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Research Article

Serial Cross-Sectional Observations of Sun-Protective Behaviors at an Annual Outdoor Motorsport Event in Tropical Queensland, Australia

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ABSTRACT

Skin cancer, the most prevalent cancer in Caucasians residing at low latitudes, can primarily be prevented by avoiding overexposure to sunlight. Serial cross-sectional observations were conducted at an outdoor motorsport event held in Townsville, Queensland each July (Southern winter) to determine whether sun-protection habits changed over time. Most (71.1%) of the 1337 attendees observed (97.6% lightly pigmented skin, 64.0% male) wore a hat (any style shading the face), while few (18.5%) wore three-quarter or full-length sleeves. While hat-wearing rates (any style) were similar in 2009 (326, 72.6%) and 2013 (625, 70.4%), the use of sun-protective styles (wide-brimmed/bucket/legionnaires) decreased from 29.2% to 18.6% over the same period, primarily because the use of sun-protective hats halved (from 28.7% to 14.0%) among females, while decreasing from 29.4% to 21.1% in males. Although relatively few individuals wore sun-protective (three-quarter-length or full-length) sleeves regardless of year (OR = 0.117, *P* < 0.0001), encouragingly, the use of sun-protective sleeves more than doubled between 2009 (10.5%) and 2013 (22.5%). Interestingly females, albeit the minority, at this sporting event were less likely to wear a hat (OR = 0.473, *P* < 0.0001) than males. These findings highlight the need for continued momentum toward skin cancer primary prevention through sun protection with a dedicated focus on outdoor sporting settings.

INTRODUCTION

Excessive, but also incidental sun exposure is responsible for melanoma and keratinocyte carcinomas (KC), as well as ocular photo-damage (1). Approximately 99 780 new melanoma cases were expected in the USA in 2022 (2). The economic burden of treating skin cancer (which is comprised of both melanoma and KC) has also risen at a faster pace (126.2% increase between 2002–2006 and 2007–2011, to $USD 8.1 billion annually) than for other cancers over the same period (25.1% increase to $USD 79.7 billion per year) (3). Given the improvements seen in melanoma treatment since 2011 (including approval of the first immune checkpoint inhibitor by the US Food and Drug Administration) (4) the current cost is likely to be much higher than suggested by these older data and is in line with projections that the annual cost of treating new patients with melanoma in the USA will reach $1.6 billion by 2030 (5).

The incidence of skin cancer in Australia and New Zealand is much higher than in other countries with predominately fair-skinned populations such as the USA, UK and Canada (6). Consequently, the burden to the Australian health care system is massive, with direct healthcare costs borne by the Government for all patients newly diagnosed with melanoma accounting for $AUD 397.9 million and $AUD 426.2 million for KCs in 2021 (7), making skin cancer the costliest of all cancers nationally (7).

Approximately 95% of melanomas can be prevented by avoiding overexposure to ultraviolet radiation (UVR) (8). Despite the health and economic gains of sun-safety campaigns conducted in Australia since the 1980s, such as “Slip Slop Slap” to raise awareness of the potentially fatal consequences of sun exposure (9), skin cancer incidence has continued to rise in all but the youngest cohorts (8).

Primary prevention with basic complements of sun protection requires a dedicated focus in outdoor settings, both occupational and recreational. In 2009, we (10) found that while most spectators (72.2%) observed at an outdoor motorsport event held in tropical Queensland’s intense ambient UVR environment wore a hat of some kind, only 29.1% of attendees wore hats that provided adequate sun protection (wide-brimmed, bucket or legionnaires hat), while 10.6% wore three-quarter or full-length sleeves. Caps were the most popular choice, worn by 41.9% of

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spectators. At an outdoor event in New South Wales in 2015, over half the attendees wore a hat, while only 14.4% wore sun-protective clothing (11). Furthermore, our recent observational study of the sun-protective behaviors of pedestrians in Brisbane found that 86.6% and 66.9% of those observed were not wearing a hat or sunglasses (12). Gender also appears to influence the use of sun-protective hats and clothing in Queensland, with fewer women in Queensland observed wearing these (10,12). It is, however, possible that they were wearing sunscreen.

