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Occupational sun protection: workplace culture, equipment provision and outdoor workers' characteristics.

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Abstract

Objectives: The aim of this study was to describe outdoor workers' sun-protective practices, workplace sun-safety culture and sun-protective equipment provision; investigate the association of demographic, personal and occupational factors with sun-protective practices; and identify potential strategies for improving workers' sun protection.

Methods: The present study used a clustered survey design with randomly identified employers in nine occupations. Employees provided questionnaire measures of demographics, personal characteristics (skin type, skin cancer risk perceptions, tanning attitudes, sun-exposure knowledge), personal occupational sun protection practices (exposure reduction, use of sun-protective clothing, sunscreen and shade), workplace sun-protective equipment provision and perceived workplace sun-safety culture. Summative scores were calculated for attitudes, knowledge, workplace provision and culture. A multivariable model was built with worker and workplace variables as plausible predictors of personal sun protection.

Results: In this study, 1,061 workers (69% participation) from 112 workplaces provided sufficient information for analysis. Sex, age, prioritized ethnicity, education and risk perception differed significantly between occupational groups ($p<0.001$), as did workers' sun-protective practices and workplace sun-protection equipment provision and supportive culture. After adjustment, each one-point increase in Workplace Sun-safety Culture Score (range 12 points) was associated with a 0.16 higher Personal Sun-Protection Score ($p<0.001$), and each one-point increase in Workplace Provision Score (range 4 points) was associated with a 0.14 higher score ($p<0.001$). Sun Protection Score was significantly associated with skin response to sun exposure ($p<0.001$), female sex ($p=0.021$), tanning attitudes ($p=0.022$) and occupation ($p=0.049$), but not ethnicity, age education, knowledge or skin cancer risk perception.

Conclusions: Protective equipment provision and sun-protective workplace culture are promising components for the development of comprehensive programs to improve outdoor workers' sun-protective practices.

Key words: Occupational health, outdoor workers, risk perceptions, skin cancer, sun exposure, sun protection.

Introduction

Skin cancer, the most common cancer[1)], accounts in New Zealand (NZ) for around 80% of new cancers or 70,000 cases / year in a population of approximately 4.35 million[2)]. Around 2,000 are melanoma cases, producing age standardized (WHO world population) incidence rates of 43.0 and 37.4 per 100,000 for men and women, respectively[3)]. The balance is the estimated number of nonmelanoma skin cancers (NMSC), mostly basal and squamous cell carcinomas (BCC, SCC), based on extrapolation from regional laboratory data, because NMSC incidence is not routinely recorded in the NZ Cancer Registry system. Although melanoma results in greater mortality (371 of 425 skin cancer deaths in 2008), the larger number of NMSC cases has a significant population impact, places a substantial burden on the health system (estimated at $5.7 million and $51.4 million, for melanoma and NMSC, respectively), and additional economic costs[2)]. With many lesions located on the head, face and neck, there can also be substantial personal impact from disfigurement[4)].

Epidemiological studies have identified links between sun exposure, melanoma and NMSC[5, 6)]. Skin cancer risk is related to interactions of genetic factors with the pattern and amount of unprotected sun exposure-melanoma and BCC tending to be linked with intermittent exposure, whereas SCC is related most strongly to chronic exposure[7)]. Outdoor workers are at significantly increased NMSC risk[8)], particularly SCC[9, 10)], but also BCC[11)], and may experience elevated melanoma risk at highly exposed sites, the face, head and neck[12, 13)].

A UK report estimated that NMSC attributed to solar UVR exposure ranked fourth among occupational cancer registrations, accounting for 53% of occupational NMSC registrations[4)]. Furthermore, NMSC was considered "substantially under-registered." Comparable estimates are not available for NZ, where there is increased risk because the population is largely Caucasian; perihelion occurs during the Southern Hemisphere summer; the climate is largely temperate and often windy, providing misleading cues based on temperature; the atmosphere is relatively pollution free; and recent ozone depletion has contributed to elevate risk. Summer UVR can be 40% higher than that experienced at similar Northern Hemisphere latitudes[14)], and frequently reaches "extreme" (UVI ≥11) levels[15)]. The personal UVR exposures of a sample of NZ outdoor workers[16)] universally exceeded conservative "ceiling values" for the eye, which have also been identified as "desirable goals for the skin"[17)].

An estimated 14.5% of the NZ workforce is employed in mostly outdoor occupations[18]. The primary protective strategy of reducing sun exposure during peak UVR is problematic in many outdoor occupations, making other strategies more feasible and acceptable. However, qualitative research investigating perceptions of the risks of excess sun exposure among a large, diverse sample of NZ outdoor workers identified a pervasive nonchalant attitude towards sun exposure and protection[19]. Sun protection tended to be afforded a low priority relative to other workplace protective behaviors. Protection, predominantly through the use of sunscreen, hats and clothing, was argued to be inconvenient and uncomfortable, especially when work was physically demanding or required motor skills. Personal risk management was often little more than early summer tanning attempts, with the expectation that this would provide some protection from the risk of later, more severe sunburn. However, any minimal protective effect of facultative pigmentation (tanning) is considered to be outweighed by the damage incurred during tan acquisition[20], particularly among at-risk skin types, as "all types of UV-induced tanning result in DNA and cellular damage, which can eventually lead to photocarcinogenesis"[21]. Australian studies also found that outdoor workers' sun protection tends to be poor and inconsistent, despite high sun exposure[22, 23]. A high proportion of workers were not required to wear sun protection, regardless of skin type and high levels of sun exposure[20]. Perceived workplace support for sun protection is positively associated with sunscreen use and sun protection among NZ workers[24], which suggests that employer-led interventions may offer a potentially promising direction for policy development and implementation[25]. Nevertheless, comprehensive programs aimed at both employers and employees are considered likely to have greatest impact on protective practices[26]. Some occupational groups, such as construction workers[27], employees in smaller-sized workplaces[28] and some subgroups (e.g., males, and those with a lower perceived risk of skin cancer)[26], may be less well protected, and certain strategies (e.g. workplace feedback about skin damage)[29] may be influential.

