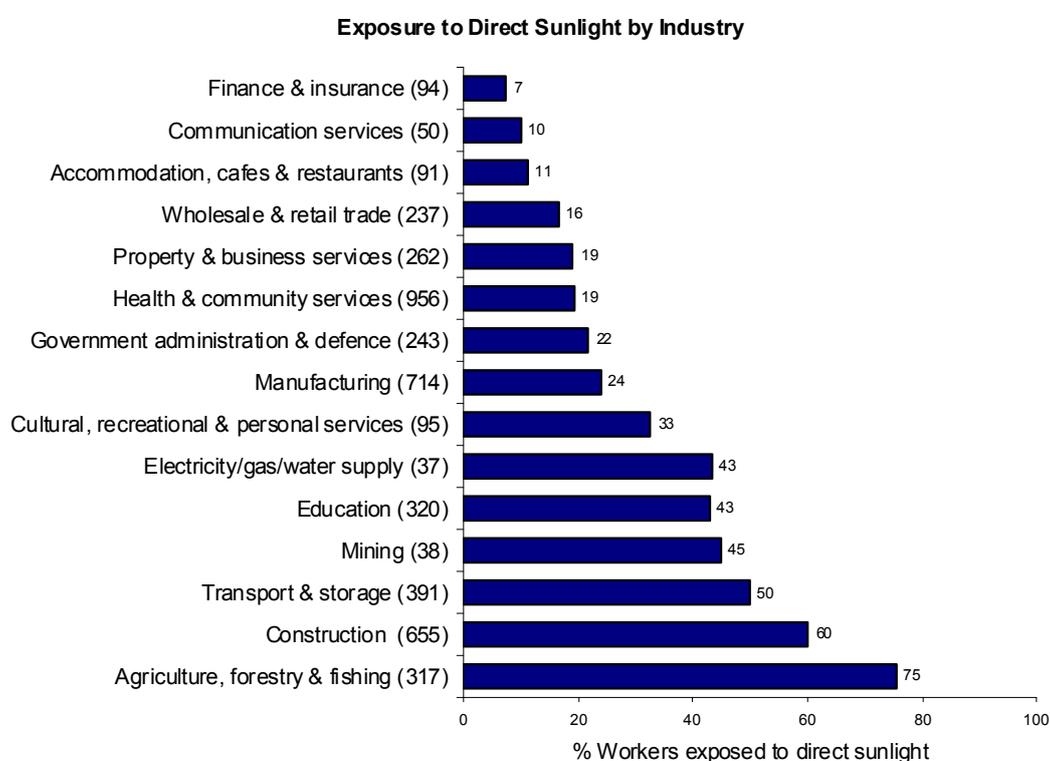
Detailed findings

3.1 Analysis 1: Exposure to Direct Sunlight

3.1.1 Summary of Australian workers' exposure to direct sunlight²

Overall, 34% of the participants in the NHEWS survey reported that they were exposed to direct sunlight during their working day. Workers who reported a typical daily exposure to direct sunlight were exposed for 4.4 hours on average per day while workers who reported a typical weekly exposure to direct sunlight were exposed for an average of 12.2 hours per week.

As presented in Figure 1 and Table 3 below, the industries with the greatest percentage of workers who reported exposure to direct sunlight were Agriculture, forestry and fishing (75%) and Construction (60%). The industry with the lowest percentage of workers who reported exposure to direct sunlight was the Finance and insurance industry (7%).



Base: Total sample (n=4500). Question: On a typical day at work last week, how long did you work in direct sunlight, with or without protective lotions or clothing?

Figure 1. The percentage of workers who reported exposure to direct sunlight by industry

² This information was sourced from the National Hazard Exposure Worker Surveillance (NHEWS) Survey: 2008 Results Report

<http://www.safeworkaustralia.gov.au/swa/AboutUs/Publications/2008ResearchReports.htm>

Table 3. Basic statistics for exposure to direct sunlight last week by industry of employment

Industry	Sample size	Did not work in sunlight	≥ 1 hour a day	≥ 1 hour a week	Total exposed	Daily exposure		Weekly exposure	
						Sample size	Daily mean (hours)	Sample size	Weekly mean (hours)
Manufacturing	714	76%	13%	10%	24%	95	3.03	74	8.53
Transport & storage	391	50%	35%	15%	50%	137	4.60	57	12.03
Construction	655	40%	36%	24%	60%	234	5.58	158	18.97
Agriculture, forestry & fishing	317	26%	49%	26%	75%	155	5.56	81	22.22
Health & community services	956	81%	11%	8%	19%	105	2.66	75	4.42
Electricity, gas & water supply	37	57%	24%	19%	43%	9	~	7	~
Wholesale & retail trade	237	84%	7%	10%	16%	16	4.13	23	5.00
Accommodation, cafes & restaurants	91	89%	2%	9%	11%	2	~	8	~
Communication services	50	90%	4%	6%	10%	2	~	3	~
Finance & insurance	94	93%	3%	4%	7%	3	~	4	~
Property & business services	262	81%	10%	10%	19%	25	2.76	25	10.99
Government administration & defence	243	78%	12%	9%	22%	30	3.98	23	8.09
Education	320	56%	15%	29%	43%	47	1.81	92	4.01
Cultural, recreational & personal services	95	67%	20%	13%	33%	19	4.74	12	10.42
Mining	38	55%	26%	18%	45%	10	4.65	7	~

Notes: ~ Mean not provided if base size is 10 or less.

Base: Total sample (n=4500); respondents who had daily exposure (n=889); respondents who had weekly exposure (n=649). Question: On a typical day at work last week, how long did you work in direct sunlight, with or without protective lotions or clothing?

3.1.2 Demographic and employment factors that affect exposure to high levels of sunlight

The logistic regression models revealed that there were a number of demographic and employment characteristics that differed between workers who were exposed to a high level of direct sunlight and those who were not (no exposure or low/medium exposure). The model explained approximately 26% of the variation in exposure to direct sunlight. The output of the model is presented in Table 4 and the main outcomes of the model are summarised below.

