Changes in sun protection behaviours, sun exposure and shade availability among adults, children and adolescents in New South Wales, 2003-2016

Andre Ying-Song Liew,[1] Anne E. Cust[2,3]

Abstract

Objective: To inform skin cancer prevention policies and campaigns, we investigated changes over time in sun protection behaviours, sunburn, sun exposure and shade availability in public spaces among people living in New South Wales (NSW), Australia, between 2003 and 2016.

Methods: We analysed cross-sectional data from the NSW Population Health Survey collected in 2003, 2007, 2014 and 2016, which included approximately 15,000 respondents of all ages in each year. Logistic regression models were used to analyse overall changes over time and for different age, sex and sociodemographic groups.

Results: The use of sunscreen and protective clothing and the availability of shade increased between 2003 and 2016, but sunburn and sun exposure during peak times of ultraviolet radiation also increased. In subgroup analyses, there was no improvement in sun protection behaviours among adolescents and increases in sunburn and sun exposure were observed only among adults, particularly women and in areas with less social disadvantage.

Conclusions: Sun protection behaviours have improved over time among some population subgroups, but over-exposure to ultraviolet radiation remains prevalent.

Implications for public health: Skin cancer prevention initiatives that specifically target adolescents and sun exposure during peak times are needed to help reduce population skin cancer risk.

Key words: sun protection, sun exposure, sunburn, skin cancer, prevention

Australia has the highest incidence of melanoma and keratinocyte carcinomas (non-melanoma skin cancers) in the world.[1,2] The major cause of melanoma and other skin cancers is excessive exposure to ultraviolet radiation (UV) from the sun, with the high rate of melanoma in Australia largely attributable to high ambient levels of UV and the substantial proportion of people with fair, sun-sensitive skin types.[3-5] The risk of developing melanoma increases with cumulative lifetime exposure to UV, and with more intermittent exposures such as those that lead to sunburn.[4,5] Improving sun protection behaviours such as regularly wearing sunscreen can reduce the risk of melanoma and other skin cancers.[6-9] The availability of shade in public spaces also affects skin cancer risk since high-quality shade can substantially reduce UV exposure.[10]

Trends in sun protection behaviours, sun exposure, sunburn and the availability of shade can inform how the population risk of melanoma and other skin cancers is evolving. These trends can also help to guide priorities for cancer prevention campaigns. Even within Australia, sun-related behaviours and the availability of shade can vary considerably due to the weather, local policies and societal norms. Recent Australian studies that have examined trends over time in primary prevention of skin cancer have been conducted in Western Australia[11,12] and Victoria,[13,14] but there are limited published data for New South Wales, the most populous state of Australia. Using population-based data, we investigated changes over time in sun protection behaviours, sun exposure, sunburn and the availability of shade in public spaces among people in the state of New South Wales (NSW) in Australia between 2003 and 2016.

Methods

Population sample

We analysed data from the NSW Population Health Survey, an annual cross-sectional survey conducted by the Centre for Epidemiology and Research at the NSW Department of Health. Respondents were surveyed using computer-assisted telephone interviewing (CATI) about their health behaviours, health outcomes and other socio-demographic factors.[15,16] Interviews were conducted continuously between February and December each year. Households were selected using random digit dialling and one person only from that household was randomly selected for inclusion in the survey. If the selected respondent was a child under 16 years old, a parent or carer was selected

1. Sydney Medical School, Faculty of Medicine and Health, The University of Sydney, New South Wales
2. Daffodil Centre, The University of Sydney, a joint venture with Cancer Council NSW
3. Melanoma Institute Australia, The University of Sydney, New South Wales
Correspondence to: Professor Anne Cust, Level 3, Edward For Building A27, Camperdown NSW 2050; e-mail: anne.cust@sydney.edu.au
Submitted: November 2020; Revision requested: March 2021; Accepted: March 2021
The authors have stated they have no conflict of interest.

Aust NZ J Public Health. 2021; 45:462-8; doi: 10.1111/1753-6405.13112

as a proxy respondent for the child for all questions.

The target sample for the survey was 1,000 people from each health administrative area, corresponding to a total sample of around 16,000 participants each year. Weights provided with the survey data were applied to the sample data so that their characteristics matched the target population, which is all residents living in private households in NSW.[15] We analysed data from 2003, 2007, 2014 and 2016, the years in which data related to sun protection were collected. Sun protection data were also available for 2010; however, the questions included in the survey that year were not consistent with those collected in other years and so were excluded from our analysis. Specifically, in 2010, the survey asked about sun exposure and protection over the previous summer; whereas, in the other years the reference period was the previous four weeks.[17]

Outcomes

We analysed changes in the frequency of four sun protection behaviours: wearing a hat, applying sunscreen, wearing protective clothing and wearing sunglasses. We also analysed changes in the ability of respondents to find shade in three public spaces – local sporting areas, outdoor swimming pools and public parks – as well as the frequency of sun exposure at times of peak UV (11am–3pm) and sunburn. Data relating to the availability of shade in public areas and wearing sunglasses were collected in 2007, 2014 and 2016. All other variables were collected in 2003, 2014 and 2016.