NZ guidelines for minimizing hazardous occupational solar UVR exposure are available[30], but have not been evaluated. Although educational strategies have been initiated in NZ occupational contexts[31], the magnitude of the impact of skin cancer,[32] the probable increase in incidence[33] and its potential preventability serve to strengthen the case for occupational monitoring and intervention development[34]. In Australia, recent employer compensation payments for occupational skin cancer may have helped focus attention on occupational sun protection[35]. With no-fault injury compensation in NZ, that particular incentive is lacking.

Although there is an obligation for employers to protect workers, and for workers to comply in NZ[30], barring a successful legal case for exemplary damages, which is unlikely, other incentives are likely to be required. Given the estimated treatment costs associated with skin cancer[2], the quantification of skin cancers among outdoor workers[4] may assist in highlighting the need for primary prevention. However, since there is currently no requirement to register NMSC in NZ, surveillance would be challenging to establish. Overall, there is a need to raise the profile of occupational skin cancer[34] and increase the priority of primary prevention.

The present paper aims to extend earlier investigations, with the goal of helping to inform and guide occupational skin cancer prevention advocacy and the development of potentially evaluable interventions. First, we report the distributions of demographic (sex, ethnicity, educational attainment and age) and personal factors (skin sensitivity to sun exposure, perceptions of skin cancer risk, attitudes towards tanning and knowledge about the effects of sun exposure) for nine key occupational groups. Second, the distributions of eight recommended sun-protective practices are described, summed into personal sun protection scores and reported for each occupation. Third, workers' reports of workplace provision of sun protective equipment and perceptions of workplace sun-protective culture are summed, respectively, into workplace "provision" and "culture" scores. Fourth, variation between workplaces within occupational groups is considered. Finally, factors from the demographic, personal and workplace domains are included in multivariable modeling to investigate which, if any, are significantly associated with personal sun-protection scores. In relation to these multivariable results, we discuss potential intervention strategies to improve outdoor workers' sun protection.

Methods

Sample selection

Nine occupations (Table 1) were selected on the basis of their potential for excessive sun exposure. Given the lack of an outdoor occupation database [24], a clustered survey design was employed whereby individual employers and companies in the Auckland, Waikato and Hawke's Bay regions of the North Island (Auckland is the most populous city, and the North Island the most populated island) were identified at random from trade directories (Yellow Pages ™ http://www.yellow.co.nz/ and Universal Business Directories http://www.ubd.co.nz/). For eight occupations, a letter was sent to workplace managers outlining study intentions and requirements for participation. Follow-up telephone calls were made to discuss participation criteria. With management permission, study information was made available to employees who worked outdoors for ≥50% of their standard working week. Farmers were accessed and surveyed, on site, at regional livestock sale venues.

Table 1. Sample composition by occupational group

	Businesses contacted	**Businesses participating**	**Business response**	**Eligible workers**	**Workers available on day**	**Workers' data usable for modelling**	
	n	*n*	*%*	*n*	*n*	*n*	*% of available*
Occupation							
Forestry	11	11	100.0	210	154	101	65.6
Roading	20	16	80.0	332	233	172	73.8
Sawmilling	19	17	89.5	229	166	120	72.3
Postal	1	1	100.0	200	128	117	91.4
Viticulture	16	15	93.8	220	152	83	54.6
Landscaping	43	37	86.0	247	219	164	74.9
Construction	20	16	80.0	190	155	101	65.2
Horticulture	25	20	80.0	199	181	97	53.6
Farming	n/a	n/a	n/a	n/a	150	106	70.7
Totals	**155**	**133**	**85.8**	**1,827**	**1,538**	**1,061**	**69.00**

Instrument and measures

An anonymous self-completion questionnaire, using established scales and new measures developed from prior research[19], was developed to assess sun-protective practices. The four demographic items included were sex, age, educational attainment (NZ Census classifications), and self-defined ethnicity, with multiple ethnic identification prioritized, as recommended[36]. Participants' skin reactions to sun exposure were defined by

response options to the question "Which best describes your skin after being in the sun without sun-protection?" namely, "it always burns", "usually burns", "sometimes burns", "rarely burns", consistent with Fitzpatrick Skin Types I-IV[37]. Perceived risk of skin cancer was assessed by asking respondents to place a mark along a visual analogue scale from zero ("not at all likely") to 100 ("completely certain"). Fixed response options to the question "When you are going out into the sun for more than 10 minutes, what type of sun protection do you usually use?" were collated into an unweighted, additive eight item Personal Sun-protection Score with each item rated as either "yes" (scored as 1) or "no" (scored as zero). These items were (1) a hat (either "wide brimmed" or "with flap covering the neck and ears"), (2) a shirt, (3) clothing other than a shirt, (4) sunglasses, (5) sunscreen ≥SPF 15+ on the face, (6) sunscreen ≥SPF 15+ on all exposed body areas, (7) shade and (8) limiting of exposure from 10am to 4pm. Employee reports of workplace provision of the following sun-protection items were also obtained: (1) "broad-brimmed hat" and / or "cap with flap to cover neck and ears'; (2) "long-sleeved shirts"; (3) ≥SPF 15+ sunscreen and (4) shade (e.g., moveable or a canopy for vehicle). Workplace provision was assessed by combining these four items to obtain an unweighted, additive Workplace Provision Score.

