



# Sun protective behaviours during maximum exposure to ultraviolet radiation when undertaking outdoor activities: an integrated literature review

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## Abstract

**Aim** The aim of this review is to describe current patterns of adolescent and adult sun-protective behaviours in Australia and overseas.

**Subjects and methods** A systematic search of electronic databases was conducted in CINAHL, ProQuest, Medline, PubMed and Informit (Australian) for studies that included participants aged  $\geq 12$  years and reported proportions of participants' sun-protective behaviours. The search period covered 14 years from January 2004 to April 2018. Selected studies were critically appraised by two independent reviewers using the *Effective Public Health Practice Project* Quality Assessment tool.

**Results** A total of 29 relevant articles were identified. The review found that self-reported sun-protective behaviours differ markedly from observed behaviours, with observed behaviours indicating lower levels of sun protection. Sun-protective behaviours are highest among outdoor workers with mandatory personal protective equipment, boaters and snow skiers. A majority of the studies reviewed revealed that sun-protective behaviour continues to be poor during outdoor activities, indicating people are at risk of developing sun-related skin conditions such as skin cancer. These findings offer important insights for future sun safety campaigns.

**Conclusion** Despite numerous sun safe campaigns over time, it appears that low perceptions of risk are undermining the messages. Future health promotion campaigns should focus on appearance-based interventions, avoidance of harmful ultraviolet radiation exposure in all climates, and the importance of sun-protective clothing and eye protection necessary during necessary periods of high ultraviolet radiation exposure.

**Keywords** Leisure activities · Outdoor workers · Literature review · Sun-protective behaviours · Ultraviolet radiation

## Introduction

Premature ageing, drying and wrinkling of the skin and, more importantly, non-melanoma and melanoma skin cancers have all been linked to excessive sun exposure (Arthey and Clarke 1995; Kennedy et al. 2003). Skin cancers are more likely to

occur in populations living in high sun-exposure areas, in areas where the ultraviolet radiation (UVR) index is high, and in groups who work and have leisure time outside in the sun (Moan et al. 2008). Despite the many sun-safe campaigns conducted in Australia over the past 3 decades, the knowledge, attitudes and behaviours related to dangerous sun exposure and associated UVR have not translated into sun-protective behaviours (Nikles and Harrison 2014). In 1981, a prominent sun smart campaign was launched in Australia—the Slip, Slop, Slap campaign [Australian Cancer Research Foundation (ACRF) 2014; Cancer Council NSW 2016]. At the time, melanoma rates were climbing and evidence of a link between UVR and skin cancer was mounting in Australia. In 2007, the slogan was updated to ‘Slip Slop Slap Seek Slide’ to reflect the importance of seeking shade and sliding on wrap-around sunglasses to prevent sun damage [Australian Institute of Health and Welfare (AIHW) 2016]. The message was considered successful and believed to have been absorbed into the Australian psyche (ACRF 2014). However, between 1982 and

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2010 the diagnosis of melanoma in Australia increased by 60% (ACRF 2014).

The incidence of melanoma in Australia and New Zealand is four times higher than in Canada, the UK and the USA (AIHW 2016). In 2016, an estimated 13,280 new cases of melanoma are predicted to be diagnosed in Australia, and 1770 people are expected to die from the disease (AIHW 2016). In addition, more than 750,000 new cases of basal cell carcinoma and squamous cell carcinoma are expected to be diagnosed and treated each year in Australia. Melanoma is the most common cancer in young Australians aged between 15 and 39 years (ACRF 2014). The age-standardised incidence of melanoma has increased from 27 cases per 100,000 in 1982 to 49 per 100,000 in 2016. More than 1600 Australians died from melanoma in 2013, 4 people each day (AIHW 2016). However, for people younger than 40 the incidence rate has dropped from a peak of 13 cases per 100,000 in 2002 to an estimated 9.4 per 100,000 in 2016, indicating that sun-protective messages may be effective in some populations (Nikles and Harrison 2014). This leads to the question, for which groups or populations are sun-protective messages translating into better sun-protection behaviours?

Australian trends over time in self-reported sun-protective behaviours show that while some aspects of sun protective behaviour have improved slightly, the use of sun protection remains relatively low. A 10-year study (February 2001 to December 2011) of Australian adolescents found hat wearing (usually or always) had significantly decreased over the period of the study from just under 50 to 31%, while the use of sun-protective clothing remained relatively stable at < 30% most years (Koch et al. 2016). Use of sunglasses fluctuated over the period but mostly stayed under 50% (Koch et al. 2016). The use of sunscreen was relatively unchanged from February 2001 (68%) to December 2011 (66%).

National Australian surveys (April 2003 to November 2010) of trends in adult sun-protective behaviours also show a significant reduction in hat wearing (48 to 45%) over the study period (Volkov et al. 2013). Sun-protective clothing (long- or ¾-sleeve shirt) increased slightly but remained low at < 20%. Use of sunglasses was relatively unchanged over the period at approximately 60%, while use of sunscreen increased slightly from 33 to 36%. Adults reporting two or more sun-protective behaviours rose from 32% in April 2003 to 44% in November 2010 (Volkov et al. 2013).