For protective behaviours, respondents were asked on a four-point scale how often over the past four weeks they (or their child) engaged in these behaviours when they were outside in the sun for more than 15 minutes. We coded response categories so that higher numbers were associated with more frequent behaviours: Rarely/Never=1, Sometimes=2, Often=3 and Always=4. For sun exposure and sunburn, respondents were asked on a five-point scale how often over the past four weeks they were out in the sun for more than 15 minutes between 11 am and 3 pm, and how often they got sunburnt so that their skin was sore or tender the next day. For sun exposure, we coded responses so that Never=1, Rarely=2, Sometimes=3, Often=4 and Always=5. For sunburn, we recoded responses so that Not at all=0 and One or more times=1 due to the rarity of multiple incidences of sunburn. For the availability of shade in public spaces, respondents were asked whether it was easy (yes/no) in their local area to find shade at a particular outdoor space.

Statistical analysis

Data analyses were conducted using Stata 13. Population weights (provided by the Department of Health) were applied so that the estimated statistical models were representative of the target population.[15,16] Due to their ordinal scale, we used each of the four sun protection behaviours as well as sun exposure as dependent variables in ordinal logistic regression models, so the odds ratio (OR) represents the odds of a one-unit increase in the survey response, e.g. from rarely/never to sometimes, or from sometimes to often, or from often to always. We also conducted binomial logistic regression to analyse sunburn incidence and shade availability as binary variables.

To analyse changes over time in the dependent variables, the survey year was included in each of the models as the main covariate of interest. The first survey year – 2007 for sunglasses and shade availability, and 2003 for the other explanatory variables – was used as a baseline year to compare separately with 2014 and 2016. ORs, 95% confidence intervals (CIs), and corresponding p-values were used to compare the effect of being surveyed in 2014 and 2016 relative to the baseline (earliest) year. Statistical significance was inferred at $p<0.05$.

Comparing both 2014 and 2016 with the baseline year helps to ensure that any changes identified are not simply due to temporal factors affecting the more recent years, such as particularly hot weather, which we are unable to control for in our models. Potential confounders – age, sex, country of birth and socioeconomic disadvantage quintile – were included as covariates in all logistic regression models, to produce adjusted ORs. The socioeconomic disadvantage of respondents was defined using the Index of Relative Socio-economic Disadvantage, which is calculated based on the proportion of households in the postcode with low income, people with no qualifications and people working in low skill occupations in a given postcode.[18]

To analyse whether the changes over time observed in sun protection behaviours, sun exposure, sunburn and shade availability were consistent across different age groups, for females and males and different levels of socioeconomic disadvantage, we performed subgroup analyses stratified by age (children <12, adolescents 12–17, adults ≥18 years), sex and socioeconomic disadvantage (greater socioeconomic disadvantage – quintiles 4 and 5; less socioeconomic disadvantage – quintiles 1, 2 and 3).

Results

Sample characteristics

The number of respondents interviewed for the NSW Population Health Survey varied between 14,732 and 16,160 in 2003, 2007, 2014 and 2016 (Table 1). The mean age increased across the survey years from 44 years (SD=24 years) in 2003 to 51 years (SD=25 years) in 2016. Females made up 57% to 59% of survey samples. Participants who were part of the least disadvantaged quintile comprised 12% to 15% of the sample, and 21% to 24% comprised the most disadvantaged quintile. The proportion of respondents who were born in Australia declined over the study period.

Table 1: Unweighted characteristics of NSW Population Health Survey participants.

	Year			
	2003	2007	2014	2016
	N=15,837	N=16,160	N=14,732	N=15,884
Age (mean; SD)	43.5 (23.7)	45.5 (24.3)	48.9 (23.8)	51.3 (24.6)
Female (%)	56.9	58.9	57.2	57.3
Born in Australia (%)	83.4	79.2	75.3	76.6
Index of relative socio-economic disadvantage quintile (%)				
1st quintile (least disadvantaged)	11.8	15.0	14.2	13.7
2nd quintile	18.1	16.6	17.3	16.6
3rd quintile	21.8	21.6	21.4	21.2
4th quintile	26.9	24.9	24.7	24.2
5th quintile (most disadvantaged)	21.4	22.0	22.4	24.2

Descriptive statistics

Based on visual inspection of mean survey responses, wearing sunglasses was the sun protection behaviour participants engaged in most frequently across survey years (Table 2). The least frequent behaviour in 2003 was applying sunscreen, whereas wearing a hat was the least frequent behaviour in 2016. For sun exposure, 'sometimes' and 'often' were the most common responses in each year. Across the survey years, 8–12% of participants reported one or more sunburns over the past month. Participants reported that shade was most commonly available at public parks and least commonly available at sporting areas in each survey year.