For each of the remaining three combined scores, component items were developed from the findings of a formative grounded-theory study based on 13 focus groups with 67 workers from 7 outdoor occupational groups[19]. Each score included up to four items that had undergone pilot testing and principle components analysis. Each of the final items was categorized along a five-point Likert-type scale (from 1=strongly agree to 5=strongly disagree), and items were combined to obtain an unweighted, additive score. Three items were combined into a Workplace Sun-safety Culture Score: "Remembering to use sun protection has a high priority within my workplace"; "I feel comfortable about applying sunscreen in front of my work mates"; "I would tell my work mate if I think s/he is getting sun burnt." Similarly, poor knowledge about the effect of sun exposure was assessed by three items combined into a Deficient Knowledge Score: "Getting a tan early in the season will protect my skin throughout summer", "Getting a tan in summer protects my skin from sunburn" and "I believe that it is safe for skin to be exposed to the sun to develop a tan naturally." Positive attitudes towards tanning were assessed by four items combined into a Pro-tan Attitude Score: "I try to work on my tan when I'm at work", "I feel more healthy with a suntan", "working outside helps me to maintain a good tan" and "a suntan makes me feel better about myself." The Cronbach's alpha coefficients for Workplace Culture (α=0.70),

Deficient Knowledge (α=0.80) and Pro-tan Attitudes (α=0.85) indicated acceptable internal consistency. Alphas were not calculated for the Workplace Provision and Personal Protection Scores as these did not represent psychometric constructs, but were simple, unweighted counts of protective items for which internal consistency would not necessarily be expected. Higher values for these five scores indicates, respectively, a more sun-safe workplace culture, poorer knowledge of sun protection, a more pro-tan attitude, better workplace provision with respect to sun protection and better personal sun-protection practices. These score components have not yet been validated among the NZ outdoor occupational workforce in terms of predicting sunburn, skin damage or melanoma risk but have face and content validity, and where appropriate, internal consistency supports construct validity.

Procedures

Each workplace was sent sufficient questionnaires for the workforce, a letter outlining the process required for distribution and a self-addressed Freepost envelope for questionnaire return. Some employers preferred the surveys to be collected by a researcher at the workplace. The questionnaire (estimated 15-minute maximum completion time) was completed at the workplace, usually during work breaks, between February and April (Southern Hemisphere summer / early autumn). Up to two telephone calls were made to managers of workplaces for which questionnaire returns were outstanding. Ethical approval was granted by the University of Auckland Human Participants Ethics Committee (Reference 03/Q/057).

Analysis

Descriptive statistics by occupational group were used to summarize sample demographics, personal characteristics, workers' sun protective practices and workplace provision of sun protective equipment. Differences in the distribution of categorical and binary variables between occupations were examined using chi-squared tests. Differences between occupations in continuous measures, including scales and individual items that could be treated as continuous, were investigated using linear regression with residuals inspected for approximate normality and homoscedasticity. Linear regression was used in unadjusted and adjusted models looking at predictors of personal protection scores. Log transformations were investigated to see if this improved residuals following all linear regression models. All analyses were adjusted for workplace clustering.

The Stata version 12.1 statistical software was used for the analyses. Two-sided $p<0.05$ was considered statistically significant.

Results

Demographic characteristics by occupational group

Of the 1,827 eligible workers (Table 1), 1,538 were present at work on the survey day, and 1,061 returned a questionnaire with demographic information sufficient for reporting distributions by occupational group (Table 2) and suitable for modelling purposes (69% participation). There were 112 workplaces (range 9 to 22 per occupation), with between 1 (farming) and 38 workers. There were more females (65%) than males only among postal workers; farmers had the highest mean age (53.4 years), and the highest percentage of Māori were employed in forestry (63%). A tertiary qualification was most frequent in viticulture (41%) and least common in forestry (7%).

Workers' personal characteristics

With respect to the tendency of their skin to burn without sun protection, 39% of respondents reported being in the higher risk categories ("always burns" or "usually burns"), with the highest percentages in viticulture (47%) and lowest percentages in forestry (28%) (Table 3). On a scale of zero to 100, the participants' mean perceived personal risk of developing skin cancer during the next 10 years was highest for postal workers (51.6) and lowest for forestry workers (41.3). Although some statistically significant, but weak, differences were observed between the occupational groups with respect to specific pro-tan attitude measures, differences between occupations in overall Pro-tan Attitudes Scores failed to reach statistical significance (p=0.066).