The odds of being exposed to direct sunlight were:

- 37% higher for workers in northern states (QLD, NT, WA) compared with southern states (NSW, ACT, SA, VIC, TAS)
- 2.9 times higher for men than women
- 1.8 times higher for workplaces with less than five employees than for workplaces with 200+ employees
- 53% lower for employees with a university level education compared with employees with only a high school level education, and
- 18 times higher for workers in the Agriculture, forestry and fishing industry, 8.8 times higher for workers in the Construction industry, 5.5 times higher for workers in the Transport and storage industry, 6.1 times higher for workers in the Cultural, recreational & personal services industry and just over twice as high for workers in the Government administration & defence industry when each industry was compared with the Manufacturing industry.

Table 4. Results of logistic regression models comparing demographic and employment variables for those exposed to high levels of direct sunlight

Exposure: No, low, med vs. high		
	Odds ratio [95% CI]	P-value
State		0.004
Southern states (ref.)	1.000	
Northern states	1.374* [1.105,1.709]	
Gender		<0.001
Female (ref.)	1.000	
Male	2.920* [2.159,3.948]	
Highest level of education		<0.001
High school (ref.)	1.000	
Trade certificate/TAFE	0.812 [0.636,1.036]	
University	0.468* [0.324,0.675]	
Work type		0.501
For employer (ref.)	1.000	
Own business	0.852 [0.621,1.170]	
Contractor	1.061 [0.692,1.628]	
Number of employees		0.014
<5 employed	1.805* [1.189,2.740]	
5-19 employed	1.332 [0.903,1.966]	
20-199 employed	1.084 [0.745,1.577]	
≥200 employed (ref.)	1.000	
Industry		<0.001
Manufacturing (ref.)	1.000	
Transport & storage	5.502* [3.441,8.798]	
Construction	8.784* [5.701,13.54]	
Agriculture, forestry & fishing	18.29* [11.38,29.41]	
Health & community service	0.987 [0.527,1.851]	
Wholesale & retail	0.934 [0.397,2.198]	
Property & business services	1.033 [0.457,2.336]	
Government admin & defence	2.282* [1.137,4.581]	
Education	1.074 [0.427,2.703]	
Cultural, recreational & personal services	6.078* [3.018,12.24]	
Observations	4026	
Pseudo R ²	0.256	
Hosmer-Lemeshow goodness-of-fit	$\chi^2 (8) = 8.66$	0.372

Notes: * p < 0.05

3.2 Analysis 2: Access to Risk Controls

3.2.1 Summary of the provision of sun protective risk controls³

Most of the participants in the NHEWS survey who reported that they worked in direct sunlight were provided with some form of protection for their sun exposure. The most common forms of protection were sunscreen, hats or protective clothing. As can be seen in Table 5, those who worked in the Health and community services, Education and Property and business services industries were most likely to report that they or their organisation had done nothing to prevent health problems caused from being exposed to direct sunlight.

Table 5. Basic statistics on the provision of sun exposure controls to workers exposed to direct sunlight by industry of employment

Industry*	n	Provide sunscreen	Provide protective clothing	Provide hat	Provide sunglasses	Reorganise work outside peak UV hours	Nothing
Manufacturing	169	58%	64%	62%	59%	17%	20%
Transport & storage	194	61%	68%	66%	53%	13%	16%
Construction	392	75%	76%	78%	66%	21%	8%
Agriculture, forestry & fishing	236	69%	68%	78%	59%	30%	9%
Health & community services	180	58%	29%	33%	15%	28%	31%
Electricity, gas & water supply	16	88%	81%	94%	94%	25%	0%
Wholesale & retail trade	39	41%	46%	54%	23%	8%	28%
Property & business services	50	48%	46%	54%	40%	16%	30%
Government administration & defence	53	91%	87%	81%	60%	25%	6%
Education	139	53%	10%	22%	4%	17%	36%
Cultural, recreational & personal services	31	61%	71%	68%	39%	16%	10%
Mining	17	88%	100%	94%	88%	35%	0%

Base: Respondents who worked in direct sunlight last week (n=1516). Question: ('Do you/'Does your employer') do any of the following to prevent health problems caused by exposure to direct sunlight or sunburn?

Notes: * Industries with a base size of 10 or less are not displayed (Accommodation, cafes & restaurants; Communication services; Finance & insurance).

³ This information was sourced from the National Hazard Exposure Worker Surveillance (NHEWS) Survey: 2008 Results Report

<http://www.safeworkaustralia.gov.au/swa/AboutUs/Publications/2008ResearchReports.htm>

3.2.2 How do demographic and employment factors and sun exposure levels affect the provision of individual sun exposure controls?

If workers reported that they were exposed to direct sunlight, the NHEWS survey investigated the provision of the following measures to prevent health problems associated with exposure to direct sunlight or sunburn: sunscreen, protective clothing, hats, sunglasses and being able to reorganise work outside peak UV hours. The following analyses investigated whether or not there were any demographic or employment factors that affected the provision of the aforementioned sun exposure controls. All workers who reported exposure to direct sunlight (n = 1551) were included in these analyses.

Table 6 presents an overview of the analyses; a more detailed analysis output is included in Appendix A (Tables A1-A6).

3.2.2.1 Sunscreen

Despite the Hosmer-Lemeshow test indicating that the model examining the provision of sunscreen fitted the data, the model itself explained very little of the variation in the provision of this sun exposure control (pseudo $R^2 = 0.046$). This is probably due to the wide provision and use of sunscreen. Consequently, the results of this model should be interpreted with caution.

The majority of the employment and demographic characteristics of workers exposed to direct sunlight did not affect the provision of sunscreen. However, both workplace size (number of employees in the workplace) and industry of employment affected the provision of this sun exposure control.

The odds of workers being provided with sunscreen were:

- 53% lower in workplaces with less than five employees, 39% lower in workplaces with between five and 19 employees, and 37% lower in workplaces with between 20 and 199 employees when compared with large workplaces (200 employees or more).
- 1.7 times higher in the Agriculture, forestry and fishing industry, 2.4 times higher in the Construction industry, and 6.2 times higher in the Government administration and defence industry when each industry was compared with the Manufacturing industry.