Changes over time

ORs for sun protection behaviours, sun exposure, sunburn and shade availability between 2003 and 2016 are shown in Table 2, with the earliest year used as the reference category for the ORs. Compared with 2003, there was an increase in sunscreen use in 2014 and 2016. An OR of 1.52 (for 2016) implies that for participants surveyed in 2016 the odds of reporting higher sunscreen use (i.e. a one-unit increase in survey response) was 52% higher than for participants surveyed in 2003, holding constant other covariates. Wearing protective clothing also increased over this period as did hat wearing. However, there was no change in sunglass wear over time. There was an increase in sun exposure during times of peak UV in 2014 (OR=1.09 per one-unit increase in the survey scale; p=0.004) and 2016 compared with 2003. Respondents also reported increased incidence of sunburn over this period. Respondents reported increased availability of shade in public spaces between 2007 and 2016. This included at local sporting areas, outdoor swimming pools and public parks.

Changes over time according to age group, sex and socioeconomic disadvantage

Shown in Table 3, the increase in the use of sunscreen between 2003 and 2016 was driven by both children <12 years and adults; whereas, sunscreen use by adolescents (12–17 years) showed only a modest improvement of borderline statistical significance. Increased wearing of protective clothing was observed among adults but among children there was a decline in 2016 compared with 2003. While there was no

Table 2: Changes in sun protection behaviours, sun exposure, sunburn and shade availability.

	Year			
	2003 N=15,837	2007 N=16,160	2014 N=14,732	2016 N=15,884
Hat wear				
Mean (SD)	2.16 (1.29)		2.19 (1.28)	2.18 (1.27)
% Rarely/Never	49.5		47.2	47.3
% Sometimes	12.5		13.4	13.6
% Often	10.4		12.9	12.6
% Always	27.5		26.5	26.4
OR (95% CI)	1.00		1.09 (1.02-1.16)	1.07 (1.00-1.14)
p-value			0.01	0.05
Sunscreen use				
Mean (SD)	1.94 (1.20)		2.25 (1.24)	2.23 (1.25)
% Rarely/Never	55.4		41.1	43.4
% Sometimes	14.8		18.5	16.7
% Often	10.3		14.6	13.9
% Always	19.4		25.8	26.1
OR (95% CI)	1.00		1.50 (1.40-1.60)	1.52 (1.42-1.63)
p-value			<0.001	<0.001
Protective clothing				
Mean (SD)	2.21 (1.24)		2.40 (1.21)	2.30 (1.19)
% Rarely/Never	43.7		33.3	36.5
% Sometimes	16.6		21.0	20.7
% Often	14.5		18.2	18.5
% Always	25.2		27.4	24.3
OR (95% CI)	1.00		1.30 (1.22-1.39)	1.14 (1.07-1.21)
p-value			<0.001	<0.001
Sunglass wear				
Mean (SD)		2.37 (1.32)	2.57 (1.30)	2.54 (1.31)
% Rarely/Never		41.3	34.1	35.4
% Sometimes		13.8	13.3	12.8
% Often		11.4	14.5	13.7
% Always		33.5	38.1	38.0
OR (95% CI)		1.00	1.02 (0.95-1.10)	0.99 (0.92-1.07)
p-value			0.61	0.87
Sun exposure				
Mean (SD)	3.67 (1.00)		3.71 (0.98)	3.73 (0.98)
% Never	0.0		0.0	0.0
% Rarely	14.0		12.5	12.0
% Sometimes	30.6		30.0	29.1
% Often	30.1		32.0	32.9
% Always	25.2		25.5	26.0
OR (95% CI)	1.00		1.09 (1.03-1.16)	1.12 (1.05-1.18)
p-value			0.004	<0.001
Sunburn				
% None	92.0		89.6	88.2
% 1 or more times	8.0		10.4	11.8
OR (95% CI)	1.00		1.15 (1.00-1.31)	1.35 (1.18-1.53)
p-value			0.05	<0.001
Shade in sporting areas				
% Easy to find shade		58.7	67.6	68.5
% Not easy to find shade		41.3	32.4	31.5
OR (95% CI)		1.00	1.47 (1.35-1.60)	1.54 (1.41-1.68)
p-value			<0.001	<0.001
Shade at public pools				
% Easy to find shade		72.9	75.9	78.0
% Not easy to find shade		27.1	24.1	22.0
OR (95% CI)		1.00	1.20 (1.08-1.35)	1.33 (1.19-1.48)
p-value			0.001	<0.001
Shade at public parks				
% Easy to find shade		75.4	78.9	81.0
% Not easy to find shade		24.6	21.1	19.0
OR (95% CI)		1.00	1.23 (1.12-1.35)	1.41 (1.28-1.55)
p-value			<0.001	<0.001