Workplace provision of protective equipment and sun safety culture

Workers' reports of workplace provision of protective equipment (Table 4) indicate that "any hat" was the most commonly provided item, followed by sunscreen, a highly protective hat and a shirt, with shade being least commonly provided. Workplace provision of protective equipment varied significantly by occupational group for all items except a highly protective hat. Overall, horticulture was perceived as the least well-provided occupation and postal work the best-provided occupation. The three workplace sun safety culture items

displayed acceptable internal consistency (alpha 0.70). There was a correlation between workplace culture and the workplace provision score ($r=0.26$, $p<0.001$). Workplace culture varied significantly between occupations.

Workers' personal sun protective practices

Personal sun protective practices at work, using products either provided by the workers themselves or the workplace, are presented in Table 4. The most commonly reported practice was the use of "any hat", followed by sunglasses, a shirt, sunscreen on all exposed body areas, a highly protective hat - either broad brimmed or with flaps to protect the neck and ears - and sunscreen for the face only. The least commonly reported strategies were the use of shade and limiting exposure. There were statistically significant differences between occupational groups in the use of highly protective hats, sunglasses and sunscreen, as well as in mean Sun-protection Score, with forestry the least protective occupation and viticulture the most protective occupation.

Effects of adjustment for demographic factors

In order to examine the question of whether apparent differences between occupations might be attributable to demographic differences, overall scores were modelled adjusting for age group, sex, ethnicity and education. Adjusted mean scores are shown in Table 5.

Overall, little change was observed in the results for Workplace Provision Scores (none of the covariates were statistically significant here). For the Workplace Culture Score, the mean for forestry increased by 0.5, reflecting the higher proportions in this occupation of males, younger workers, those of Māori ethnicity and those with lower education. The mean Personal Protection Score increased for forestry by 0.3 for similar reasons. The mean for postal workers was, however, 0.3 lower after adjustment, reflecting the higher proportion of females and those with higher education in that occupation. The previously observed differences in Risk Perception Scores were no longer statistically significant after adjustment. There was relatively little effect on Pro-tan Attitudes Scores after adjustment, although younger workers (25 years and under) had lower scores than older workers (26 years and older). Adjusted mean Deficient Knowledge Scores increased for forestry workers (by 0.6), but were lower (by 0.6) for postal workers and those in viticulture (0.3) and landscaping (0.3) after adjustment due to females and those of European ethnicity having higher scores than those of Māori or Pacific ethnicity, and scores increased with age until over 55 years.

Table 2. Distribution of demographic characteristics by occupational groups [1]

Characteristic:	All [2]		Forestry		Roading		Sawmilling		Postal		Viticulture		Landscaping		Construction		Horticulture		Farming	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
	1,061	100	101	10	172	16	120	11	117	11	83	8	164	15	101	10	97	9	106	10
Sex																				
Male	835	80	91	93	156	95	104	88	40	35	55	66	128	80	96	96	77	81	88	84
Female	204	20	7	7	9	5	14	12	74	65	28	34	33	20	4	4	18	19	17	16
Missing data	*22*		*3*		*7*		*2*		*3*		*0*		*3*		*1*		*2*		*1*	
Prioritized ethnicity																				
European	627	61	27	28	86	52	54	47	79	70	64	77	114	74	58	57	50	54	95	90
Maori	303	29	60	63	66	40	48	41	27	24	10	12	29	19	28	28	25	27	10	9
Pacific	61	6	7	7	11	7	10	9	4	4	4	5	7	5	11	11	7	8	0	0
Asian	22	2	1	1	1	1	1	1	2	2	2	2	3	2	3	3	8	9	1	1
All other	15	1	1	1	2	1	3	3	1	1	3	4	2	1	1	1	2	2	0	0
Missing data	*33*		*5*		*6*		*4*		*4*		*0*		*9*		*0*		*5*		*0*	
Highest education																				
Up to School Certificate	497	50	70	72	91	56	71	63	37	35	29	36	54	35	37	37	47	53	61	60
Completed secondary	161	16	12	12	20	12	17	15	31	29	11	14	26	17	9	9	13	15	22	22
Trade apprenticeship	132	13	8	8	18	11	15	13	9	8	7	9	26	17	35	35	8	9	6	6
Tertiary qualification	212	21	7	7	33	20	9	8	30	28	33	41	48	31	18	18	21	24	13	13
Missing data	59		4		10		8		10		3		10		2		8		4	
Age		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$		$\bar{x}$
Years		38.4		31.0		38.6		36.6		34.1		35.7		38.0		41.2		36.4		53.4
Missing data	*41*		*3*		*13*		*4*		*5*		*0*		*7*		*2*		*5*		*2*	

[1] The distribution of all demographic characteristics differed significantly by occupational group ($p \leq 0.001$).

[2] Columns list frequencies with percentages of column totals presented adjacent (except for age, where the mean is presented). Missing data (*n*) are presented in italics.