Prior to this article, the most recent literature review of Australian and overseas sun-protective behaviours covered the period 1990 to 2003 (Stanton et al. 2004). Since this review, new technologies have been developed including a range of smart phone applications (apps) that provide information about sun exposure, the UV index, time in the sun and mole monitoring. Sun-protection factor (SPF) 50+ sunscreen was launched in Australia in 2012–13, sun-

protective swimwear made from fabric rated ultraviolet protection factor 50+ is now available, and photoaging apps have been developed that can be used for melanoma prevention (Brinker et al. 2017). It is reasonable to speculate that these developments may induce behavioural change regarding sun protection. This review updates Stanton et al.'s review with contemporary literature and aims to describe current patterns of adolescent and adult sun-protective behaviours in Australia and overseas in light of these recent developments.

## Methods

An integrative review of the literature was undertaken, which is an appropriate approach where the selected studies include experimental and non-experimental designs (Whittemore and Knafl 2005). Prior to undertaking the literature search, a research protocol was developed collaboratively with the research team. The protocol was not registered a priori; the review method did not deviate from the protocol.

A systematic search of electronic databases was conducted in CINAHL, ProQuest, Medline, PubMed and Informit (Australian) using the search terms 'sun protect\* behaviour' OR 'sun protect\* behavior' AND 'outdoor event' OR 'leisure' OR 'work'. A further search was carried out using Google Scholar, and a hand search of the reference lists of all included articles was also conducted.

## Inclusion criteria for the selected studies

Studies that examined sun-protective behaviours (for the purpose of this study, defined as wearing of hats, long and ¾ sleeves, long pants, sunglasses and use of sunscreen) of adolescents  $\geq 12$  years and adults, studies that clearly detailed proportions of participants observed or self-reported sun-protective behaviours, RCTs, longitudinal, interventional (case/control), cross-sectional and qualitative studies published in English language peer-reviewed journals between January 2004 and April 2018 were eligible to be included.

## Exclusion criteria for the selected studies

Articles were excluded if they could not be accessed in English language and were not published in a peer-review journal. In addition, studies that examined the sun-protective behaviours of children aged < 12 years, studies of organ transplant recipients, studies of previous melanoma patients, studies that did not focus on sun-protective behaviours, studies without defined participant proportions, literature reviews, reports and grey literature were ineligible to be included.

## Process

One author (FB) conducted the literature search with advice from a specialist librarian. The initial search resulted in 790 articles with 740 remaining after duplicates were removed. Of these 740 articles, a further 629 were removed after screening the titles and abstracts, leaving 111 articles for full text review. Two authors (FB, CW) independently reviewed the full texts of the remaining 111 studies and discussed any discrepancies until a consensus decision was reached. Following review, 82 studies were excluded (Online resource 1), leaving 29 articles for inclusion in the review (Fig. 1). A scan of the reference lists of the final articles failed to identify any further articles that met the search criteria.

## Data extraction

A standardised data extraction tool was developed by the authors (FB, CW) to ensure a consistent approach to data extraction. Information about sun-protective behaviours was extracted by the first author. Behaviours examined included wearing sun-protective hats, sun-protective sleeves, long trousers and sunglasses and using sunscreen.

## Quality appraisal

The studies were independently appraised by two authors (FB, CW) for research rigour and quality using the *Effective Public Health Practice Project* (EPHPP) Quality Assessment tool

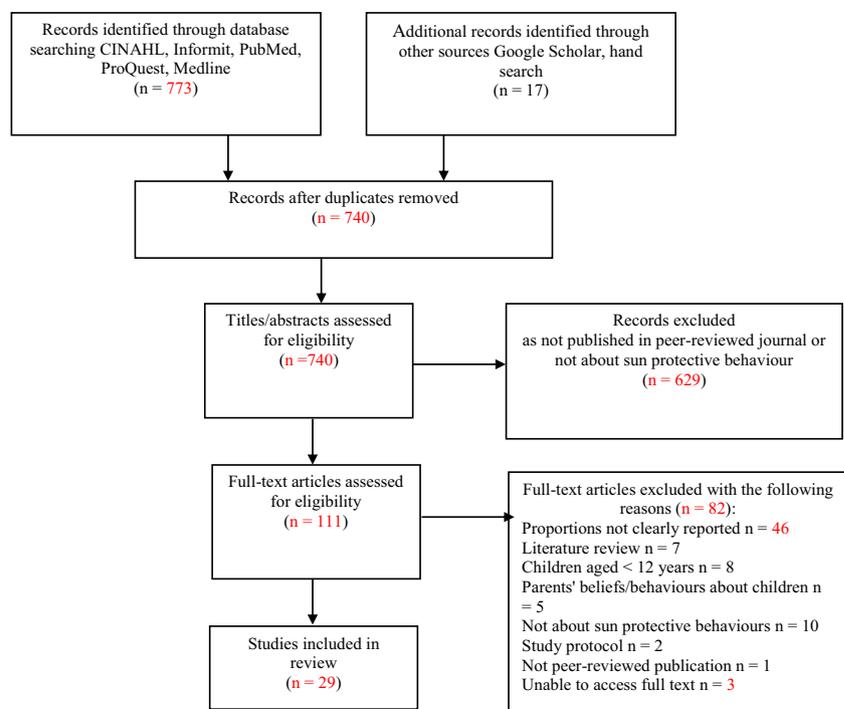
(Thomas et al. 2004). Initially the authors independently rated one study and reached interrater agreement. Then each study was assessed independently by both authors, results were compared and discussed, and a consensus decision was reached about the quality and rigour of each study.