This research compares serial observations of sun-protective behaviors recorded at the same annual outdoor motorsport event in 2009 (10) and 2013 to determine whether the proportion of attendees using personal sun protection during peak UVR times changed over this period. The most recent data will also serve as a baseline from which changes in sun-protection behaviors can be measured over time and will be of benefit in evaluating the impact of the federally funded AU$10 million national awareness campaign launched during Summer 2022 (8,9). This is the first national mass media skin cancer prevention campaign to be conducted in Australia in more than a decade (9).

MATERIALS AND METHODS

Data collection. The personal sun-protection practices of attendees at both the 2009 and the 2013 annual V8 Supercar championships that were held mid-winter (Southern Hemisphere) in Townsville, Queensland, Australia (Latitude 19.25°S, Longitude 146.77°E) were observed by one experienced researcher (SLH) from 11 A.M. to 12:30 P.M. on Sunday 12th of July 2009 (final race day) as described elsewhere (10) and 11 researchers (including SLH) throughout the day from 4 to 7 July 2013, inclusive. All observers assisting SLH at the 2013 event were trained to correctly use the data collection sheet to record hat-style (three categories: none; nonSunSmart = caps and visors; SunSmart = wide-brimmed, legionnaires and bucket hats), sleeve-length (two categories: nonSunSmart = sleeves covering less than three-quarters of the arm; SunSmart = three-quarter-length and full-length sleeves), use of sunglasses (No/Yes), gender, skin color (light/dark) and time of day (three categories: before 10 A.M.; 10 A.M.–3 P.M.; /after 3 P.M.). These descriptors were printed in the column headings of the data collection sheet for ease of use and to improve accuracy. Observations were conducted unobtrusively from a position close to the spectator entrance to the motor racing precinct. Observations of personal sun protection were recorded on the data collection sheets in consecutive order as children and adults walked through the unshaded entry gate. This helped to minimize the risk of double counting individuals. The prevailing meteorological conditions were similar for both the 2009 and 2013 events (Table 1) (13).

The Townsville V8 supercar championship is usually held over 3 days with teams arriving earlier to set up and familiarize themselves with the track. The Townsville Street Circuit at Reid Park has five viewing mounds and unshaded grandstands capable of seating 12 000 spectators (16). Shade at the venue is limited, for both race visibility and logistic reasons (10).

Statistical analysis. Data analyzed in this research were limited to observations conducted between 10 A.M. and 3 P.M. in 2013, to reflect peak UVR times and to increase the comparability of the approach used to conduct observations in 2013 with those conducted 4 years earlier. The variables recorded for analysis were binary coded: date (0 = 2009, 1 = 2013); gender (0 = Male, 1 = Female); wearing any hat (0 = No, 1 = Yes); wearing a SunSmart Hat (0 = No: includes no hat, a cap or visor, 1 = Yes: includes wide-brimmed, legionnaires or bucket hat); and SunSmart sleeves (0 = No, 1 = Yes). The "Yes" category of wearing SunSmart sleeves included three-quarter-length and full-length sleeves, while the "No" category included nonSunSmart sleeves (short-sleeves, small cap-sleeves, or no sleeves, *e.g.* sleeveless tops like singlets and tank tops).

All analyses were conducted in R studio (17) using R software (18) and utilized the package "car" (19) for variable recoding and labelling. Data were cleaned and basic descriptive statistics and categorical frequencies were explored. Log-Linear analysis was used to determine if any relationships among the observed frequencies of the four categorical variables "Date," "Gender," "Any hat" and "SunSmart sleeves" were statistically significant. Expanding on the Chi-squared contingency analysis (which is limited to analyzing pairs of categorical variables), log-linear analysis enabled exploration of the relationships between the four variables simultaneously (20). The zero coded level of each variable served as the reference level and model parameter estimates and odds ratios were, therefore, interpreted as the effect on frequencies when changing from the reference level to the level 1 category within each binary variable.

Log-linear analysis assumes that the expected frequencies of all table cells are greater than one and that 80% of expected frequencies are greater than five (20). These criteria were checked using contingency tables of paired variables and all assumptions were met. A backward process of elimination was used to sequentially remove uninformative interaction effects from the model and evaluate the improved fit of successive nested models. The final model was that which showed no significant improvement in residual deviance with the addition of extra terms and was determined using ANOVA with a significance level of P = 0.05. The accuracy of the model was then assessed by comparing the range of deviances between observed and fitted values.