Table 3. Distribution of personal characteristics by occupational groups [1]

Personal characteristic:	All *n*=1061		Forestry *n*=101		Roading *n*=172		Sawmilling *n*=120		Postal *n*=117		Viticulture *n*=83		Landscaping *n*=164		Construction *n*=101		Horticulture *n*=97		Farming *n*=106		
	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	*p*-value
Skin response to sun																					0.361
Always burns	13		11		12		20		9		15		10		10		13		13		
Usually burns	26		17		24		23		32		32		27		31		24		24		
Sometimes burns	44		51		43		44		42		38		48		37		44		43		
Rarely burns	18		22		21		13		17		15		15		23		19		19		
Missing data (n)	*10*		*0*		*3*		*0*		*0*		*2*		*1*		*0*		*2*		*2*		
Risk perception																					
Risk Perception Score (0-100)		***45.1***		***41.3***		***41.7***		***43.8***		***51.6***		***43.1***		***47.1***		***45.4***		***43.5***		***48.3***	***<0.001***
Missing data (n)	*66*		*11*		*10*		*5*		*8*		*3*		*11*		*3*		*11*		*4*		
Pro-tan attitudes																					
I work on my tan at work		2.3		2.2		2.4		2.0		2.2		2.4		2.2		2.2		2.4		2.3	0.065
I feel healthier with a tan		2.7		2.6		2.8		2.4		2.8		2.8		2.9		2.8		2.6		2.7	0.030
A tan makes me feel better		2.7		2.6		2.7		2.4		2.8		2.8		2.9		2.8		2.7		2.8	0.033
Outdoor work helps me tan		2.9		2.9		3.0		2.5		3.0		3.0		2.9		2.9		2.8		3.0	0.015
Pro-tan Attitudes Score (0-20)		***10.6***		***10.4***		***10.9***		***9.3***		***10.8***		***11.0***		***11.0***		***10.7***		***10.4***		***10.7***	***0.066***
Missing data (n)	*62*		*6*		*14*		*3*		*5*		*0*		*8*		*8*		*9*		*9*		
Deficient knowledge																					
An early season tan protects		3.6		3.3		3.4		3.8		3.9		3.7		3.6		3.5		3.6		3.4	<0.001
A summer tan protects		3.6		3.3		3.4		3.7		3.9		3.7		3.8		3.4		3.6		3.5	<0.001
A natural suntan is safe		3.4		3.0		3.3		3.5		3.8		3.4		3.5		3.4		3.5		3.4	<0.001
Deficient Knowledge Score (0-15)		***10.6***		***9.6***		***10.0***		***11.0***		***11.7***		***10.9***		***10.9***		***10.3***		***10.5***		***10.3***	***<0.001***
Missing data (n)	*56*		*3*		*13*		*4*		*6*		*0*		*8*		*8*		*9*		*5*		

[1] Columns list percentages (for skin response to sun exposure) or means (for all other variables). Missing data (*n*) are listed in italics. Column percentages may not add to 100% due to rounding effects. All variables are adjusted for age, sex, ethnicity and education.

Table 4. Sun protection: workplace provision, workplace culture and personal practices by occupational group.

	All *n*=1,061		**Forestry** *n* =101		**Roading** *n*=172		**Sawmilling** *n*=120		**Postal** *n*=117		**Viticulture** *n*=83		**Landscaping** *n*=164		**Construction** *n*=101		**Horticulture** *n*=97		**Farming** *n*=106		
	%	$\bar{x}$	***%***	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*%*	$\bar{x}$	*p*-value
Workplace provision score items:																					
Hat (any) [1]	69		84		76		61		98		42		64		83		35		68		<0.001
Hat (broad brim/flaps)	33		27		46		25		56		16		37		27		10		32		0.078
Long sleeved shirt	25		16		22		13		85		4		30		13		11		22		<0.001
Other protective clothing[1]	22		18		38		18		9		22		30		12		14		19		0.012
Shade	17		18		20		18		2		43		20		7		14		15		<0.001
Sunscreen	56		50		63		49		95		73		66		43		33		20		<0.001
Workplace Provision Score (0-4)		***1.4***		***1.2***		***1.6***		***1.1***		***2.4***		***1.4***		***1.6***		***0.9***		***0.8***		***1.0***	***<0.001***
Missing data	*60*		*7*		*10*		*9*		*0*		*1*		*5*		*3*		*9*		*16*		
Workplace culture score items:																					
Sun protection is a priority		3.3		3.1		3.4		3.0		3.8		3.8		3.5		3.1		3.2		3.1	<0.001
Comfortable applying sunscreen		3.8		3.4		3.9		3.5		4.2		4.0		4.1		3.7		3.6		3.6	<0.001
Tell workmates about sunburn		3.8		3.4		3.9		3.6		3.8		4.0		4.2		3.7		3.8		3.9	<0.001
Workplace Culture Score (0-15)		***11.0***		***9.9***		***11.2***		***10.2***		***11.7***		***11.7***		***11.8***		***10.5***		***10.5***		***10.6***	***<0.001***
Missing data (n)	*67*		*5*		*11*		*4*		*5*		*0*		*12*		*4*		*10*		*16*		
Personal protection score items:	*%*		*%*		*%*		*%*		*%*		*%*		*%*		*%*		*%*		*%*		
Hat (any) [2]	87		86		89		88		91		88		84		88		79		89		0.206
Hat (broad brim/flaps)	27		16		22		28		27		34		32		20		19		44		<0.001
Shirt (incl. t-shirt)	55		54		61		59		45		57		56		51		56		56		0.296
Other protective clothing	18		21		19		16		14		23		20		19		20		15		0.850
Sunglasses	58		47		66		73		69		60		59		52		43		47		0.003
Shade	15		9		20		19		19		12		13		16		14		6		0.103

Limit exposure	6	4	6	10	9	5	4	6	5	7	0.369
Sunscreen[3] on face	20	14	22	15	26	25	25	13	13	24	0.046
Sunscreen[3] - all exposed skin	34	18	33	33	58	59	40	27	22	20	<0.001
No protection[2]	5	9	5	2	2	1	6	8	3	4	0.103
Personal Protection Score (0-8)	***2.8***	***2.3***	***3.0***	***3.0***	***3.0***	***3.2***	***2.9***	***2.5***	***2.5***	***2.6***	***<0.001***
Missing data	*6*	*0*	*0*	*1*	*3*	*1*	*0*	*0*	*0*	*1*	

All variables are adjusted for age, sex, ethnicity and education.