3.2.2.2 Protective clothing

The model examining the provision of protective clothing explained approximately 19% of the variation in the provision of this control. There were a number of demographic and employment factors that affected the provision of protective clothing. These were gender, education achievement, work type, workplace size and industry of employment. A summary of the main findings of this model are presented below.

The odds of workers being provided with protective clothing were:

- 1.5 times higher for male workers than for female workers
- 32% higher for workers with a trade certificate/TAFE education and 19% lower for workers with a university education when compared with workers with only a high school education
- 2.4 times higher for owner operators when compared to workers who work for an employer
- 1.9 times higher for workers in the Construction industry and 4.1 times higher for workers in the Government administration and defence industry when compared to workers in the Manufacturing industry, and

- 65% lower for workers in the Health and community services industry and 88% lower for workers in the Education industry when compared with workers in the Manufacturing industry.

3.2.2.3 Hats

The model that examined the provision of hats to workers who are exposed to direct sunlight found no effect of state group, gender, education level, or the hours exposed to the sun on the provision of this sun exposure control. However, workplace size, work type and industry of employment all affected the provision of hats. The main findings of this model, which explained approximately 17% of the variation in the provision of hats, are summarised below.

The odds of workers being provided with hats were:

- 67% lower in workplaces with less than five employees, 65% lower in workplaces with between five and 19 employees and 48% lower in workplaces with between 20 and 199 employees when compared with large workplaces (200 employees or more)
- 4.5 times higher for owner operators and 2.8 times higher for contractors when compared with workers who worked for an employer
- 2.6 times higher for workers in the Government administration and defence industry and 1.8 times higher for workers in the Construction industry when compared with workers in the Manufacturing industry, and
- 60% lower for workers in the Health and community services industry and 69% lower for workers in the Education industry when each industry was compared with workers in the Manufacturing industry.

3.2.2.4 Sunglasses

There were many employment and demographic factors that affected the provision of sunglasses to workers who reported they were exposed to direct sunlight. These included gender, education level, work-type, workplace size, industry and the number of hours the worker was exposed to the sun each day. The model that examined the provision of sunglasses explained 21% of the variation in the provision of this sun exposure control. The main findings of the model are summarised below.

The odds of workers being provided with sunglasses were:

- 1.7 times higher for male workers than for female workers
- 53% higher for workers with medium sun exposure (>1 hour & ≤4 hours per day) and 65% higher for workers with high exposure (>4 hours per day) when compared to workers with low levels of exposure (≤1hour per day)
- 3.1 times higher for owner operators and 2.3 times higher for contractors when compared with workers who worked for an employer, and
- 93% lower for workers in the Education industry, 82% lower for workers in the Health and community services industry and 71% lower for workers in the Wholesale and retail trade industry when each industry was compared with the Manufacturing industry.

3.2.2.5 Reorganise work outside peak UV times

There were only two employment and demographic characteristics of workers who reported exposure to direct sunlight that affected whether or not they could reorganise work outside peak UV times. These were gender and work type. However, these results need to be interpreted with caution because the model explained only 5% of the variation in this sun exposure control measure. The findings are summarised below.

The odds of workers of having their work reorganised outside of peak UV times were:

- 42% lower for male workers than for female workers, and
- 2.0 times higher for owner operators when compared with workers who worked for an employer.

3.2.2.6 No access to risk controls

The following employment and demographic characteristics all affected the likelihood that workers who reported they were exposed to direct sunlight were not provided with any sun exposure controls: education level, work type, daily hours exposed to the sun and industry of employment. The model explained only 13% of the variation in providing no access to sun exposure controls and the results, summarised below, should therefore be interpreted with caution.

The odds of workers having no access to sun protective controls were:

- 53% higher for workers with a university education when compared with workers with only a high school education
- 38% lower for workers with medium sun exposure (>1 hour & ≤4 hours per day) and 50% lower for workers with high sun exposure (>4 hours per day) when compared to workers with low sun exposure (≤1hour per day)
- 76% lower for owner operators and 63% lower for contractors when compared with workers who worked for an employer, and
- 79% lower for workers in the Government administration and defence industry and 51% lower for workers in the Construction industry when each was compared with the Manufacturing industry.

Table 6. Results of logistic regression models comparing demographic and employment characteristics of workers exposed to direct sunlight in terms of the provision of specific sun exposure control measures. The data presented are the p-values of each model factor and the odds ratios of the levels within each factor. Also presented are the model diagnostics (Pseudo r-square, n observations and goodness of fit).

Dependant variables: Prevention from direct sunlight	Sunscreen	Protective clothing	Hat	Sunglasses	Reorganise work outside peak UV	No access to risk controls
State	p = 0.481	p = 0.800	p = 0.516	p = 0.232	p = 0.218	p = 0.614
Southern states (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Northern states	1.087	0.968	1.086	1.165	0.842	0.925
Gender	p = 0.540	p = 0.018	p = 0.085	p = 0.003	p = 0.004	p = 0.497
Female (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Male	0.907	1.501*	1.339	1.740*	0.583*	0.879
Highest level of education	p = 0.856	p = 0.012	p = 0.269	p = 0.019	p = 0.093	p = 0.021
High school (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Trade certificate/TAFE	0.981	1.322	1.092	1.289	1.013	0.881
University	0.905	0.812	0.822	0.800	0.667	1.525
Hours exposed per day	p = 0.246	p = 0.160	p = 0.165	p = 0.006	p = 0.075	p = 0.002
Low sun exposure (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Medium sun exposure	1.211	1.187	1.164	1.526*	1.240	0.623*
High sun exposure	1.283	1.376	1.375	1.647*	0.849	0.499*
Work type	p = 0.395	p = <0.001	p <0.001	p = <0.001	p = 0.001	p = <0.001
For employer (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Own business	1.268	2.389*	4.485*	3.066*	2.046*	0.238*
Contractor	0.964	1.599	2.824*	2.346*	0.955	0.372*
Workplace size (number of employees)	p = 0.016	p < 0.001	p < 0.001	p < 0.001	p = 0.161	p = 0.637
<5 employed	0.474*	0.268*	0.328*	0.303*	1.082	1.410
5-19 employed	0.611*	0.276*	0.348*	0.264*	1.015	1.305
20-199 employed	0.626*	0.505*	0.520*	0.422*	0.693	1.144
≥200 employed (ref.)	1.000	1.000	1.000	1.000	1.000	1.000