RESULTS

A total of 1337 spectators were observed across the two data collection periods (449 in 2009; 888 in 2013), most of whom had lightly pigmented skin (1305, 97.6%) and were male (856, 64.0%). Most spectators did not wear SunSmart (three-quarter or full-length) sleeves (81.5%), yet the majority (71.1%) wore a hat

Table 1. Meteorological conditions during the V8 Supercar championship held in Townsville, Queensland, Australia in 2009 and 2013.

Event	Observation dates	Observation period	Total number of spectators all days combined	Rainfall (mm)	Min temp (°C)	Max temp (°C)	Daily global solar exposure $MJ^{-2‡}$(13)
2009	12.7.2009	11 A.M.–12:30 P.M.	168 057 (14) [59 984]*	0	12.5	25.2	18.0§
2013	4.7. 2013	10 A.M.–3 P.M.†	≈147 000 (15)	0	12.6	27.2	17.0§
	5.7.2013	10 A.M.–3 P.M.†		0	16.2	26.6	15.2‖
	6.7.2013	10 A.M.–3 P.M.†		0	14.9	27.8	14.6‖
	7.7.2013	10 A.M.–3 P.M.†		0	21.3	27.5	14.2‖

≈, Approximately. * The number of spectators present on race day, Sunday 12 July 2009. † Observations were collected over the entire day on all 4 days of the 2013 event and time of day was recorded categorically as (i) before 10 A.M.; (ii) 10 A.M.–3 P.M., or (iii) after 3 P.M. Only data, which were collected from 10 A.M.–3 P.M. were included in this analysis to improve the comparability of these two cross-sectional data sets. ‡The total solar energy for a day falling on a horizontal surface measured from midnight to midnight, expressed as Mega Joules (MJ) per square meter. The values are usually highest in clear sun conditions during the summer and lowest during winter or very cloudy days. Historic mean for Townsville in July is 16.7 MJ^{-2}(13) § Above historical mean global solar exposure for July. ‖ Below historical mean global solar exposure for July.

of some type. While there was little overall change in hat-wearing rates between 2009 (326, 72.6%) and 2013 (625, 70.4%), closer examination of the data revealed that overall use of SunSmart hats declined from 29.2% in 2009 to 18.6% in 2013. Hat-wearing rates (any kind) decreased from 2009 to 2013 among females (65.9, 58.3%), while remaining stable for males (76.6%, 77.0%), while SunSmart hat-use declined to 21.1% for males and 14.0% for females after starting from similar levels in 2009 (29.4% *vs* 28.7%, respectively).

Proportionally more males (471, 82.1%) than females (216, 68.8%) were observed wearing sunglasses in 2013 (data not collected in 2009). Table 2 reports the frequencies of observed sun-protection behaviors recorded in both 2009 and 2013 by gender. The most observed category was comprised of males who wore a hat (any kind) and nonSunSmart sleeves (342, 25.6%) to the 2013 event, while the least common category was comprised of males who wore SunSmart sleeves, but no hat, to the 2009 event (4, 0.3%; Table 2).

The change in residual deviance between the saturated log-linear model (incorporating all possible terms) and the final fitted model (Table 3) was not significant (χ^2 (9) = 14.494, $P < 0.057$) indicating that including additional terms would not significantly improve the fit of the model. Similarly, the residual differences between observed and fitted frequencies in each category (Table 2) are generally small, with the largest differences occurring for females in 2013, who wore a hat (any kind) and nonSunSmart sleeves (difference = 17.3) and the no hat and no SunSmart sleeves category (difference = 11.8).

The generally close fit of the model-fitted values to the observed frequencies in Table 2 supports the statistical relationships displayed in Table 3. Although relatively few individuals were observed wearing SunSmart sleeves regardless of year (OR = 0.117, $P < 0.0001$), spectators were more than twice as likely to be wearing SunSmart sleeves in 2013 as in 2009 (OR = 2.486, $P < 0.0001$, Table 3), with rates more than doubling from 10.5% in 2009 to 22.5% in 2013. In contrast, attendees were more than three times as likely to be observed wearing a hat (any kind) than no hat (OR = 3.323, $P < 0.0001$), regardless of their gender or year of attendance.

A statistically significant relationship was found between gender and hat-wearing indicating that females were less likely to be observed wearing hats than males (OR = 0.473, $P < 0.0001$). Because observations were conducted over the entire multiday event in 2013 rather than just the final race day as in 2009, almost twice as many spectators were observed in 2013 (888) compared to 2009 (449). Consequently, the significance of the variable "year" in the log-linear model is unremarkable (OR = 1.711, $P < 0.0001$).