Notes: SD, standard deviation; OR, odds ratio; CI, confidence interval

All odds ratios were adjusted for age, sex, country of birth and area-based socioeconomic disadvantage quintile.

Table 3: Changes in sun-related behaviours and shade availability according to age-group, sex and socio-economic disadvantage.

Sun-related factor	Year 2003	2007	2014	2016
Hat wear				
Children	N=2,055	N=2,205	N=1,459	N=1,559
OR (95% CI)	1.00		1.17 (0.96-1.41)	0.94 (0.78-1.14)
p-value			0.12	0.53
Adolescents	N=1,054	N=1,025	N=771	N=927
OR (95% CI)	1.00		1.09 (0.82-1.46)	1.08 (0.82-1.42)
p-value			0.54	0.57
Adults	N=12,728	N=12,930	N=12,502	N=13,398
OR (95% CI)	1.00		1.03 (0.95-1.11)	1.01 (0.93-1.09)
p-value			0.50	0.84
Males	N=6,831	N=6,641	N=6,312	N=6,778
OR (95% CI)	1.00		1.10 (1.00-1.21)	1.08 (0.98-1.19)
p-value			0.06	0.14
Females	N=9,006	N=9,519	N=8,420	N=9,106
OR (95% CI)	1.00		1.08 (0.99-1.18)	1.07 (0.97-1.17)
p-value			0.10	0.16
Greater socioeconomic disadvantage	N=7,648	N=7,567	N=6,939	N=7,678
OR (95% CI)	1.00		1.03 (0.93-1.14)	1.03 (0.93-1.14)
p-value			0.59	0.58
Less socioeconomic disadvantage	N=8,168	N=8,589	N=7,786	N=8,190
OR (95% CI)	1.00		1.13 (1.03-1.23)	1.09 (1.00-1.19)
p-value			0.01	0.05
Sunscreen use				
Children				
OR (95% CI)	1.00		1.57 (1.32-1.87)	1.49 (1.24-1.79)
p-value			<0.001	<0.001
Adolescents				
OR (95% CI)	1.00		1.27 (0.99-1.63)	1.27 (0.99-1.63)
p-value			0.06	0.06
Adults				
OR (95% CI)	1.00		1.49 (1.38-1.61)	1.53 (1.42-1.65)
p-value			<0.001	<0.001
Males				
OR (95% CI)	1.00		1.54 (1.40-1.71)	1.58 (1.42-1.75)
p-value			<0.001	<0.001
Females				
OR (95% CI)	1.00		1.46 (1.33-1.59)	1.48 (1.35-1.61)
p-value			<0.001	<0.001
Greater socioeconomic disadvantage				
OR (95% CI)	1.00		1.48 (1.33-1.64)	1.40 (1.26-1.57)
p-value			<0.001	<0.001
Less socio-economic disadvantage				
OR (95% CI)	1.00		1.51 (1.38-1.64)	1.58 (1.44-1.73)
p-value			<0.001	<0.001
Protective clothing				
Children				
OR (95% CI)	1.00		1.01 (0.84-1.21)	0.80 (0.66-0.96)
p-value			0.92	0.02
Adolescents				
OR (95% CI)	1.00		1.15 (0.90-1.47)	1.18 (0.91-1.53)
p-value			0.25	0.20
Adults				
OR (95% CI)	1.00		1.36 (1.26-1.46)	1.17 (1.09-1.26)
p-value			<0.001	<0.001
Males				
OR (95% CI)	1.00		1.26 (1.15-1.39)	1.10 (1.00-1.21)
p-value			<0.001	0.04
Females				
OR (95% CI)	1.00		1.34 (1.23-1.46)	1.17 (1.08-1.28)
p-value			<0.001	<0.001

Table 3 cont.: Changes in sun-related behaviours and shade availability according to age-group, sex and socio-economic disadvantage.