[1] These items are not components of the Workplace Provision Score.

[2] These items are not components of the Personal Protection Score.

[3] ≥SPF15+

Table 5. Effect on mean summary scores of adjustment for demographic factors by occupational group.

	All *n*=974		**Forestry** *n* =93		**Roading** *n*=152		**Sawmilling** *n*=109		**Postal** *n*=107		**Viticulture** *n*=80		**Landscaping** *n*=149		**Construction** *n*=97		**Horticulture** *n*=86		**Farming** *n*=101		
	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	$\bar{x}$	$\Delta\bar{x}$	*p*-value
Workplace Provision Score (0-4)	1.4	0	1.2	0	1.7	+0.1	1.1	0	2.3	-0.1	1.3	-0.1	1.5	-0.1	0.9	0	0.8	0	1.2	+0.2	<0.001
Workplace Culture Score (0-15)	11.0	0	10.4	+0.5	11.5	+0.3	10.4	+0.2	11.5	-0.2	11.6	-0.1	11.6	-0.2	10.6	+0.1	10.6	+0.1	10.4	-0.2	0.001
Personal Protection Score (0-8)	2.8	0	2.6	+0.3	3.2	+0.2	3.2	+0.2	2.7	-0.3	3.0	-0.2	2.8	-0.1	2.6	+0.1	2.5	0	2.5	-0.1	0.017
Risk Perception Score (0-100)	44.8	-0.3	43.5	+2.2	41.3	+0.4	45.9	+2.1	48.7	-2.9	42.4	-0.7	45.6	-1.5	46.3	+0.9	44.3	+0.8	45.9	-2.4	0.126
Pro-tan Attitudes Score (0-20)	10.6	0	10.2	-0.2	11.1	+0.2	9.3	0	10.7	-0.1	10.8	-0.2	11.0	0	10.9	+0.2	10.4	0	10.9	+0.2	0.002
Deficient Knowledge Score (0-15)	10.6	0	10.2	+0.6	10.1	+0.1	11.2	+0.2	11.1	-0.6	10.6	-0.3	10.6	-0.3	10.4	+0.1	10.7	+0.2	10.1	-0.2	0.005

Δ = direction and magnitude of any change from unadjusted mean

Multivariable modeling

In the adjusted multivariable model (Table 6), there was no evidence for any association of ethnicity, education, age or Perceptions of Skin Cancer Risk Score with Personal Protection Score. Occupation remained marginally associated, and male sex and Pro-Tan Attitude Score remained negatively associated. There was evidence of a difference between skin response categories (test for linear trend $p<0.001$, no evidence of higher-order trends $p=0.726$), with a 0.20-point decrease in personal protection per increase in skin response category (95% CI 0.12 to 0.28, $p<0.001$), equivalent to a lower score for "rarely burns" versus "always burns" (95% CI 0.35 to 0.84). In the same model, both the Workplace Provision and Culture Scores had independent effects on Personal Protection Score, with each unit increase in Workplace Culture Score associated with a 0.16 unit increase in Personal Protection Score, and each unit increase in the Workplace Provision Score associated with a 0.15 increase.

Models comparing Personal Sun-protection Scores across each industry (before and after adjusting for worker age, sex, ethnicity, and education as well as workplace provision and culture scores) found some evidence for differences between workplaces in the following occupations: (unadjusted scores followed by adjusted scores) roading ($p=0.047$, $p=0.071$), sawmilling ($p=0.058$, 0.013), viticulture ($p=0.046$, 0.620), horticulture ($p=0.040$, 0.571), and farming ($p=0.035$, 0.068), but not other occupations. Within roading (n=11) and sawmilling (n=17), the mean personal protection scores for workplaces ranged from 2.1 to 4.5 and 1.4 to 4.7, respectively, indicating considerable heterogeneity between workplaces. The heterogeneity between workplaces among those working in viticulture and horticulture appear to be explained by worker and workplace characteristics, and only sawmilling was statistically significant after adjustment.

Table 6: Statistical modelling with predictors of Personal Sun-protection Scores, unadjusted and adjusted coefficients, 95% confidence intervals and *p*-values