Dependant variables: Prevention from direct sunlight	Protective clothing				Reorganise work outside peak UV	No access to risk controls
	Sunscreen	Protective clothing	Hat	Sunglasses		
Industry	p < 0.001	p < 0.001	P < 0.001	p < 0.001	p = 0.128	p = 0.001
Manufacturing (ref.)	1.000	1.000	1.000	1.000	1.000	1.000
Transport & storage	1.064	1.208	0.980	0.708	0.800	1.057
Construction	2.380*	1.880*	1.821*	1.131	1.184	0.491*
Agriculture, forestry & fishing	1.673*	1.314	1.614	0.933	1.275	0.693
Health & community services	1.030	0.354*	0.395*	0.183*	1.509	1.516
Wholesale & retail	0.583	0.688	0.926	0.293*	0.375	1.408
Property & business services	0.804	0.726	0.774	0.646	0.699	1.666
Government administration & defence	6.190*	4.082*	2.631*	1.004	1.888	0.207*
Education	0.938	0.116*	0.310*	0.072*	1.310	1.153
Cultural, recreational & personal services	1.454	2.363	1.116	0.489	0.631	0.424
Observations	1423	1423	1423	1423	1423	1423
Pseudo R ²	0.046	0.192	0.171	0.211	0.054	0.130
Hosmer-Lemeshow	$\chi^2(8)=5.60$ p = 0.692	$\chi^2(8)=6.75$ p = 0.564	$\chi^2(8)=4.75$ p = 0.784	$\chi^2(8)=7.57$ p = 0.476	$\chi^2(8)=9.19$ p = 0.327	$\chi^2(8)=6.18$ p = 0.627
Goodness-of-fit						

Notes: * p < 0.05

3.2.3 How do demographic and employment factors and sun exposure level affect the provision of primary and secondary sun exposure controls?

The provision of sun exposure controls can also be examined with respect to the provision of primary and secondary sun exposure controls. Primary controls are those that reduce the time a worker is physically exposed to direct sunlight. In the NHEWS survey, this information was captured by the control variable 'reorganising work outside peak UV times'. Secondary controls do not prevent exposure but attempt to reduce the impact or limit the extent of the exposure. In the NHEWS data set, secondary controls included sunscreen, protective clothing, hat and sunglasses. For this analysis, the controls provided to each worker who reported they were exposed to direct sunlight were categorised as follows: no sun exposure controls; secondary sun exposure controls only; and primary controls only or primary and secondary controls. 'Primary controls only' was included with 'primary and secondary controls' because only 12 workers were provided with primary sun exposure controls only. Primary only / primary and secondary controls were the reference group in the multinomial logistic regression model. The model is

therefore interpreted in terms of being provided with either no sun exposure controls or secondary sun exposure controls only relative to being provided with primary only / primary and secondary sun exposure controls.

3.2.3.1 Provision of primary and secondary sun exposure controls

There were several employment and demographic characteristics that affected the provision of primary and secondary sun exposure control measures. These included gender, education, work type and industry. Furthermore, the level of sun exposure (low, medium or high) also influenced the likelihood of the provision of primary or secondary sun exposure controls. The model explained only about 10% of the variation in the provision of primary and secondary controls. Therefore, the results of this analysis, which are shown in Table 7 and are summarised below, should be interpreted with caution.

State group and workplace size (number of employees) did not affect the level of access to sun exposure control measures. However, compared to being provided with primary sun exposure controls only or primary and secondary sun exposure controls, the relative risk that a worker would be provided with no sun exposure controls was:

- 85% lower for owner operators when compared with workers who work for an employer
- 53% lower for workers in the Construction industry and 85% lower for workers in the Government administration and defence industry when each industry was compared to workers in the Manufacturing industry
- 1.9 times higher for workers with a university education when compared with workers with only a high school education, and
- 42% lower for workers with medium sun exposure (>1 hour & ≤4 hours per day) when compared to workers with low sun exposure (≤1hour per day). Workers with high sun exposure (>4 hours per day) showed a similar, but not statistically significant, trend to workers with medium sun exposure when compared with workers with low sun exposure.

Furthermore, compared to being provided with primary sun exposure controls only or primary and secondary sun exposure controls, the relative risk that a worker would be provided with secondary controls only were:

- 1.9 times higher for male workers when compared with female workers
- 49% lower for workers in the Health and community services industry when compared to workers in the Manufacturing industry. This suggests that workers in the Health and community services industry are able to reorganise their works schedule around peak UV periods, and
- 39% lower for owner operators when compared with workers who work for an employer.

Table 7. Results of multinomial logistic regression examining the provision of primary and secondary sun exposure controls

	No sun exposure controls	Secondary sun exposure controls only
State		
Southern states (ref.)	1.000	1.000
Northern states	1.102 [0.766,1.586]	1.227 [0.925,1.628]
Gender		
Female (ref.)	1.000	1.000
Male	1.371 [0.868,2.165]	1.885* [1.290,2.753]
Highest level of education		
High school (ref.)	1.000	1.000
Trade certificate/TAFE	0.919 [0.584,1.445]	0.995 [0.713,1.389]
University	1.848* [1.058,3.229]	1.371 [0.872,2.154]
Level of sun exposure per day		
Low sun exposure (ref.)	1.000	1.000
Medium sun exposure	0.582* [0.379,0.895]	0.916 [0.644,1.301]
High sun exposure	0.651 [0.394,1.075]	1.377 [0.940,2.017]
Work type		
For employer (ref.)	1.000	1.000
Own business	0.146* [0.0726,0.293]	0.613* [0.405,0.926]
Contractor	0.406 [0.157,1.052]	1.262 [0.694,2.296]
Workplace size (number of employees)		
<5 employed	1.307 [0.657,2.603]	0.838 [0.492,1.428]
5-19 employed	1.284 [0.704,2.343]	0.890 [0.545,1.453]
20-199 employed	1.503 [0.847,2.668]	1.427 [0.885,2.302]
≥200 employed (ref.)	1.000	1.000
Industry		
Manufacturing (ref.)	1.000	1.000
Transport & storage	1.256 [0.591,2.670]	1.257 [0.679,2.328]
Construction	0.473* [0.234,0.957]	0.928 [0.551,1.565]
Agriculture, forestry & fishing	0.719 [0.334,1.549]	0.812 [0.455,1.446]
Health & community services	0.987 [0.480,2.030]	0.507* [0.272,0.947]
Wholesale & retail trade	3.302 [0.819,13.32]	2.468 [0.681,8.948]
Property & business services	2.157 [0.733,6.343]	1.206 [0.458,3.178]
Government administration & defence	0.154* [0.0388,0.608]	0.667 [0.304,1.464]
Education	0.886 [0.388,2.028]	0.643 [0.309,1.334]
Cultural, recreational & personal services	1.023 [0.210,4.983]	1.777 [0.592,5.341]
Observations	1423	
Pseudo R ²	0.095	

