

# When to apply sunscreen: a consensus statement for Australia and New Zealand

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Cancers of the skin, including melanomas and keratinocyte cancers (basal cell carcinomas and squamous cell carcinomas), are the most common cancers in humans. The populations of Australia and New Zealand have the highest skin cancer incidence and mortality in the world. Each year, more than 1,500 Australians die from melanoma and a further 600 die from cutaneous squamous cell carcinomas. In 2008–09 (the most recent year for which data are available) the health system costs of diagnosing and treating non-melanoma skin cancers in Australia were the second highest of all cancers.<sup>1</sup>

The amassed evidence from epidemiologic and, more recently, genomic studies provides definitive proof that solar ultraviolet (UV) radiation is the principal causal factor for most of these cancers.<sup>2–5</sup> The fraction of melanoma attributable to solar UV radiation exposure has been estimated at between 65% and 90%;<sup>6,7</sup> for keratinocyte cancers the population attributable fraction approaches 100%.<sup>8</sup> Of the three approaches to control skin cancer (*viz.* primary prevention, early detection and better treatment), primary prevention is the most cost-effective and the only strategy that can lower the rate at which new cancers arise.<sup>9</sup>

Australia and New Zealand lead the world in efforts to control skin cancers. Sunscreen application is one component of primary prevention campaigns; every agency in Australia and New Zealand that offers sun protection advice to the public also advises that other strategies should be adopted, including use of clothing and shade, and

## Abstract

**Introduction:** Cancers of the skin are the most common cancers in humans, with Australia and New Zealand having the world's highest incidence. Primary prevention campaigns advise people to apply sunscreen to exposed body sites when outdoors. However, despite growing evidence that cumulative sub-erythemal exposures cause mutational damage, and trial data demonstrating benefit from daily sunscreen use, current policies do not consider the hazards of incidental (everyday) sun exposure. Thus, a Sunscreen Summit was convened to review the evidence and update the policies for people living in Australia and New Zealand.

**Results:** After reviewing the benefits and risks of sunscreen application, the policy group concluded that people living in Australia and New Zealand should be advised to apply sunscreen to the face/head/neck and all parts of the body not covered by clothing on all days when the ultraviolet index is forecast to reach three or greater, irrespective of their anticipated activities. For planned outdoors activities, sunscreen should be used alongside other sun protection measures.

**Conclusions:** People living in Australia and New Zealand are now advised to apply sunscreen every day when the UV index is predicted to reach 3 or above.

**Implications for public health:** Increased use of sunscreen as part of the daily routine to reduce incidental sun exposure will lead to decreased incidence of skin cancer in the future.

**Key words:** sunscreen, skin cancer, position statement

minimising outdoor exposure during times of peak UV flux (see supplementary file for links to existing policies). Until now, the consensus in Australia and New Zealand has been that sunscreen should be applied prior to planned outdoor exposures and re-applied during prolonged exposures; no agency currently provides specific advice about applying sunscreen routinely to guard against sun exposure that occurs incidentally during everyday activities such as travelling to and from work, doing household chores or shopping.

Recently, there has been recognition that the skin incurs cumulative mutational damage through repeated, sub-erythemal exposures

to sunlight.<sup>10</sup> Further, the National Sun Survey reported that sunburn commonly occurs as a result of incidental exposures.<sup>11</sup> This body of research prompted a trans-Tasman initiative to bring together key stakeholders with the aim of reviewing the evidence to determine whether existing sunscreen policies should be changed.

## Consensus process

A Sunscreen Summit was held over two days at the QIMR Berghofer Medical Research Institute in Brisbane (19–20 March, 2018). The summit was convened by the Australian Skin and Skin Cancer Research Centre (ASSC:

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Submitted: October 2018; Revision requested: December 2018; Accepted: December 2018

The authors have stated they have no conflict of interest.