DISCUSSION

Australians have a cultural love of the great outdoors, and sporting events constitute a major part of this. Consequently, behavioral observations conducted in these settings provide useful, objective information about the sun-protective practices of the Australian population.

Table 2. Frequency of observed and fitted sun-protection behaviors by gender and year of attendance and gender. Fitted values are based on the log-linear analysis shown in Table 3.

			2009		2013		
Gender	Any hat	SunSmart sleeves*	Observed frequency (% of total)	Fitted values	Observed frequency (% of total)	Fitted values	Total Observed frequency (% of total)
Male	No	No	62 (4.6)	59.53	104 (7.8)	101.89	166 (12.4)
	No	Yes	4 (0.3)	6.96	28 (2.1)	29.62	32 (2.4)
	Yes	No	200 (15.0)	197.84	342 (25.6)	338.60	542 (40.6)
	Yes	Yes	16 (1.2)	23.13	100 (7.5)	98.43	116 (8.7)
Female	No	No	48 (3.6)	56.73	108 (8.1)	96.23	156 (11.7)
	No	Yes	9 (0.7)	6.57	23 (1.7)	27.97	32 (2.4)
	Yes	No	92 (6.9)	88.40	134 (10.0)	151.29	226 (16.9)
	Yes	Yes	18 (1.3)	10.34	49 (3.7)	43.98	67 (5.0)
		Total	449 (33.6)		888 (66.4)		1337 (100)

*SunSmart sleeves are garments with full-length or ¾ length sleeves *versus* nonSunSmart sleeves, which include upper-body garments without any sleeves (*e.g.* singlets), cap-sleeves and short-sleeves (cover the upper-arm only).

Table 3. Results of log-linear analysis showing factors that significantly influence relationships between gender, sun-protective behaviors and year.

Model	Estimate	SE	*Z*	Pr (>|z|)	Odds ratio (95% CI)
Year (2013)	0.54	0.063	8.56	<0.0001	1.71 (1.51, 1.94)
Gender (Female)	−0.05	0.102	−0.51	0.611	–
Any hat (Yes)	1.20	0.081	14.8	<0.0001	3.32 (2.84, 3.90)
SunSmart sleeves* (Yes)	−2.15	0.154	−13.9	<0.0001	0.12 (0.09, 0.16)
Year (2013): SunSmart sleeves* (Yes)	0.91	0.174	5.24	<0.0001	2.49 (1.78, 3.53)
Gender (Female): Hat (Yes)	−0.76	0.124	−6.12	<0.0001	0.47 (0.37, 0.60)

*SunSmart sleeves are garments with full-length or ¾ length sleeves *versus* nonSunSmart sleeves, which include upper-body garments without any sleeves (*e.g.* singlets), cap-sleeves and short-sleeves (cover the upper-arm only).

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Encouragingly, this study demonstrated that hat-wearing rates (any style that shaded the face) were generally good for both the 2009 (72.6%) and 2013 (70.4%) cross-sections, noting that most attendees (64.0%) were male. Our results are not unlike those reported for the Australian Open in Melbourne, January 2001 (Southern-Hemisphere summer), where on average, 70% of tennis spectators at the day session were observed wearing a hat (21).

The proportion of attendees observed wearing adequately sun-protective (three-quarter or full-length) sleeves was poor in 2009 but improved by 2013. Interestingly females had poorer hat-wearing and sleeve-wearing practices than males in this setting. While this finding mirrors that reported for incidental exposure around solar noon on weekdays in summer (12) it contrasts that reported for nonsporting events and outdoor leisure settings where females tend to be better protected than males (11,22,23), possibly reflecting the nature of this outdoor motorsport event. With over three times more people wearing hats than not, our results suggest that the message about hat-wearing may have stuck in the public consciousness over the years. Future observations will determine whether the gender differences reported here persist, informing future health promotion strategies, including whether social targeting of women as a specific group in sun-protection messages may be beneficial.

The use of sun-protective clothing was poor, with attendees at this event being much less likely to be seen wearing garments with three-quarter or full-length sleeves than tops with shorter sleeves or no sleeves (such as singlets). There is, however, some indication that the tendency to wear sun-protective sleeves improved between 2009 and 2013, but observational data will need to be collected at this event in the future to determine if this is an anomaly or a persistent trend. The benefit of log-linear analysis is that it removed the influence of the difference in sample size between the time periods when looking at the main effects of hat and sleeve use.