Notes: Reference category for the multinomial regression equation was Primary only / Primary & secondary sun exposure controls.

Relative risk ratio; * p < 0.05; 95% confidence interval presented in parentheses.

Discussion

This is the first national survey that has examined the extent of occupational exposure to UV radiation from direct sunlight in Australia across all industries. Previous research in the field has concentrated on specific industry types or locations. Although the data relied on self-report, and recorded only the duration of sun exposure and not the time of day it occurred, this research highlights some key relationships between occupational sun exposure and employment and demographic factors.

Thirty-four percent of Australian workers reported being exposed to direct sunlight during working hours. The duration of direct sun exposure was categorised into four levels to enable the analyses to predict the factors related to extreme personal exposure. The analyses presented in this report focus on high exposure to UV radiation (greater than four hours per day). However, it is important to remember that workers with low to medium exposure durations could also be in hazardous situations depending on the season, location and time of exposure. Ultraviolet radiation is more intense closer to the equator and also when the sun is higher in the sky between 10am and 3pm (Liley & McKenzie 2006). For example, research has shown that in January at midday, fair-skinned individuals may experience sunburn (erythema) in as little as eight minutes in Brisbane, compared with 27 minutes in Hobart (Samanek et al. 2006).

The research findings indicated that there were significant differences in the duration of direct sunlight exposure between southern and northern states. Workers in northern states had greater odds of being exposed to a higher level (i.e. longer duration) of direct sunlight, which is of particular concern given that they are also likely to be exposed to more intense levels of UV radiation.

The odds of high exposure to direct sunlight for people in workplaces with less than five employees were 80% greater than workplaces with 200 plus employees. Furthermore, workers in small workplaces showed reduced odds of being provided with sun protective controls such as sunscreen, protective clothing, a hat and sunglasses. As the financial expense of providing sun exposure controls may be a potential barrier for small to medium workplaces, initiatives such as tax-deductible sun protective products and clothing should be clearly promoted. This sub-population would therefore be a key target for future interventions and regulations.

Industries with high levels of exposure included Agriculture, forestry and fishing, Construction, Transport and storage, Cultural, recreational and personal services and Government administration and defence. The Construction and Government administration and defence industries were the most consistent in providing sun protective measures such as sunscreen, hats and protective clothing. A number of key cohorts of workers can be identified where effort should be made to raise the profile of sun exposure and sun exposure controls to minimise overexposure to UV radiation. The first of these is the Agriculture, forestry and fishing industry, where 74% of workers reported some level of exposure to direct sunlight. Second, the Transport and storage industry where 16% of workers who reported they were exposed to sunlight received no protective controls. Finally, the Education industry where although exposure duration was relatively short e.g. 1.8h per day, 43% of workers were exposed to direct sunlight and of these 36% were not provided with any sun exposure controls. If exposures occur during peak UV, even relatively short durations of exposure, such those reported in the Education industry, can result in sunburn amongst fair skinned workers.

The odds of workers with a university level education being exposed for long durations (i.e. greater than four hours per day) were significantly reduced compared with workers

with a high school education. However, those university educated workers who were exposed had a greater relative risk of not having access to any sun exposure controls, i.e. not being provided with anything to prevent the health problems caused by overexposure to direct sunlight or sunburn. Therefore, although university educated people were less likely to be exposed, when they were exposed they were also less likely to be provided with sun exposure controls.

No significant associations were found between work type (i.e. work for an employee, run own business or contractor) and being exposed to a longer duration of direct sunlight. However, in relation to access to risk controls, owner operators and contractors showed reduced odds and risk ratios of not having access to any type of risk control. These workers are therefore not an immediate priority for regulators and/or interventions.

The duration of exposure to direct sunlight only affected the provision of sun exposure control measures when workers had a medium level of exposure. These workers were less likely to not be provided with sun exposure controls than workers with a low exposure level. Although workers with a high level of exposure also showed a reduced relative risk of not being provided with a control measure, the relationship was not statistically significant. Therefore, there is limited evidence that workers exposed to longer durations of UV radiation are more likely to have access to protective controls than workers with a low level of exposure.

The results of this research will provide valuable guidance for policy development and future interventions to limit exposure to this occupational hazard. Educating workers about the risks of overexposure to UV radiation and how to work safely in the sun is necessary to support policy. Specifically, regulators and interventions should target the following groups as immediate priorities:

- industries with high levels of occupational exposure (Agriculture, forestry and fishing and Construction in particular)
- smaller sized workplaces as opposed to workplaces with more than 200 employees, and
- workers in northern Australia where occupational exposure to UV radiation for long durations is more common, and the UV radiation is more intense and harmful.

The Safe Work Australia Guidance Note for the Protection of Workers from the Ultraviolet Radiation in Sunlight (ASCC 2008), and the Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2006) are currently the two main sources of information and advice for employers. The standard currently operates as a set of guidelines with regard to solar UV radiation exposure but it is not regulated, enforced, or monitored by any government agency or industry group. It is research such as this that can assist with the advocacy of raising awareness of these sources of information and promoting implementation.

In addition to the current self-reported measures, there is a need for further research into actual workplace UV exposure levels. Scientific evidence of workers' excessive exposure to UV radiation is vital for use in advocacy efforts with companies, peak bodies and government.