	Unadjusted				Adjusted			
Predictor*	**Coeff**	**95% CI**		***p*-value**	**Coeff**	**95% CI**		***p*-value**
		Lower	**Upper**			**Lower**	**Upper**	
Sex *(Male)*								
Female	0.58	0.34	0.83	<0.001	0.32	0.05	0.58	0.021
Ethnicity *(NZ European)*								
				0.044				0.468
Maori	-0.08	-0.58	0.41		0.20	-0.33	0.73	
Pacific	-0.32	-0.80	0.15		0.19	-0.28	0.66	
Asian/Indian	-0.35	-0.60	-0.10		-0.03	-0.28	0.22	
MELAA/other	-0.61	-1.24	0.02		-0.56	-1.39	0.27	
Age *(Per 5 years)*	0.03	-0.01	0.07	0.133	0.02	-0.02	0.06	0.244
Education *(Secondary)*								
Post-secondary	0.24	0.07	0.41	0.007	0.09	-0.07	0.26	0.273
Occupation *(Roading)*								
				<0.001				0.049
Forestry	-0.69	-1.05	-0.33		-0.45	-0.88	-0.03	
Sawmilling	-0.04	-0.51	0.43		-0.06	-0.49	0.37	
Postal	0.04	-0.36	0.44		-0.53	-0.86	-0.20	
Viticulture	0.17	-0.27	0.60		-0.18	-0.59	0.23	
Landscaping	-0.16	-0.60	0.29		-0.39	-0.70	-0.07	
Construction	-0.53	-1.06	-0.01		-0.48	-0.84	-0.12	
Horticulture	-0.54	-0.96	-0.13		-0.47	-0.87	-0.07	
Farming	-0.44	-0.85	-0.02		-0.53	-0.98	-0.09	
Pro-tan Attitude Score *(Range 4–20, per unit increase)*	-0.07	-0.10	-0.03	<0.001	-0.04	-0.08	-0.01	0.022
Deficient Knowledge Score *(Range 4–12, per unit increase)*	0.12	0.09	0.15	<0.001	0.03	-0.01	0.07	0.201
Skin response *(Always burns)*								
				<0.001				<0.001
Usually burns	-0.18	-0.52	0.16		-0.02	-0.34	0.30	
Sometimes burns	-0.58	-0.89	-0.27		-0.27	-0.56	0.01	
Rarely burns	-0.94	-1.27	-0.60		-0.55	-0.87	-0.23	
Perception of Risk Score *(Range 0-100, per 5% increase)*	0.02	0.00	0.05	0.021	0.01	-0.02	0.03	0.634
Workplace Sun-safety Culture Score *(Range 3–15, per unit increase)*	0.22	0.17	0.26	<0.001	0.16	0.11	0.21	<0.001
Workplace Provision Score *(Range 0–4, per unit increase)*	0.29	0.19	0.38	<0.001	0.14	0.06	0.23	0.001

* (*Italics):* reference group; score range, difference per unit.

Discussion

Our findings represent the first comprehensive quantitative report of key sun-protection practices among a large sample of workers drawn from a wide range of major outdoor occupations in New Zealand, where ambient summer UVR can reach "extreme" levels[15] and skin cancer is both common and costly to treat[2]. Our results confirm aspects of our own and other earlier reports and, particularly through multivariable analysis, extend those findings in ways potentially useful for focusing advocacy efforts and developing effective workplace interventions.

Workers' demographic and personal characteristics

The distributions of all demographic characteristics (sex, ethnicity, educational status and age) differed significantly between occupations (Table 2). Although demographic factors are usually not modifiable, knowledge about them can help inform the targeting and tailoring of protective messages. For example, given the high percentage of Māori forestry workers, there is potential value in working with Māori to develop culturally acceptable and appropriate occupational interventions.

Studies have tended to focus on factors associated with variation in sun exposure and sun protection within single occupational groups[25, 38, 39]. However, in multi-occupation studies, demographic variation may help to explain some of the significant differences in personal sun-protective practices observed between occupations, for example, the significantly poorer protection reported among construction than transportation workers[27]. In our study, such differences between occupational groups were far stronger in the unadjusted than the adjusted analyses, indicating that, in a multivariable context, factors other than occupational group were more strongly associated with personal protection.

Apart from the Perceptions of Risk Score, personal characteristics did not differ significantly between occupational groups. Given the potential for workplace policies and practices to override demographic and personal factors in influencing sun-protection practices at work, a lack of statistical control of plausible factors from within the workplace domain is likely to limit the value of information about associations of personal and demographic factors, such as younger age and male gender, with workplace sun protection[25, 40].

Personal Protection Scores (PPS): the outcome of interest

Although it is reassuring that only 5% of workers reported wearing no sun protection, protection was far from satisfactory. The recommended optimal protection for outdoor workers in NZ, which in the present study would approximate to a Personal Sun-protection Score of 8, may be difficult to achieve in some work situations, nevertheless the failure of any occupational group to reach a mean of even half that level of protection, a modest target for all of the occupations included here, indicates the extent of potential room for improvement. There was also statistically significant variation between occupations. That forestry had the lowest mean PPS may, in part, relate to the type of work. For example, when operating a chainsaw or working with log hauling equipment, the immediacy of potential serious injury may mean that sun protection appears a relatively minor, distant problem. However, comparable risks exist in some other occupations, so it is possible that the relatively less structured forestry industry, which in NZ depends largely on subcontracted teams, may permit a more "macho", less protective culture. Nevertheless, the highest wearing rate for appropriately sun-protective hats (44%) was reported for farming, an occupation that has strong masculine cultural associations and often involves self-employment. Further qualitative research in this area may be instructive.

With respect to the PPS components, hat wearing was the most commonly reported practice, but less than one third of the hats worn (only 16% in forestry) had either a broad brim or flaps to protect the face, neck and ears-areas where skin cancers commonly develop from chronic sun exposure[4)]. Furthermore, it was only the wearing of such hats with the greatest potential to reduce that risk, which differed significantly between occupations. However, broad-brimmed hats have sometimes been reported as cumbersome and awkward[19)], causing overheating, and requiring a neck strap when worn in windy conditions, which are common in NZ. The improvement of neck straps and airflow around the crown have the potential to increase comfort in windy and hot conditions. The snap-on neck veil for hard hats exemplifies the development of an acceptable sun safety practice that is also compatible with the use of other safety gear, such as eye and ear protection.