One of the strengths of this study is the assessment of observed behavior. It has been found that there is a marked difference between self-reported and observational studies of sun protection, with self-reported use of sun protection usually much higher than those obtained by objective means such as observation (23). This suggests that participants overreport their use of sun protection most likely to provide what they perceive to be a desirable response. Despite the objectivity, improved accuracy, and other benefits of observational studies of sun-protective behaviors, relatively few observational studies appear in the literature (10–12,22–28).

This study reinforces the need for continued investment in skin cancer primary prevention programs to achieve high levels of sun protection in both males and females, particularly in outdoor sports settings. It is a corporate responsibility to reinforce the sun-safe message and support attendees to adequately protect themselves by providing adequate high-quality shade structures (even if portable) and SPF 50+ broad-spectrum protection sunscreen at a minimum. Although wind is rarely a problem at this event, which is held during winter in tropical Queensland, high winds have the potential to interfere with hat-wearing practices, particularly brimmed hats with no chin strap. This makes ready access to free sunscreen dispensers even more vital in outdoor sports settings to encourage attendees to protect the skin of the face, neck and scalp (particularly in bald individuals), in addition to other skin surfaces not protected by clothing. Horsham and coworkers increased sunscreen use more than three-fold by providing free sunscreen and UVR-detection stickers at a rugby league carnival in regional Queensland (29). This relatively low-cost intervention could be implemented by organizers or sponsors at outdoor sporting events such as this. Consideration should also be given to incorporating at least one sun-protective hat and clothing option (*e.g.* a broad-brimmed hat and a long-sleeved shirt option) in the merchandise range on sale at this event.

One disadvantage of the discrete observation method that we used is that it prevented us from assessing sunscreen use. Also, the availability and utilization of shade was not documented at either event. Although we expanded data collection to include the use of sunglasses in the 2013 cross-section in response to limitations of the 2009 study published elsewhere (10) the 2013 component of this study could have been strengthened by conducting inter-rater reliability testing to measure potential differences in the sun-protection observations of the researchers.

Although these data were collected some time ago now, the 2013 cross-section represents a period in Australia's history when no national mass media skin cancer prevention campaigns had been conducted for several years. Consequently, these data provide a useful baseline from which the impact of the first national mass media skin cancer prevention campaign conducted in Australia in more than a decade can be assessed (8,9). The primary aim of the 2022 mass media campaign is to encourage Australians to use sun protection whenever the UV-index reaches 3 or greater (8). We plan to undertake future observations at this outdoor motorsport event to use to good advantage its potential as an avenue for monitoring sun-protection behaviors in a subset of the population (which we will seek to define using deidentified residential postcode data from annual ticket-sales). Observations of sun-protection behaviors in real-world settings provide an opportunity to partially compensate for the gap in understanding and monitoring of skin cancer prevention that has arisen since the National Sun-Protection Survey (the primary source of data used to inform and evaluate skin cancer prevention initiatives in Australia for the past 25 years) was discontinued (9). Given the recent return of significant numbers of spectators to many major outdoor sporting events in Australia, New Zealand and indeed globally, post the COVID-induced hiatus, which began March 2020 (30), the focus on sun protection in outdoor settings takes on even greater importance.

Without continued action to improve prevention and early detection, it is estimated that between 2022 and 2030 a further 205 000 Australians will be diagnosed with melanoma, 14 000 of whom will die, resulting in costs of $AUD 8.7 billion (comprised of economic loss of life of $4.4b; treatment costs >$3.1b and $1.2b in out-of-pocket costs) and 136 000 years of life lost, before even considering those affected by KC (8).

This study highlights the trends in sun-protection behaviors over time at an Australian outdoor sports event. While reassuringly stable use of hats (any style) and clothing were demonstrated, gender-specific differences were noted that need addressing as well as the tendency for most attendees to shun wearing long-sleeves. These data will be interesting to compare with future trends influenced by the 2022 national skin cancer prevention campaign, which was long overdue in the country where skin cancer is indeed "the national cancer." Future analyses need to focus on gender and age-specific differences and better explore the reasons for certain sun-protective practices in these cohorts and shape preventive messaging accordingly.

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