Sun-related factor	Year 2003	2007	2014	2016
Protective clothing cont.				
Greater socioeconomic disadvantage				
OR (95% CI)	1.00		1.16 (1.05-1.28)	1.09 (0.99-1.20)
p-value			0.004	0.09
Less socioeconomic disadvantage				
OR (95% CI)	1.00		1.40 (1.28-1.52)	1.17 (1.07-1.27)
p-value			<0.001	<0.001
Sunglass wear				
Children				
OR (95% CI)		1.00	0.86 (0.69-1.07)	0.89 (0.72-1.12)
p-value			0.17	0.32
Adolescents				
OR (95% CI)		1.00	0.61 (0.46-0.80)	0.63 (0.48-0.83)
p-value			<0.001	0.001
Adults				
OR (95% CI)		1.00	1.00 (0.92-1.09)	0.98 (0.90-1.07)
p-value			0.97	0.67
Males				
OR (95% CI)		1.00	1.10 (0.99-1.22)	1.01 (0.91-1.13)
p-value			0.09	0.85
Females				
OR (95% CI)		1.00	0.95 (0.86-1.05)	0.98 (0.88-1.08)
p-value			0.32	0.64
Greater socioeconomic disadvantage				
OR (95% CI)		1.00	1.11 (0.99-1.24)	0.99 (0.88-1.11)
p-value			0.07	0.81
Less socioeconomic disadvantage				
OR (95% CI)		1.00	0.96 (0.87-1.06)	1.00 (0.91-1.10)
p-value			0.43	0.97
Sun exposure				
Children				
OR (95% CI)	1.00		1.03 (0.85-1.24)	1.00 (0.84-1.17)
p-value			0.77	0.95
Adolescents				
OR (95% CI)	1.00		1.04 (0.82-1.32)	1.06 (0.82-1.37)
p-value			0.75	0.64
Adults				
OR (95% CI)	1.00		1.12 (1.05-1.19)	1.15 (1.08-1.23)
p-value			0.001	<0.001
Males				
OR (95% CI)	1.00		1.01 (0.92-1.10)	1.02 (0.94-1.12)
p-value			0.86	0.59
Females				
OR (95% CI)	1.00		1.17 (1.09-1.27)	1.22 (1.12-1.31)
p-value			<0.001	<0.001
Greater socioeconomic disadvantage				
OR (95% CI)	1.00		1.08 (0.98-1.18)	0.99 (0.91-1.09)
p-value			0.11	0.90
Less socioeconomic disadvantage				
OR (95% CI)	1.00		1.09 (1.01-1.18)	1.20 (1.11-1.29)
p-value			0.02	<0.001
Sunburn				
Children				
OR (95% CI)	1.00		0.92 (0.52-1.61)	1.36 (0.88-2.09)
p-value			0.76	0.17
Adolescents				
OR (95% CI)	1.00		0.85 (0.57-1.27)	1.30 (0.91-1.86)
p-value			0.43	0.14

Table 3 cont.: Changes in sun-related behaviours and shade availability according to age-group, sex and socio-economic disadvantage.

Sun-related factor	Year 2003	2007	2014	2016
Sunburn cont.				
Adults				
OR (95% CI)	1.00		1.35 (1.16-1.58)	1.53 (1.32-1.78)
p-value			<0.001	<0.001
Males				
OR (95% CI)	1.00		1.03 (0.85-1.24)	1.20 (1.00-1.43)
p-value			0.77	0.05
Females				
OR (95% CI)	1.00		1.31 (1.08-1.58)	1.56 (1.29-1.88)
p-value			0.01	<0.001
Greater socioeconomic disadvantage				
OR (95% CI)	1.00		1.11 (0.90-1.37)	1.09 (0.89-1.32)
p-value			0.34	0.41
Less socioeconomic disadvantage				
OR (95% CI)	1.00		1.18 (0.99-1.40)	1.53 (1.29-1.82)
p-value			0.07	<0.001
Shade in sporting areas				
Greater socioeconomic disadvantage				
OR (95% CI)		1.00	1.44 (1.26-1.64)	1.51 (1.32-1.73)
p-value			<0.001	<0.001
Less socioeconomic disadvantage				
OR (95% CI)		1.00	1.50 (1.33-1.67)	1.55 (1.39-1.74)
p-value			<0.001	<0.001

Table 3 cont.: Changes in sun-related behaviours and shade availability according to age-group, sex and socio-economic disadvantage.