A systematic evidence-based review indicated that interventions that promote sun-safe practices and environments for workplaces provide encouraging results, but to date yield insufficient evidence to recommend current strategies as effective (Glanz et al. 2007). Glanz et al. recommended comprehensive workplace sun safety interventions should be aimed at both employees and employers for the greatest possible impact.

In order to support workplaces in the provision of sun protective controls and their use by employees, future research should also be aimed at investigating personal protective products and clothing that are best for industry, taking into account useability and acceptance by workers as well as practical and financial implications.

In conclusion, progress has been made in raising awareness, building capacity and changing policy regarding UV protection in the workplace; however, further attention and action is required as demonstrated by this report.

References

- ABS: Australian Bureau of Statistics (2007) 'Causes of death 2007. 3303.0. 3303.0.' Canberra, Australia.
- AIHW: Australian Institute of Health and Welfare (2005) 'Health system expenditures on cancer and other neoplasms in Australia, 2000-2001', Canberra, Australia. AIHW cat.no. HWE 29.
- Armstrong, B. K. (2004) 'How sun exposure causes skin cancer: an epidemiological perspective'. In: H. D, E. JM and E. DR (Eds.). *Prevention of skin cancer*. Dordrecht, The Netherlands, Kluwer Academic Publishers: 89–116.
- Armstrong, B. K. & A. Kricger (1993) 'How much melanoma is caused by sun exposure?' *Melanoma research* 3(6): 395-401.
- ARPANSA: Australian Radiation Protection and Nuclear Safety Agency (2003) 'Resource guide for UV protective products', Yallambie, Australia.
- ARPANSA: Australian Radiation Protection and Nuclear Safety Agency (2006) 'Radiation protection standard for occupational exposure to ultraviolet radiation', Yallambie, Australia.
- ASCC: Australian Safety and Compensation Council (2006) 'Report on indicators for occupational disease', Canberra, Australia.
- ASCC: Australian Safety and Compensation Council (2008) 'Guidance note for the protection of workers from the ultraviolet radiation in sunlight', Canberra, Australia.
- CCA (2007) *Position statement: Risks and benefits of sun exposure*. Retrieved 4 January 2010, from <http://cancer.org.au/Healthprofessionals/PositionStatements/sunsmart/risksandbenefitsofsunexposure.htm>.
- CCA & ERA: Cancer Council Australia & Eye Research Australia (2008) *Position Statement: Eye protection*. Retrieved 4 January 2010, from <http://cancer.org.au/Healthprofessionals/PositionStatements/sunsmart/eyeprotection.htm>.
- Fritschi, L. & T. Driscoll (2006) 'Cancer due to occupation in Australia'. *Australian and New Zealand journal of public health* 30(3): 213.
- Gies, H. P., C. R. Roy, S. Toomey, R. MacLennan & M. Watson (1995) 'Solar UVR exposures of three groups of outdoor workers on the Sunshine Coast, Queensland'. *Photochemistry and photobiology* 62(6): 1015-1021.
- Gies, P. & J. Wright (2003) 'Measured Solar Ultraviolet Radiation Exposures of Outdoor Workers in Queensland in the Building and Construction Industry'. *Photochemistry and photobiology* 78(4): 342-348.
- Glanz, K., D. B. Buller & M. Saraiya (2007) 'Reducing ultraviolet radiation exposure among outdoor workers: State of the evidence and recommendations'. *Environmental health perspectives* 6(1): 22.
- Holman, C. D. J., I. M. Gibson, M. Stephenson & B. K. Armstrong (1983) 'Ultraviolet irradiation of human body sites in relation to occupation and outdoor activity: Field studies using personal UVR dosimeters'. *Clinical and Experimental Dermatology* 8(3): 269-277.
- Liley, J. B. & R. L. McKenzie (2006) 'Where on earth has the highest UV?' *UV Radiation and its Effects: An Update*. Dunedin, New Zealand, National institute of water and atmospheric research.
- Livingston, P. M., V. White, J. Hayman & S. Dobbins (2007) 'Australian adolescents' sun protection behavior: Who are we kidding?' *Preventive Medicine* 44(6): 508-512.
- Papadimitropoulos, E., G. Wells, B. Shea, W. Gillespie, B. Weaver, N. Zytaruk, A. Cranney, J. Adachi, P. Tugwell & R. Josse (2002) 'Meta-analyses of therapies for postmenopausal osteoporosis VIII: Meta-analysis of the efficacy of vitamin D treatment in preventing osteoporosis in postmenopausal women'. *Endocrine reviews* 23(4): 560-569.

- Parisi, A., L. R. Meldrum, M. G. Kimlin, J. C. F. Wong, J. Aitken & J. S. Mainstone (2000) 'Evaluation of differences in ultraviolet exposure during weekend and weekday activities'. *Physics in Medicine and Biology* 45(8): 2253-2262.
- Samaneck, A. J., E. J. Croager, P. Gies, E. Milne, R. Prince, A. J. McMichael, R. M. Lucas & T. Slevin (2006) 'Estimates of beneficial and harmful sun exposure times during the year for major Australian population centres'. *Medical Journal of Australia* 184(7): 338-341.
- Shih, S. T. F., R. Carter, C. Sinclair, C. Mihalopoulos & T. Vos (2009) 'Economic evaluation of skin cancer prevention in Australia'. *Preventive Medicine* 49(5): 449-453.
- Somerville, P. (2003) 'Liability more than skin deep'. *National Safety General News*: 26-29.
- Trivedi, D. P., R. Doll & K. T. Khaw (2003) 'Effect of four monthly oral vitamin D3 (cholecalciferol) supplementation on fractures and mortality in men and women living in the community: randomised double blind controlled trial'. *British Medical Journal* 326(7387): 469-475.