## Results

The 29 selected studies were conducted in Australia ( $n = 15$ ), the USA ( $n = 6$ ), Spain ( $n = 1$ ), Canada ( $n = 2$ ), Denmark ( $n = 1$ ), the USA and Canada ( $n = 1$ ), Serbia ( $n = 1$ ), Germany ( $n = 1$ ), France ( $n = 1$ ) and New Zealand ( $n = 1$ ) (Table 1). All of the studies involved observed or self-reported sun-protective behaviours. Eighteen studies reported sun-protective behaviours during leisure activities (three studies were conducted in educational settings), eight reported sun-protective behaviours during work activities and three reported behaviours during leisure and work activities.

Eleven of the selected studies included adolescents aged between 12 and 17 years as well as adults (Bocquier et al. 2016; Cercato et al. 2015; Dixon et al. 2008; Dobbinson et al. 2008a, b; Køster et al. 2010; Lagerlund et al. 2006; Marrett et al. 2010; McNoe and Reeder 2016; Nikles and Harrison 2014; Woloszyn et al. 2010). Three of the studies examined adolescents only (Cassel et al. 2018; Miljkovic and Jovanovic Ljeskovic 2016; Pettigrew et al. 2016). Although parents have a major influence on adolescents' sun-protective behaviours, adolescents aged 12 years or older were included

Fig. 1 PRISMA flowchart



**Table 1** Characteristics of reviewed studies

Author and country	Study type	Site(s) and recruitment	Study sample	Hats	Sleeves/trousers	Sunglasses/goggles	Sunscreen
Lagerlund et al. (2006) Australia	Longitudinal observational study-leisure	Purposive sample 4 outdoor venues	42,207 People aged ≥ 14 years	11.0%	7.5% sleeves	36.2%	–
Dixon et al. (2008) Australia	Longitudinal observational study-leisure	Purposive sample 4 outdoor venues	46,810 People aged ≥ 14 years	–	51.8% (> 50% clothing cover)	–	–
Nikles and Harrison (2014) Australia	Cross-sectional observational study-leisure	Purposive sample outdoor spectator	405 People aged > 12 years	27.1%	10.6% sleeves	–	–
Woloszyn et al. (2010) Australia	Cross-sectional observational study-leisure	Sporting event Purposive sample 25 beaches	1180 People aged ≥ 16 years	35.8% (shirts and hats)	–	–	–
McNoe and Reeder (2016) New Zealand	Cross-sectional Observational study-leisure	Purposive sample	1225 Students aged 13–18 years 215 Adults	3.4% 25.2%	Sleeves 19.0% Trousers 21.4% Sleeves 49.3% Trousers 59.5% Clothing 20%	1.7% 4.2%	–
Shahman et al. (2017) Australia	Cross-sectional survey-leisure	Purposive sample	507 University students aged 18–24 years	8.0%	19% Sleeves 44% trousers	42%	30.0%
Volkov et al. (2013) Australia	Cross-sectional survey-leisure (2010–11)	Random sample (telephone interview)	5412 Adults aged 18–69 years	45%	–	57%	36%
Cercato et al. (2015) Spain	Cross-sectional survey-leisure	Purposive sample 2 beaches	630 Beachgoers aged 13–82 years	21.6%	18.7% Sleeves	49.5%	79.1%
Woolley and Buettner (2009) Australia	Cross-sectional survey-leisure	Purposive sample boat users	114 Boat users aged ≥ 18	80%	60% Sleeves 20% trousers	100%	95%
Bocquier et al. (2016) France	Cross-sectional survey-leisure	Random national survey 2010	3359 People aged 15–85 years	51.5%	–	73.6%	42.7%
Dobbinson et al. (2008a) Australia	Cross-sectional survey-leisure	Australian national survey 1987–88 to 2001–02	11,589 people aged 14–69 years	39% (2001–02)	27% Sleeves 66% trousers (2001–02)	–	27% (2001–02)
Dobbinson et al. (2008b) Australia	Cross-sectional survey-leisure	Australian national survey 2003–2004	5073 Adults and 699 adolescents aged 14–69 years	38%-Adolescents 48%-adults	Sleeves 11%-adolescents 18%-adults Trousers 37% adolescents 46% adults 31% Light clothing	22%-Adolescents 55%-adults	37%-Adolescents 33%-adults
Koster et al. (2010) Denmark	Cross-sectional survey-leisure	Population-based sample	4451 People aged 15–59 years	34%	–	–	–
Lawler et al. (2007) Australia	Cross-sectional survey-leisure	Random sample in census districts	1992 Adults aged 20–65 years	53%	58% Sleeves	–	49%
Pettigrew et al. (2016) Australia	Cross-sectional survey-leisure	Purposive sample	4150 Adolescents aged 14–17 years	32.0%	Protective clothing 27.3%	–	–
Miljkovic and Jovanovic (2016) Serbia	Cross-sectional survey-leisure	Purposive sample	1721 Adolescents aged 16–17 years 2008/2012	32.9%	Protective clothing 1.9%	46.8%	64.85%