The use of other clothing protection did not differ significantly between occupations. Some sun protective clothing may be viewed as cumbersome, even potentially dangerous, in situations where it could restrict vision or movement, and loose fitting clothing can present a danger of being snagged, for example, in moving

machinery. Appropriate workplace clothing design needs to follow the innovative lead provided by outdoor recreational wear, for example, in minimizing the risk of overheating by using breathing fabrics.

Sunscreen use, both on the face alone and all exposed skin, differed significantly between occupations, with forestry workers reporting lowest usage for the latter. Limiting exposure was the least common protective practice reported, overall, followed by the use of shade, but neither differed significantly between occupations. These two strategies present major practical challenges in outdoor occupations. Nevertheless, scheduling work to follow the movement of shade is sometimes possible, for example in the construction industry, and the use of movable shade structures may be practical in circumstances where work is focused on relatively contained areas. The focus of much personal protection research has tended to be on sunscreen use and clothing, but limiting exposure and using shade, particularly during the middle of the day- including lunch breaks, deserve further investigation.

Workplace provision and culture

There is considerable scope for improvement in the workplace provision of sun-protective equipment, with mean Workplace Provision Scores (WPS) ranging from 0.8 (horticulture) to 2.4 (postal workers) out of a possible total of 4. Although a hat was the item most commonly provided, often it was not appropriately sun protective with neither a broad brim nor flaps to protect the neck and ears. The “culture” of cap wearing is strong in NZ, and caps with promotional logos are often distributed by commercial interests with which some workers may identify, so changing this culture at source may prove challenging. Postal workers stand out as being best provisioned, both overall and with respect to all protective items except shade and “other” clothing. This status may relate to postal delivery services being nationally organized in a single agency with common, long-established health and safety guidelines. The Workplace Culture Score also differed significantly between occupations, both each item and the total score, with the lowest overall score for forestry, consistent with that occupation also having the lowest mean PPS and a low WPS.

Multivariable modeling

In multivariable modeling, the Perceptions of Risk Score was not statistically significantly associated with Personal Sun-protection Scores and neither was the Knowledge Score, which here represented poor

knowledge, confirming that education and information, alone, are likely to be insufficient to influence sun-protective behaviour[41]. Female sex and occupation were relatively weakly statistically associated with protective practices, as was the Pro-Tan Attitude Score. The only strongly associated personal factor was skin response to sun exposure—a plausible finding, consistent with studies of other adult populations[42]. The other factors most strongly, and independently, associated with the Personal Protection Score were the two workplace scores. These findings suggest that the targeting of workers' knowledge, personal attitudes and risk perceptions, other than skin type awareness, is unlikely to be the most fruitful approach for improving sun protective practices. In contrast, ensuring workplace provision of protective equipment and promoting a supportive workplace culture would seem likely to be most productive for improving sun-protective practices across outdoor occupations.

Study strengths and limitations

The study sample was large and included participation from all age groups, indigenous Māori and females across a broad range of outdoor occupations. It also included other demographic, personal and workplace information, which permitted multivariable analysis to identify which factors were associated with the key outcome of interest—worker's sun protection. Among skin cancer prevention studies, it is uncommon to be able to draw on such a comprehensive database. However, the data are cross sectional, and so we are only able to report associations rather than attribute causality to the observed relations between plausible predictors and the outcome of interest, Personal Sun-protection Scores. The components of our summary psychometric scores were items developed from prior qualitative research among the study population of NZ outdoor workers, which reinforces score credibility. Furthermore, the alpha coefficients of the psychometric scores fell within the acceptable range. Nevertheless, study findings could be considerably strengthened by research to examine test-retest reliability and validate the measures as predictive of future sunburn, skin damage or melanoma risk.

The survey was completed between February and April (Southern Hemisphere summer and early autumn), the busiest time of year for many outdoor occupations, so the overall participation rate of 69% could be considered high. However, there were relatively fewer participants from the horticulture and viticulture industries (Table 1), due to late and sporadic harvests, which affected access to workers. We only report data for those who

worked outdoors for at least 50% of their normal working week, so caution needs to be exercised in extending our findings to those workers who spend less time outdoors, but may nevertheless experience substantial, more intermittent, sun exposure, which may put them at risk of skin cancer.

Conclusions

The levels of personal protection found in our study confirm that there remains a need to raise the profile of occupational skin cancer[34] and increase the priority given to primary prevention, particularly in the forestry, horticulture, farming and construction sectors. The optimal approach is likely to be a comprehensive one [26], that addresses personal factors as part of a broader program promoting the development of workplace contexts that positively support sun protection[43]. Although we found that the Pro-Tan Attitude Score was positively associated with protective practices, indicating that attitudes merit attention, this study both confirms and extends our earlier findings about the relatively strong association of workplace equipment provision and supportive culture with workers' sun protection[24, 41], confirming that employer-led interventions may offer a potentially promising direction for policy development and implementation[25]. Our results strongly suggest that workplace factors are likely to be among the most influential in achieving appropriate sun protection, albeit with worker cooperation, and that educational efforts to change workers' knowledge and attitudes, alone, are unlikely to be sufficient to significantly improve sun-protective behaviors.

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