Appendix A: Analysis Output

Table A1. Prevention from direct sunlight – Provide sunscreen

	Odds Ratio	95% Confidence Interval	P Value
State			0.481
Southern states (ref.)	1.000		
Northern states	1.087	[0.861,1.372]	
Gender			0.540
Female (ref.)	1.000		
Male	0.907	[0.664,1.239]	
Highest level of education			0.856
High school (ref.)	1.000		
Trade certificate/TAFE	0.981	[0.741,1.298]	
University	0.905	[0.626,1.308]	
Hours exposed to the sun per day			0.246
Low sun exposure (ref.)	1.000		
Medium sun exposure	1.211	[0.908,1.614]	
High sun exposure	1.283	[0.941,1.749]	
Work type			0.395
For employer (ref.)	1.000		
Own business	1.268	[0.875,1.838]	
Contractor	0.964	[0.599,1.549]	
Number of employees			0.016
<5 employed	0.474*	[0.299,0.752]	
5-19 employed	0.611*	[0.401,0.930]	
20-199 employed	0.626*	[0.424,0.925]	
≥200 employed (ref.)	1.000		
Industry			<0.001
Manufacturing (ref.)	1.000		
Transport & storage	1.064	[0.682,1.660]	
Construction	2.380*	[1.563,3.622]	
Agriculture, forestry & fishing	1.673*	[1.043,2.683]	
Health & community service	1.030	[0.632,1.677]	
Wholesale & retail	0.583	[0.283,1.201]	
Property & business services	0.804	[0.413,1.563]	
Government admin & defence	6.190*	[2.313,16.57]	
Education	0.938	[0.544,1.618]	
Cultural, recreational & personal services	1.454	[0.616,3.430]	
Observations	1423		
Pseudo R ²	0.046		
Hosmer-Lemeshow goodness-of-fit	$\chi^2 (8) = 5.60$		0.692

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

Table A2. Prevention from direct sunlight – Provide protective clothing

	Odds Ratio	95% Confidence Interval	P Value
State			0.800
Southern states (ref.)	1.000		
Northern states	0.968	[0.754,1.243]	
Gender			0.018
Female (ref.)	1.000		
Male	1.501*	[1.072,2.102]	
Highest level of education			0.012
High school (ref.)	1.000		
Trade certificate/TAFE	1.322	[0.988,1.770]	
University	0.812	[0.550,1.197]	
Hours exposed to the sun per day			0.160
Low sun exposure (ref.)	1.000		
Medium sun exposure	1.187	[0.869,1.621]	
High sun exposure	1.376	[0.992,1.908]	
Work type			<0.001
For employer (ref.)	1.000		
Own business	2.389*	[1.618,3.526]	
Contractor	1.599	[0.963,2.655]	
Number of employees			<0.001
<5 employed	0.268*	[0.163,0.439]	
5-19 employed	0.276*	[0.175,0.436]	
20-199 employed	0.505*	[0.330,0.773]	
≥200 employed (ref.)	1.000		
Industry			<0.001
Manufacturing (ref.)	1.000		
Transport & storage	1.208	[0.755,1.933]	
Construction	1.880*	[1.214,2.912]	
Agriculture, forestry & fishing	1.314	[0.806,2.140]	
Health & community service	0.354*	[0.210,0.594]	
Wholesale & retail	0.688	[0.330,1.434]	
Property & business services	0.726	[0.365,1.445]	
Government admin & defence	4.082*	[1.661,10.03]	
Education	0.116*	[0.0573,0.236]	
Cultural, recreational & personal services	2.363	[0.900,6.203]	
Observations	1423		
Pseudo R ²	0.192		
Hosmer-Lemeshow goodness-of-fit	χ^2 (8) =6.75		0.564

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

Table A3. Prevention from direct sunlight – Provide hat

	Odds Ratio	95% Confidence Interval	P Value
State			0.516
Southern states (ref.)	1.000		
Northern states	1.086	[0.846,1.394]	
Gender			0.085
Female (ref.)	1.000		
Male	1.339	[0.961,1.865]	
Highest level of education			0.269
High school (ref.)	1.000		
Trade certificate/TAFE	1.092	[0.810,1.472]	
University	0.822	[0.556,1.215]	
Hours exposed to the sun per day			0.165
Low sun exposure (ref.)	1.000		
Medium sun exposure	1.164	[0.857,1.581]	
High sun exposure	1.375	[0.990,1.909]	
Work type			<0.001
For employer (ref.)	1.000		
Own business	4.485*	[2.910,6.913]	
Contractor	2.824*	[1.625,4.910]	
Number of employees			<0.001
<5 employed	0.328*	[0.203,0.531]	
5-19 employed	0.348*	[0.225,0.536]	
20-199 employed	0.520*	[0.349,0.774]	
≥200 employed (ref.)	1.000		
Industry			<0.001
Manufacturing (ref.)	1.000		
Transport & storage	0.980	[0.615,1.562]	
Construction	1.821*	[1.170,2.832]	
Agriculture, forestry & fishing	1.614	[0.972,2.682]	
Health & community service	0.395*	[0.236,0.660]	
Wholesale & retail	0.926	[0.444,1.931]	
Property & business services	0.774	[0.385,1.556]	
Government admin & defence	2.631*	[1.192,5.808]	
Education	0.310*	[0.171,0.562]	
Cultural, recreational & personal services	1.116	[0.445,2.800]	
Observations	1423		
Pseudo R ²	0.171		
Hosmer-Lemeshow goodness-of-fit	$\chi^2 (8) = 4.75$		0.784