**Table 1** (continued)

Author and country	Study type	Site(s) and recruitment	Study sample	Hats	Sleeves/trousers	Sunglasses/goggles	Sunscreen
Janda et al. (2014), Australia	Cross-sectional survey-work	15 Randomly selected workplaces (PPE)	162 Adults aged 18–68 years	83.4%	74.1% Sleeves 61.7% trousers	75.3%	40.1%
Kearney et al. (2013) USA	Cross-sectional survey-work	Purposive sample (regional farm show attendees)	397 Adult farmers mean age 54 years	27.1%	–	44.7%	19.6%
Boyas et al. (2016) USA	Cross-sectional survey-work	Purposive sample	137 Male Latino day labourers aged ≥ 18 years	8%	1.4% Sleeves	12.4%	5.9%
Marrett et al. (2010) Canada	Cross-sectional survey-work	Modified random sample (Second National Sun Survey participants)	1490 Outdoor workers aged 16–64 years	58%	56% Sleeves	54%	29%
Kearney et al. (2016) US	Cross-sectional survey-work	Purposive sample	158 Farm workers aged 18–46+ years	27.5%	Sleeves 85.8% Trousers 98.1%	11.2%	9.1%
Zink et al. (2017) Germany	Cross-sectional survey-work	Purposive sample	353 Outdoor workers	44.7%	Sleeves 9.1% Trousers 44.2%	32.6%	27.7%
Woolley et al. (2008), Australia	Cross-sectional survey-work and leisure	Purposive sample	26 Male adult workers	69%	81% Sleeves 19% Sleeves	–	45%
		1 workplace	Leisure Mandatory PPE	54%	–	–	27%
			Mean age 42 years				
			21 Male adult workers	62%	29% Sleeves	–	38%
			Voluntary PPE	53%	32% Sleeves	–	26%
			Mean age 44 years				
Peters et al. (2016) Canada	Cross sectional survey-work and leisure	Purposive sample	78 Adults (PPE) Aged 18–69 years	79.0%	Sleeves 82.0% Sleeves 62.0%	74.0%	29.0%
			4347 Observed	53.0%	–	51.9%	–
			3531 surveyed holiday resort vacationers aged ≥ 18 years	4.9%	12.8% Sleeves 20.3% trousers	–	–
Buller et al. (2016) North America (USA & Canada)	Intervention-leisure <i>Go Sun Smart</i> (GSS) intervention Pre-test	Purposive sample Intervention randomised to 40 holiday resorts	Baseline observe Baseline Survey	5.5%	12.5% Sleeves 21.4% trousers	58.1%	59.8%
Andersen et al. (2017) North America (USA and Canada)	Intervention RCT Leisure <i>Go Sun Smart</i> (GSS) intervention Pre-post test	Purposive sample Intervention randomised to 42 holiday resorts	Intervention resort vacationers aged ≥ 18 years	–	0.63 Pre 0.63 Post (body coverage score) 0.61 Pre 0.62 Post (body coverage score)	–	55.8% Pre 53.8% Post
Rye et al. (2014) Australia	Intervention-work 18-month intervention-development of tailored	Purposive sample 4 industries/ 14 workplaces (PPE)	150 Adult workers	52.0% Pre 76.7% Post intervention	72.0% Sleeves Pre 90.7% sleeves Post intervention	73.3% Pre 79.1% Post intervention	40.3% Pre 40.7% Post intervention

**Table 1** (continued)

Author and country	Study type	Site(s) and recruitment	Study sample	Hats	Sleeves/trousers	Sunglasses/goggles	Sunscreen
Walkosz et al. (2014) US, Canada	sun protection action plans Pre- and post-treatment Intervention-work and leisure 2 treatments Intervention = health promotion materials and staff education Control = health promotion materials	Purposive sample intervention randomised to 2 ski areas (UK and Canada)	3380 Ski resort employees and guests aged 18–75+ years	82.4% Overall (Hat that covers ears)	–	91.4% overall	43.4% overall
Cassel et al. (2018) USA	School Pre-post observation Intervention = health promotion materials and 1 h educational discussion	Random sample	208 School students aged 15–17 years	12.5% (Any hat) 13.1% (Any hat)	15.4% Sleeves 38.6% trousers 20.2% Sleeves 48.2% trousers	4.1% 1.9%	– –

because at this age they have some autonomy over their sun-protective behaviours (Dobbinson and Slevin 2014; Dobbinson et al. 2014; Køster et al. 2010; Volkov et al. 2013). The remaining 15 studies all focused on the sun-protective behaviours of adults.

The methods used to identify and/or measure sun-protective behaviours differed substantially among the studies (see Table 2). Twenty-two studies used a cross-sectional design, two used a longitudinal design, and five used an intervention design.

### Sun-protective headwear

In 9 of the 26 studies that reported headwear, a majority (> 50%) of participants wore sun-protective headwear when engaging in outdoor activities (Bocquier et al. 2016; Janda et al. 2014; Lawler et al. 2007; Marrett et al. 2010; Peters et al. 2016; Rye et al. 2014; Walkosz et al. 2014; Woolley et al. 2008; Woolley and Buettner 2009). Four of the nine studies reporting > 50% use of protective headwear used a randomised or a modified randomised sample reducing selection bias (Bocquier et al. 2016; Janda et al. 2014; Lawler et al. 2007; Marrett et al. 2010), whereas the other five studies used a purposive sample (Peters et al. 2016; Rye et al. 2014; Walkosz et al. 2014; Woolley et al. 2008; Woolley and Buettner 2009). Of the ten studies that included outdoor workers, six reported > 50% of participants wore sun-protective headwear, with four reporting wearing personal protective equipment (PPE) for work purposes (two studies did not mention whether a PPE policy was in place) (Marrett et al. 2010; Walkosz et al. 2014). One study separated workers with a mandatory PPE policy and a voluntary PPE policy, but found little difference between the sun-protective behaviours of each group (Table 2) (Woolley et al. 2008). The greatest proportion of participants observed or reporting the use of sun-protective headwear was outdoor workers (83%) (Janda et al. 2014), holiday-makers in ski resorts (82%) (Walkosz et al. 2014) and boat users (80%) (Woolley et al. 2008).