Sun-related factor	Year 2003	2007	2014	2016
Shade at public pools				
Greater socioeconomic disadvantage				
OR (95% CI)		1.00	1.35 (1.14-1.61)	1.40 (1.18-1.66)
p-value			0.001	<0.001
Less socioeconomic disadvantage				
OR (95% CI)		1.00	1.12 (0.97-1.30)	1.27 (1.10-1.47)
p-value			0.13	0.001
Shade at public parks				
Greater socioeconomic disadvantage				
OR (95% CI)		1.00	1.15 (1.03-1.27)	1.26 (1.14-1.40)
p-value			0.01	<0.001
Less socioeconomic disadvantage				
OR (95% CI)		1.00	1.30 (1.15-1.47)	1.43 (1.26-1.62)
p-value			<0.001	<0.001

Notes:

SD, standard deviation; OR, odds ratio; CI, confidence interval

All odds ratios were adjusted for age, sex, country of birth and area-based socioeconomic disadvantage quintile.

Children were <12 years, adolescents 12-17 years, and adults ≥18 years.

overall change in the wearing of sunglasses between 2007 and 2016, there was a decline in use by adolescents. Sun exposure and sunburn increased among adults but not among children or adolescents.

The overall changes over time in sun protection behaviours were consistent for both females and males. However, while sun exposure and sunburn increased for females, for males there was no change in sun exposure and a weak positive association with sunburn.

Changes over time in sunscreen use, protective clothing and the availability of shade in public spaces were consistent across different levels of socioeconomic disadvantage. Hat wear increased among people with less socioeconomic disadvantage but was unchanged among people with greater socioeconomic disadvantage. Sun exposure and sunburn increased in people with less socioeconomic disadvantage but were unchanged among people with more socioeconomic disadvantage.

Discussion

Previous longitudinal research in Australia has shown that there was a marked improvement in sun protection behaviours from the 1980s until the mid-1990s, coinciding with the introduction of mass media and school-based sun protection campaigns, before this improvement plateaued in the 2000s.[12-14] Although our study design was cross-sectional rather than longitudinal, the survey was repeated in different years, was population-based and the analysis was weighted to the target population, allowing examination of changes in the population over time. Our results suggest that sun protection behaviours improved further between 2003 and 2016 in NSW. Despite this improvement, these data show that many people in NSW continue to rarely or never engage in recommended sun protection behaviour: ranging in 2016 from 35% who never/rarely wear sunglasses to 47% who never/rarely wear a hat. These results show that there remains a need for public health campaigns to improve sun-related behaviours in the population.

Despite overall improvements, our age-group analysis indicates that sun protection behaviours did not significantly improve among adolescents and for sunglass wear it worsened for this age group over the sample period. This trend is consistent with the findings for adolescents living in Victoria and Western Australia and highlights the need for effective policies to improve sun protection behaviours in this age group that is typically hard to influence.[11,19] Previous qualitative research has highlighted multiple potential causes of poor compliance among adolescents including the perceived desirability of a tan, prevailing fashion trends that discourage the wearing of protective clothing and hats, and the perception that sun protection is inconvenient.[20]

Our results also indicate that local governments have improved access to shady areas in public spaces over time and that this increase was consistent across different levels of socioeconomic disadvantage. It is important that access to shade in public areas is equitable, since previous research has found that people living in areas with more socioeconomic disadvantage have less access to shade in public spaces.[21]

In contrast to improvements in sun protection behaviours and shade availability, our results also demonstrate an increase in sun exposure and sunburn over the sample period among adults, particularly among females as well as people with less socioeconomic disadvantage. Studies across different countries have found that females are more likely to believe that tanning improves their appearance and are more likely to engage in outdoor and indoor tanning.[22-24] This suggests the need for programs that seek to reduce sun exposure and sunburn among females by reducing the appeal of tanning. People with less socioeconomic disadvantage may have more opportunity for peak-time UV exposure during leisure time and holiday travel.

The fact that rates of sunburn increased despite increased sun protection behaviours highlights that multifaceted public health initiatives are needed that not only focus on improving sun protection behaviours and attitudes towards tanning but also reduce time in the sun, particularly at times of peak UV, and increase the availability of shade in public places. Indeed, 60% of respondents in 2016 reported often or always spending more than 15 minutes in the sun between 11 am and 3 pm. However, this metric is only a blunt measure of sun exposure since it does not differentiate between spending 15 minutes and spending longer periods outside. As a result, it may not fully capture trends for people spending longer periods outside in the sun.

There are several limitations in our study. One is that the sun protection and sun exposure measures were self-reported. This could introduce bias from poor recall or from a desire of respondents to provide socially desirable responses.[25] However, self-reported sun protection behaviours and exposures have previously been shown to be correlated with more objective measures without systematic bias, and are thus valid measures.[26-28] To our knowledge, survey items regarding the availability of shade have not been validated, but compared with sun protection behaviours they may be less prone to bias from socially desirable responses. Skin colour and skin sun sensitivity were not included as covariates in the regression models because these variables were only collected in 2014 and 2016. This could have biased the estimated models, particularly if the distribution of skin types has changed over time, although this may have been partly controlled for by including respondents' country of birth as a covariate.