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

Table A4. Prevention from direct sunlight – Provide sunglasses

	Odds Ratio	95% Confidence Interval	P Value
State			0.232
Southern states (ref.)	1.000		
Northern states	1.165	[0.907,1.496]	
Gender			0.003
Female (ref.)	1.000		
Male	1.740*	[1.212,2.498]	
Highest level of education			0.019
High school (ref.)	1.000		
Trade certificate/TAFE	1.289	[0.969,1.716]	
University	0.800	[0.537,1.193]	
Hours exposed to the sun per day			0.006
Low sun exposure (ref.)	1.000		
Medium sun exposure	1.526*	[1.110,2.099]	
High sun exposure	1.647*	[1.190,2.278]	
Work type			<0.001
For employer (ref.)	1.000		
Own business	3.066*	[2.102,4.473]	
Contractor	2.346*	[1.429,3.851]	
Number of employees			<0.001
<5 employed	0.303*	[0.189,0.487]	
5-19 employed	0.264*	[0.169,0.411]	
20-199 employed	0.422*	[0.280,0.635]	
≥200 employed (ref.)	1.000		
Industry			<0.001
Manufacturing (ref.)	1.000		
Transport & storage	0.708	[0.448,1.119]	
Construction	1.131	[0.741,1.725]	
Agriculture, forestry & fishing	0.933	[0.576,1.513]	
Health & community service	0.183*	[0.102,0.330]	
Wholesale & retail	0.293*	[0.127,0.679]	
Property & business services	0.646	[0.318,1.313]	
Government admin & defence	1.004	[0.503,2.005]	
Education	0.072*	[0.0283,0.182]	
Cultural, recreational & personal services	0.489	[0.204,1.171]	
Observations	1423		
Pseudo R ²	0.211		
Hosmer-Lemeshow goodness-of-fit	$\chi^2 (8) = 7.57$		0.476

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

Table A5. Prevention from direct sunlight – Reorganise work outside peak UV hours

	Odds Ratio	95% Confidence Interval	P Value
State			0.218
Southern states (ref.)	1.000		
Northern states	0.842	[0.640,1.107]	
Gender			0.004
Female (ref.)	1.000		
Male	0.583*	[0.405,0.840]	
Highest level of education			0.093
High school (ref.)	1.000		
Trade certificate/TAFE	1.013	[0.732,1.403]	
University	0.667	[0.431,1.031]	
Hours exposed to the sun per day			0.075
Low sun exposure (ref.)	1.000		
Medium sun exposure	1.240	[0.885,1.739]	
High sun exposure	0.849	[0.585,1.233]	
Work type			0.001
For employer (ref.)	1.000		
Own business	2.046*	[1.367,3.060]	
Contractor	0.955	[0.529,1.725]	
Number of employees			0.161
<5 employed	1.082	[0.647,1.810]	
5-19 employed	1.015	[0.634,1.624]	
20-199 employed	0.693	[0.437,1.099]	
≥200 employed (ref.)	1.000		
Industry			0.128
Manufacturing (ref.)	1.000		
Transport & storage	0.800	[0.438,1.463]	
Construction	1.184	[0.710,1.974]	
Agriculture, forestry & fishing	1.275	[0.727,2.237]	
Health & community service	1.509	[0.836,2.726]	
Wholesale & retail	0.375	[0.106,1.325]	
Property & business services	0.699	[0.276,1.772]	
Government admin & defence	1.888	[0.872,4.085]	
Education	1.310	[0.652,2.633]	
Cultural, recreational & personal services	0.631	[0.213,1.866]	
Observations	1423		
Pseudo R ²	0.054		
Hosmer-Lemeshow goodness-of-fit	χ^2 (8) =9.19		0.327

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

Table A6. Prevention from direct sunlight – Nothing / No risk controls provided

	Odds Ratio	95% Confidence Interval	P Value
State			0.614
Southern states (ref.)	1.000		
Northern states	0.925	[0.684,1.251]	
Gender			0.497
Female (ref.)	1.000		
Male	0.879	[0.605,1.276]	
Highest level of education			0.021
High school (ref.)	1.000		
Trade certificate/TAFE	0.881	[0.599,1.294]	
University	1.525	[0.968,2.402]	
Hours exposed to the sun per day			0.002
Low sun exposure (ref.)	1.000		
Medium sun exposure	0.623*	[0.438,0.886]	
High sun exposure	0.499*	[0.329,0.757]	
Work type			<0.001
For employer (ref.)	1.000		
Own business	0.238*	[0.125,0.452]	
Contractor	0.372*	[0.163,0.848]	
Number of employees			0.637
<5 employed	1.410	[0.788,2.523]	
5-19 employed	1.305	[0.794,2.145]	
20-199 employed	1.144	[0.727,1.799]	
≥200 employed (ref.)	1.000		
Industry			0.001
Manufacturing (ref.)	1.000		
Transport & storage	1.057	[0.600,1.864]	
Construction	0.491*	[0.275,0.876]	
Agriculture, forestry & fishing	0.693	[0.360,1.336]	
Health & community service	1.516	[0.856,2.684]	
Wholesale & retail	1.408	[0.615,3.222]	
Property & business services	1.666	[0.772,3.595]	
Government admin & defence	0.207*	[0.0594,0.721]	
Education	1.153	[0.616,2.160]	
Cultural, recreational & personal services	0.424	[0.0915,1.965]	
Observations	1423		
Pseudo R ²	0.130		
Hosmer-Lemeshow goodness-of-fit	χ^2 (8) =6.18		0.627

Exponentiated coefficients; 95% confidence intervals in brackets; p < 0.05

List of Figures

Figure 1. The percentage of workers who reported exposure to direct sunlight by industry ..10

List of Tables

Table 1. Definition of the categorical exposure variable used in all analyses.....	6
Table 2. Frequency distributions of selected demographic and employment variables and the collapsed variables used in the analyses.....	7
Table 3. Basic statistics for exposure to direct sunlight last week by industry of employment.....	11
Table 4. Results of logistic regression models comparing demographic and employment variables for those exposed to high levels of direct sunlight.....	12
Table 5. Basic statistics on the provision of sun exposure controls to workers exposed to direct sunlight by industry of employment.....	13
Table 6. Results of logistic regression models comparing demographic and employment characteristics of workers exposed to direct sunlight in terms of the provision of specific sun exposure control measures. The data presented are the p-values of each model factor and the odds ratios of the levels within each factor. Also presented are the model diagnostics (Pseudo r-square, n observations and goodness of fit).	17
Table 7. Results of multinomial logistic regression examining the provision of primary and secondary sun exposure controls	20
Table A1. Prevention from direct sunlight – Provide sunscreen	26
Table A2. Prevention from direct sunlight – Provide protective clothing.....	27
Table A3. Prevention from direct sunlight – Provide hat.....	28
Table A4. Prevention from direct sunlight – Provide sunglasses.....	29
Table A5. Prevention from direct sunlight – Reorganise work outside peak UV hours	30
Table A6. Prevention from direct sunlight – Nothing / No risk controls provided.....	31