Of the nine studies that reported over 50% of sun-protective hat wearing, self-reported survey and intervention studies reported the highest proportion of sun-protective hat wearing whereas hat wearing recorded in high school (observational) and university students (survey), Latino day labourers (survey) and people vacationing at sunny resort environments (intervention) was much lower (between 3.4 and 8%) (Boyas et al. 2016; Buller et al. 2016; McNoe and Reeder 2016; Shahman et al. 2017).

### Wearing long sleeves/trousers

Only four of the ten workplaces included in this review had a workplace sun-protection policy in place or provided PPE. Of these ten studies of outdoor workers, eight reported on the use

**Table 2** Methods used in selected studies

First author and year	Data collection tool	Data collector	Data collected	Scales
Andersen et al. (2017)	Self-report survey observation checklist	Trained research staff	Sun-protective clothing, sunglasses and sunscreen use	Yes/no—index calculated by summing cover to each body section
Bocquier et al. (2016)	Self-report telephone survey	Market research company	Sun-protective clothing, sunglasses and sunscreen use	Measured on a five-point scale from 1 = never to 5 = always
Boyas et al. (2016)	Self-report survey	Researchers and staff	Sun-protective clothing, sunglasses and sunscreen use	Measured on a five-point scale from 1 = never to 5 = always
Buller et al. (2016)	Self-report survey observation checklist	Trained research staff	Sun-protective clothing, sunglasses and sunscreen use	Yes/no—index calculated by summing cover to each body section
Cassel et al. (2018)	Intervention Observation Pre and posttest	Trained research staff	Sun-protective clothing, sunglasses, shade and sunscreen use	Yes/no
Cercato et al. (2015)	Validated self-report survey	Trained field workers	Sun-protective clothing, sunglasses and sunscreen use	Measured on a five-point scale from 1 = never to 5 = always
Dixon et al. (2008)	Observational checklist	Trained field workers	Sun-protective clothing	Yes/no—index calculated by summing cover to each body section
Dobbinson et al. (2008a)	Self-report telephone survey	Market research company	Sun-protective clothing and sunscreen use	Yes/no
Dobbinson et al. (2008b)	Self-report telephone survey	Market research company	Sun-protective clothing and sunscreen use	Yes/no
Janda et al. (2014)	Self-report telephone survey	Unknown	Sun-protective clothing, sunglasses and sunscreen use	Measured on a 5-point scale from 1 = rarely to 5 = always
Kearney et al. (2013)	Self-report survey	Unknown	Sun-protective clothing, sunglasses and sunscreen use	Measured on a 4-point scale from 1 = always to 4 = never
Kearney et al. (2016)	Self-report survey	Researchers	Sun-protective clothing, sunglasses and sunscreen use	Measured on a 5-point scale from 1 = rarely to 5 = always
Køster et al. (2010)	Self-report telephone survey	Trained interviewers	Sun-protective clothing and sunscreen use	Yes/no
Lagerlund et al. (2006)	Observational checklist	Trained field workers	Sunglasses use	Yes/no
Lawler et al. (2007)	Self-report survey	Unknown	Sun-protective clothing and sunscreen use	Measured on a scale of 0 = never, 1 = < 50% of the time outdoors, 2 = > 50% of the time outdoors, 3 = all of the time outdoors
Marrett et al. (2010)	Self-report telephone survey	Unknown	Sun-protective clothing, sunglasses and sunscreen use	Measured on a 5-point scale from 1 = always to 5 = never
McNoe and Reeder (2016)	Observational survey	Researcher	Sun-protective clothing, sunglasses	Yes/no
Miljkovic and Jovanovic Ljeskovic (2016)	Self-report survey	Researchers	Sun-protective clothing, sunglasses, shade and sunscreen use	Yes/no
Nikles and Harrison (2014)	Observational check list	Trained observers	Sun-protective clothing	Yes/no
Peters et al. (2016)	Self-report survey		Sun-protective clothing, sunglasses, shade and sunscreen use	Measured on a 5-point scale from 1 = always to 5 = never
Pettigrew et al. (2016)	Self-report telephone survey		Sun-protective clothing, sunglasses, shade and sunscreen use	
Rye et al. (2014)	Self-report telephone survey	Researchers	Sun-protective clothing and sunscreen use	Measured on a 5-point scale from 1 = rarely to 5 = always
Shahman et al. (2017)	Self-reported on line survey	Researchers	Sun-protective clothing, sunglasses, shade and sunscreen use	
Volkov et al. (2013)	Self-report telephone survey	Market research company	Sun-protective clothing, sunglasses and sunscreen use	Yes/no
Walkosz et al. (2014)	Self-report survey and observation checklist	Researchers	Sun-protective clothing, sunglasses and sunscreen use	Yes/no
Woloszyn et al. (2010)	Observational check list	Trained observers	Sun-protective clothing	Yes/no
Woolley and Buettner (2009)	Self-report survey	Researchers	Sun-protective clothing	Yes/no
Woolley et al. (2008)	Self-report survey	Researchers	Sun-protective clothing, sunglasses	Yes/no
Zink et al. (2017)	Self-report survey	Researchers	Sun-protective clothing, sunglasses and sunscreen use	Measured on a four-point scale from 1 = never to 4 = always

of sun-protective clothing (Boyas et al. 2016; Janda et al. 2014; Kearney et al. 2013; Kearney et al. 2016; Marrett et al. 2010; Peters et al. 2016; Rye et al. 2014; Walkosz et al. 2014; Woolley et al. 2008; Zink et al. 2017). Six of the eight studies of outdoor workers reported a majority of participants wore long sleeves or trousers or a combination of both while engaging in outdoor activities. The greatest long sleeve use was reported in Woolley et al.'s (2008) and Rye et al.'s studies in workplaces with a mandatory PPE policy (81% and 91% respectively), and the lowest (1.4%) was reported among Latino day labourers (Boyas et al. 2016).