In the NSW Population Health Survey, responses for children and adolescents under 16 years of age were provided by their parents who may not have accurate knowledge of their children's sun protection behaviours and exposures outside of times they were accompanying them. Adolescents, in particular, could over-estimate their use of sun protective behaviours to their parents in order to avoid censure. However, our results for adolescents showed similar trends to previous longitudinal research that surveyed adolescents directly.[11,19] In addition, the sample size for children and adolescents was much smaller than for adults, which limits the ability to detect statistically significant associations in these subgroups in the analyses by age group.

Because the NSW Population Health Survey was collected across the whole year, our descriptive statistics are not directly comparable to other longitudinal studies that have asked participants about their sun protection behaviours and exposures during summer months. Our models also did not control for temperature or other weather conditions at the time of the survey. The average temperature in NSW and the Australian Capital Territory was 0.3 degrees higher in 2014 and 2016 compared with 2003 and 2007, but it is unknown to what extent this difference would affect sun protection behaviours and personal sun exposure.[29] Interviews were conducted continuously between February and December, so it is unlikely that the proportion of respondents surveyed in the warmer months differed across survey years. The inability to examine seasonal differences in behaviour and control for key variables such as temperature, UV and skin type means that these results should not be considered gold standard for reporting on changes in sun protection and exposure. The measures of perceived shade availability over time are likely to be less seasonally dependent and provide a useful evaluation measure for targeted improvements in shade provision by state and local governments, such as shade provision grants and other initiatives by the Cancer Institute NSW and Cancer Councils.[30,31]

Conclusion

This study has shown that sun protection behaviours improved in NSW between 2003 and 2016, but this was less apparent for adolescents. However, rates of sunburn and sun exposure during times of peak UV increased over this period among adults, particularly women and people with less socioeconomic disadvantage. These results highlight an ongoing need for sun-safe policies and campaigns to improve sun protection behaviours among adolescents and to reduce sun exposure during times of peak UV.

Acknowledgements

We thank the NSW Ministry of Health for providing the data, Lauren Humphreys for her contribution to the analysis plan, and David Espinoza for statistical support.

Funding

AEC was supported by a National Health and Medical Research Centre (NHMRC) Career Development Fellowship [1147843].

References

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2018;68(6):394-424.
2. Australian Institute of Health and Welfare. *Skin Cancer in Australia*. Canberra (AUST): AIHW; 2016.
3. Kricker A, Weber M, Sitas F, Banks E, Rahman B, Goumas C, et al. Early life UV and risk of basal and squamous cell carcinoma in New South Wales, Australia. *Photochem Photobiol*. 2017;93(6):1483-91.
4. Armstrong BK, Cust AE. Sun exposure and skin cancer, and the puzzle of cutaneous melanoma: A perspective on Fears et al. Mathematical models of age and ultraviolet effects on the incidence of skin cancer among whites in the United States. American Journal of Epidemiology 1977; 105: 420-427. *Cancer Epidemiol*. 2017;48:147-56.
5. Armstrong BK, Kricker A. The epidemiology of UV induced skin cancer. *J Photochem Photobiol B*. 2001;63(1-3):8-18.
6. Olsen CM, Wilson LF, Green AC, Bain CJ, Fritschi L, Neale RE, et al. Cancers in Australia attributable to exposure to solar ultraviolet radiation and prevented by regular sunscreen use. *Aust N Z J Public Health*. 2015;39(5):471-6.
7. Green AC, Williams GM, Logan V, Strutton GM. Reduced melanoma after regular sunscreen use: randomized trial follow-up. *J Clin Oncol*. 2011;29(3):257-63.
8. Watts CG, Drummond M, Goumas C, Schmid H, Armstrong BK, Aitken JF, et al. Sunscreen use and melanoma risk among young Australian adults. *JAMA Dermatol*. 2018;154(9):1001-9.
9. Green A, Williams G, Neale R, Hart V, Leslie D, Parsons P, et al. Daily sunscreen application and betacarotene supplementation in prevention of basal-cell and squamous-cell carcinomas of the skin: A randomised controlled trial. *Lancet*. 1999;354(9180):723-9.
10. Parsons PG, Neale R, Wolski P, Green A. The shady side of solar protection. *Med J Aust*. 1998;168(7):327-30.
11. Koch S, Pettigrew S, Hollier LP, Slevin T, Strickland M, Minto C, et al. Trends in Australian adolescents' sun-protection behaviours: Implications for health campaigns. *Aust N Z J Public Health*. 2016;40(5):468-73.
12. Koch S, Pettigrew S, Minto C, Slevin T, Strickland M, Lin C, et al. Trends in sun-protection behaviour in Australian adults 2007-2012. *Australas J Dermatol*. 2017;58(2):111-16.
13. Makin JK, Warne CD, Dobbinson SJ, Wakefield MA, Hill DJ. Population and age-group trends in weekend sun protection and sunburn over two decades of the SunSmart programme in Melbourne, Australia. *Br J Dermatol*. 2013;168(1):154-61.
14. Tabbakh T, Volkov A, Wakefield M, Dobbinson S. Implementation of the SunSmart program and population sun protection behaviour in Melbourne, Australia: Results from cross-sectional summer surveys from 1987 to 2017. *PLoS Med*. 2019;16(10):e1002932.
15. Barr M. *NSW Population Health Survey Methods – 2012 Update*. Sydney (AUST): New South Wales Department of Health Centre for Epidemiology and Evidence; 2012.
16. Barr M, Baker D, Gorringe M, Fritsche L. *NSW Population Health Survey: Description of Methods*. Sydney (AUST): New South Wales Department of Health Centre for Epidemiology and Evidence; 2008.
17. NSW Centre for Epidemiology and Evidence. *2010 Adult Health Survey Data Dictionary* [Internet]. Sydney (AUST): New South Wales Department of Health; 2010 [cited 2020 Aug 8]. Available from: https://www.health.nsw.gov.au/surveys/adult/documents/2010_adult_health_survey_data_dictionary.pdf
18. Australian Bureau of Statistics. *2033.0.55.001 - Census of Population and Housing: Socioeconomic Indexes for Areas (SEIFA)*. Canberra (AUST): ABS; 2016.