Observational reporting of sun-protective sleeves (3/4 length or long) during leisure activities was lowest for Australian adolescents and adults (7.5%) and highest for New Zealand adult participants at a school sports carnival (49.3%). Self-report survey studies of sun-protective sleeves during leisure activities showed long sleeve wearing was lowest for Australian adolescents (11%) (Dobbinson et al. 2008b) and highest for Canadian adults (62.0%) (Peters et al. 2016).

Three of the five intervention studies reported on sleeve wearing pre- and post-intervention. Andersen et al. (2017) reported a body coverage score that did not change in the intervention group, but increased slightly in the control group. Rye et al. (2014) reported outdoor workers' wearing of long sleeves increased from 72% pre-intervention to 91% post-intervention, and Cassel et al. (2018) reported adolescent school students' wearing of long sleeves increased from 15.4% pre-intervention to 20.2% post-intervention.

Ten of the 29 studies reported leg cover. The studies were conducted in Australia ( $n = 5$ ), Germany ( $n = 1$ ), New Zealand ( $n = 1$ ), the USA ( $n = 2$ ) and North America ( $n = 1$ ). Seven studies reported the wearing of trousers during leisure activities and three during outdoor work activities. Self-reported wearing of three-quarter or long leg cover during leisure activities ranged from 20% (Australian boat users) to 66% (Australian outdoor leisure activities) (Dobbinson et al. 2008a; Woolley and Buettner 2009). Observational studies reported leg cover ranging from 20.3% (North American holiday-makers) to 59.5% (New Zealand adult participants at a school sports carnival) (Buller et al. 2016; McNoe and Reeder 2016).

### Body coverage

Six of the 29 studies reported an index for percent of body coverage or recorded those wearing > 50% clothing cover. Holiday-makers at sunny resorts were observed to have the highest per cent of body coverage both pre- and post-intervention (63%) (Andersen et al. 2017), followed by Australian adolescents and adults at outdoor leisure venues (51.8% greater than 50% clothing cover) (Dixon et al. 2008), while the lowest was self-reported by adolescent school students in Serbia (1.9% protective clothing) (Miljkovic and Jovanovic Ljeskovic 2016). Apart from Andersen et al.

(2017) and Dixon et al.'s (2008) studies, the other four studies reported < 50% body coverage. A seventh study reported the combined hat and shirt wearing (35.8%) of Australian adolescent and adult beachgoers (Woloszyn et al. 2010).

### Wearing sunglasses

Twenty of the 29 studies reported on the use of sunglasses. Ten of the studies reported > 50% usage of sunglasses. The lowest usage (1.7 and 1.9%) was seen among secondary school students (McNoe and Reeder 2016; Cassel et al. 2018 respectively), Latino farmworkers (11.2%) (Kearney et al. 2016) and Latino day labourers (12.4%) (Boyas et al. 2016). The highest was among boaters (100%) and snow skiers (91%) (Woolley et al. 2008; Walkosz et al. 2014 respectively).

### Sunscreen use

Sunscreen use during outdoor activities was reported in 21 of the 29 studies. Self-reported sunscreen use among outdoor workers ranged from 5.9% of Latino day labourers (Boyas et al. 2016) to 45% of Australian outdoor workers with a mandatory PPE policy (Woolley et al. 2008). Self-reported sunscreen use among people during leisure activities ranged from 26 to 27% among Australian males (Woolley et al. 2008) to 95% among boat users (Woolley and Buettner 2009).

### Methodological quality assessment of included papers

Two reviewers separately appraised the quality of the studies and came to a consensus about the results (Table 3). All of the 29 selected studies were quantitative. Overall, the methodological quality of the studies was assessed as weak with only seven studies assessed as moderate. The selected studies had some moderate elements, particularly selection bias and data collection methods. The study design and controlling for confounders were assessed as weak for the majority of the studies as they were mainly cross-sectional in design.

### Discussion

The review was undertaken to explore and critique the available evidence regarding sun-protective behaviours while undertaking outdoor activities.

Australian and Canadian employees in workplaces with and without a mandatory sun protection policy and Australians and North Americans undertaking leisure activities such as boating and snow skiing reported the highest sun-protective behaviours. By comparison, Latino day labourers in the USA reported some of the lowest sun-protective behaviours.

**Table 3** Quality appraisal of selected studies

Author	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and dropouts	Final score
Andersen et al. (2017)	Moderate	Strong	Strong	Moderate	Strong	Moderate	Moderate
Bocquier et al. (2016)	Moderate	Moderate	Weak	Moderate	Moderate	Weak	Moderate
Boyas et al. (2016)	Moderate	Moderate	Moderate	Weak	Moderate	Weak	Moderate
Buller et al. (2016)	Moderate	Moderate	Weak	Moderate	Strong	Strong	Moderate
Cassel et al. (2018)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Cercato et al. (2015)	Moderate	Weak	Weak	Moderate	Strong	Moderate	Weak
Dixon et al. (2008)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Dobbinson et al. (2008a).	Moderate	Weak	Weak	Moderate	Moderate	Weak	Weak
Dobbinson et al. (2008b)	Moderate	Weak	Weak	Moderate	Moderate	Weak	Weak
Janda et al. (2014)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Keamey et al. (2016)	Moderate	Weak	Weak	Weak	Moderate	Weak	Weak
Keamey et al. (2013)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Køster et al. (2010)	Moderate	Weak	Strong	Moderate	Weak	Moderate	Weak
Lagerlund et al. (2006)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Lawler et al. (2007)	Moderate	Weak	Weak	Moderate	Moderate	Moderate	Weak
Marrett et al. (2010)	Moderate	Weak	Weak	Moderate	Moderate	Moderate	Weak
McNoe and Reeder (2016)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Miljkovic and Jovanovic Ljeskovic (2016)	Moderate	Weak	Weak	Weak	Moderate	Weak	Weak
Nikles and Harrison (2014)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Peters et al. (2016)	Moderate	Weak	Weak	Weak	Moderate	Weak	Weak
Pettigrew et al. (2016)	Moderate	Weak	Weak	Weak	Moderate	Weak	Weak
Rye et al. (2014)	Moderate	Moderate	Weak	Moderate	Weak	Weak	Weak
Shahman et al. (2017)	Moderate	Weak	Weak	Weak	Weak	Weak	Weak
Volkov et al. (2013)	Moderate	Weak	Strong	Moderate	Moderate	Weak	Weak
Walkosz et al. (2014)	Moderate	Moderate	Strong	Moderate	Strong	Moderate	Moderate
Woloszyn et al. (2010)	Moderate	Weak	Weak	Moderate	Weak	Moderate	Weak
Woolley and Buettner (2009)	Moderate	Weak	Strong	Moderate	Weak	Strong	Weak
Woolley et al. (2008)	Moderate	Weak	Strong	Moderate	Moderate	Moderate	Moderate
Zink et al. (2017)	Moderate	Weak	Strong	Moderate	Weak	Moderate	Weak

There was a marked difference in observed sun-protective behaviours compared with self-reported behaviours in the reviewed literature. This finding is consistent with Dobbinson et al.’s (2014) 10-year Australian study of concordance of self-reported and observed sun-protection behaviours, which found a high degree of social desirability bias in self-reported behaviours. Self-reported sun-protective behaviours were consistently reported as higher than observed behaviours (Dobbinson et al. 2014).

However, other studies examining concordance between self-reported and observed sun-protective behaviours show converse results. A concordance study of US postal employees (Oh et al. 2004) and a study of Australian electrical company outdoor employees found a high level of agreement between self-reported and observed sun-protective behaviours (Girgis et al. 1994). By contrast, a small US pilot study reported only fair to moderate agreement of self-reported and observed sun-

protective behaviours of lifeguards and adult pool users (O’Riordan et al. 2008). These studies indicate that concordance between self-reported and observed behaviours is likely to vary, and the variance may arise from participants’ potential awareness of the observations as opposed to covert observations.

Although the highest level of sun-protective behaviours was self-reported by outdoor employees in this review, these behaviours can be influenced by workplace policy, equipment provision, and education and training. Hats and protective clothing are typically the traditional clothing associated with outdoor occupations (Shoveller et al. 2000) and the majority of the reviewed studies of employee sun-protective behaviours found more than 50% of employees reported wearing hats and long sleeves. While this may be considered a relatively low level of sun-protective actions by workers (Shoveller et al. 2000) it is consistent with previous research on outdoor workers (Girgis et al. 1994). A Canadian study

reported the most common reasons outdoor workers did not take sun-protective actions were they forgot, it was inconvenient, they wanted to get a tan, and they were unconcerned about UVR exposure (Shoveller et al. 2000).

Those engaged in outdoor work activities and planned leisure activities such as boating and skiing demonstrated higher levels of sun-protective behaviours than those engaged in more general outdoor leisure activities. It is well known that snow and water reflect UV radiation; thus, it is probable that the perception of increased risk increases sun-protective behaviours. Particular activities such as boating and snow skiing also have norms about clothing that is worn for protection from the cold and UV radiation (Lawler et al. 2007). This combination of awareness and dress norms appears to lead to higher sun-protective behaviours.

The majority of studies of outdoor workers selected for this review were conducted in areas of high average summer temperatures and high UVR across most of the year (Boyas et al. 2016; Janda et al. 2014; Kearney et al. 2013; Kearney et al. 2016; Rye et al. 2014; Woolley et al. 2008). Many workplaces encourage or mandate sun-protective clothing and sunscreen use for outdoor workers, particularly in Queensland because of the higher risk of harmful UVR exposure. Excluding Latino day labourers, the lowest sun-protective behaviours were demonstrated by people engaged in leisure activities in Melbourne, Australia (Lagerlund et al. 2006). The average summer temperature in Melbourne is 21 °C; however, the UVR rating over the summer months ranges from very high to extreme. The cooler climate may lead to lower perceptions of risk of harmful sun exposure and thus fewer sun-protective behaviours.