19. Volkov A, Dobbinson S, Wakefield M, Slevin T. Seven-year trends in sun protection and sunburn among Australian adolescents and adults. *Aust N Z J Public Health*. 2013;37(1):63-9.
20. Potente S, Coppa K, Williams A, Engels R. Legally brown: Using ethnographic methods to understand sun protection attitudes and behaviours among young Australians 'I didn't mean to get burnt--it just happened!'. *Health Educ Res*. 2011;26(1):39-52.
21. Anderson C, Jackson K, Egger S, Chapman K, Rock V. Shade in urban playgrounds in Sydney and inequities in availability for those living in lower socioeconomic areas. *Aust N Z J Public Health*. 2014;38(1):49-53.
22. Holman DM, Watson M. Correlates of intentional tanning among adolescents in the United States: A systematic review of the literature. *J Adolesc Health*. 2013;52(5 Suppl):52-9.
23. Pettigrew S, Jongenelis M, Strickland M, Minto C, Slevin T, Jalleh G, et al. Predictors of sun protection behaviours and sunburn among Australian adolescents. *BMC Public Health*. 2016;16:565.
24. Kasparian NA, McLoone JK, Meiser B. Skin cancer-related prevention and screening behaviors: A review of the literature. *J Behav Med*. 2009;32(5):406-28.
25. Van de Mortel TF. Faking it: Social desirability response bias in self-report research. *Aust J Adv Nurs*. 2008;25(4):40-8.
26. Glanz K, McCarty F, Nehl EJ, O'Riordan DL, Gies P, Bundy L, et al. Validity of self-reported sunscreen use by parents, children, and lifeguards. *Am J Prev Med*. 2009;36(1):63-9.
27. Glanz K, Gies P, O'Riordan DL, Elliott T, Nehl E, McCarty F, et al. Validity of self-reported solar UVR exposure compared with objectively measured UVR exposure. *Cancer Epidemiol Biomarkers Prev*. 2010;19(12):3005-12.
28. O'Riordan DL, Nehl E, Gies P, Bundy L, Burgess K, Davis E, et al. Validity of covering-up sun-protection habits: Association of observations and self-report. *J Am Acad Dermatol*. 2009;60(5):739-44.
29. Bureau of Meteorology. *Annual Mean Temperature Anomaly NSW/ACT (1910 to 2019)* [Internet]. Canberra (AUST): BOM; 2019 [cited 2020 Aug 8]. Available from: http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Dtmean%26area%3Dnsw%26season%3D0112%26ave_yr%3D0
30. Cancer Council New South Wales. *Guidelines to Shade*. Sydney (AUST): Cancer Council NSW; 2013.
31. Cancer Council New South Wales. *Shade and Sun Protection* [Internet]. Sydney (AUST): Cancer Council NSW; 2019 [cited 2021 Mar 7]. Available from: https://www.cancercouncil.com.au/cancer-prevention/sun-protection/shade-and-sun-protection/