The intervention studies showed varying success. Interventions to promote sun-protective behaviours may have limited effects on people on holidays because of spontaneity and more risk-taking behaviours while away from their usual routine. Workplace interventions were found to be more effective, especially when supported by management. A New Zealand study found workplace policies have little effect on employees' sun-protective behaviours but perceived workplace support was strongly associated with sun-protective behaviours (Hammond et al. 2008).

Sun-protective behaviours among outdoor workers in a Canadian study reflected the findings of earlier research from Australia and the USA, confirming that in general, outdoor workers report low levels of sun-protective behaviour (Shoveller et al. 2000). The authors found that clothing is a more convenient sun protection in such situations than reapplying sunscreen, seeking shade or avoiding the sun, and therefore interventions emphasising protective clothing and hats are more likely to be successful (Shoveller et al. 2000).

Studies of health promotion interventions specific to sun-protective behaviours have had mixed results, but those that focus on appearance-based interventions have been more successful. Mahler et al.' (2010) appearance-based intervention

study with US college students found that viewing images of photoaging resulted in non-significant marginally greater student perceptions of UVR damage, a lower desire to tan and more positive sun-protective intentions compared with the control group. In contrast, Stock et al. (2009) conducted a similar appearance-based intervention with US highway workers using photoaging images and also showing cancer-related videos. Twelve months post-intervention, the intervention group reported significantly increased sun-protection behaviours compared with the control group, indicating long-term efficacy. Weinstock et al. (2002) conducted an RCT with a multicomponent intervention with US adolescent and adult beachgoers. The intervention strategies included educational information, provision of sunscreen, photoaging images and a sun-sensitivity assessment. Twenty-four months post-intervention, the intervention groups had significantly increased their sun-protective behaviours compared with the control group, again indicating long-term efficacy.

Health promotion interventions that create a supportive environment such as workplace, childcare and school sun-protection policies, shade over children's swimming pools, and mass media health promotion campaigns have influenced knowledge, attitudes and values about tanning and the health risks of sun exposure (Montague et al. 2001). The many Australian sun-safe health promotion campaigns over the past 3 decades have impacted sun-protection policy at the local government level and workplace health and safety level, but have only marginally increased personal sun-protective behaviours during outdoor leisure activities. An Australian longitudinal survey study of trends in weekend sun protection and sunburn from 1987 to 2002 reported an upward trend in sun-protective behaviours over time, particularly when the surveys were conducted in conjunction with high exposure to sun-smart media campaigns (Dobbinson et al. 2014). However, media campaigns to promote sun-protective behaviours may not have long-term sustained effects unless they are combined with other strategies to prevent risky behaviour (Smith et al. 2002). Based on the results of National Australian surveys, adolescents and young adults are the group at highest risk (Koch et al. 2016). Graphic hard-hitting health promotion media campaigns may be necessary, such as those used to prevent HIV/AIDS and drunk driving, to minimise risky behaviour and to encourage self-protective behaviour in this group (Montague et al. 2001). However, there is some evidence that these campaigns are beginning to lose impact almost 20 years after introduction, and there is a need to revisit and update these campaigns on a regular basis. It may be timely to revisit the *Slip Slap Slop Seek Slide* media campaign to ensure it is targeting the most at-risk groups.

The results of this review indicate that previous health promotion strategies have had limited success in increasing sun-protective behaviours and reducing the risk of harmful UVR

exposure. While mandatory workplace policies appear to have increased the sun-protection behaviours of outdoor employees, lower personal perceptions of the risk of harmful UVR exposure may exist in temperate climates compared with perceptions of risk in sub-tropical and tropical climates even though the UVR rating is similar. Future health promotion campaigns should focus on increasing knowledge of the risk of harmful UVR exposure in mild temperatures and the importance of protective clothing and eye protection during periods of high UVR exposure. In particular, health promotion should focus on promoting sun-protection behaviours and increasing risk awareness in the context of outdoor leisure activities and large social events such as outdoor spectator sporting events (Egger 1999). In terms of long-term efficacy, the use of graphic images with shock value, in conjunction with other strategies, may be effective in creating a sustained improvement in sun-protection behaviours in adolescents and young adults. The use of appearance-based interventions are recommended as they have proven to be effective when combined with information and education components, especially information about risks of cancer.

## Strengths and limitations

The review's strength is that the quality and rigour of studies were assessed independently and a data extraction tool was used to ensure data were systematically and consistently gathered. This review has limitations that must be considered. Literature was sourced from 2004 to 2018 to examine the most current research. Seminal studies may have been excluded because of this time frame. Even though a thorough, systematic search was undertaken, it is possible that some literature was missed. The study protocol was not registered; however, methods were consistently followed. Studies were excluded if they did not clearly report percentages of sun-protective behaviours, which excluded many studies. Publication bias (small study bias) in some studies may have affected the synthesis of the results, and findings should be interpreted with caution. Due to the diversity of the study methods, data collection tools and populations, and a lack of homogeneous data, a meta-analysis could not be performed.

## Conclusion—Implications for applied practice

Gaining a greater understanding of sun-protective behaviours will help to identify current areas of risk and identify health promotion strategies needed to reduce new cases of skin cancer. While there is evidence that individuals are aware the sun is harmful, many people continue to expose their skin to harmful UV radiation with few sun-protection behaviours. Such risky behaviour needs to be better understood so that effective strategies can be developed to assist behaviour change in the future.

## Compliance with ethical standards

**Conflict of interest** The authors declare they have no conflict of interest.

**Ethical approval** For this type of study formal consent is not required.

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