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*Aust NZ J Public Health.* 2019; Online; doi: 10.1111/1753-6405.12873

www.assc.org.au) and brought together more than 100 representatives from cancer control agencies, government departments, specialist medical colleges, research institutions and consumer organisations. Attendees paid their own travel and accommodation costs, with the ASSC bearing additional costs. No sunscreen industry sponsorship was sought.

On the first day of the Summit, invited experts delivered a series of presentations to provide the most up-to-date evidence regarding the benefits and harms of sunscreen application. The second day comprised a closed policy workshop attended by representatives from the peak bodies delivering sun protection advice, together with consumer organisations and regulatory agencies (organisations represented are shown in Box 1; hereafter the 'Policy Group'). The closed workshop was tasked with critically reviewing the evidence presented the previous day with the goal of developing an evidence-based consensus statement about routine use of sunscreen.

The new position statement is shown in Box 2. The recommendation to apply sunscreen daily when the UV index is forecast to reach 3 or higher is classified on the NHMRC levels of evidence scale<sup>13</sup> as "A" (the body of evidence can be trusted to guide practice), and on the GRADE system<sup>14</sup> as: "high quality of evidence; and strong recommendation for using an intervention". The evidence considered in arriving at this statement is described below.

## Evidence base regarding use and effects of sunscreen

### Current sunscreen policies

A systematic desktop review of 69 policies (12 international and 42 Australian) found considerable variability in the advice given (Presented by M. Janda at the Sunscreen Summit on 19/03/2018; manuscript under review). However, most Australian national policy documents (N=12) advised using sunscreen with an SPF 30 or higher,

#### Box 1: Organisations represented at the Sunscreen Summit.

Australasian College of Dermatologists, Australian Skin and Skin Cancer Centre, Cancer Council Australia, Cancer Council New South Wales, Cancer Council Queensland, Cancer Council Victoria, Cancer Council Western Australia, Cancer Society New Zealand, Health Promotion Agency (New Zealand), Melanoma Institute Australia, Melanoma Patients Australia, QIMR Berghofer Medical Research Institute, Queensland Health, Skin Cancer College Australasia, The Skin and Cancer Foundation Inc, Therapeutic Goods Administration, The University of Queensland, Victorian Melanoma Service.

reapplying every two hours, applying liberally, and using in conjunction with other protection measures. Notably, existing policy documents focused on the use of sunscreen during planned exposures, with no specific recommendations for reducing incidental exposure to UV radiation.

### Benefits of routine sunscreen application

Skin cancer is mainly caused by UVB-induced DNA photodamage that, if unrepaired, leads to mutations in critical genes. The action spectra for sunburn (erythema) and photodamage overlap, and there is consistent and compelling experimental evidence that sunscreens designed to prevent erythema also prevent DNA damage when applied to human skin before UVB exposure.<sup>15</sup>

The potential for sunscreen to protect against skin neoplasia has been confirmed in four randomised-controlled trials that investigated the effect of daily sunscreen use on premalignant lesions,<sup>16-18</sup> keratinocyte cancers<sup>12</sup> and melanoma.<sup>19</sup> (For this summary, 'pre-malignant lesions' includes naevi, which are benign melanocytic tumours that can, very infrequently, progress to melanoma). The methods and outcomes of these studies are summarised in Supplementary Table 1.

All four trials reported beneficial effects of sunscreen, although the Policy Group noted some limitations in the evidence. Firstly, only one study has been conducted in children.<sup>17</sup> The setting was an environment of relatively low ambient UV radiation and the control

group also used considerable amounts of sunscreen. The likely consequence of this is that the benefit of sunscreen was underestimated. All other trials were conducted in older adults<sup>12,18</sup> (or those with a history of actinic keratosis or keratinocyte cancer)<sup>16</sup> over relatively short timeframes (six months to 4.5 years) so the benefits of applying sunscreen from a younger age and for a longer time are unclear. The Policy Group also noted the evidence for lack of effect for preventing BCC in the only trial that included it as an outcome (the Nambour Trial).<sup>12</sup> One possible explanation is that participants in the Nambour Trial were too old to prevent the onset of BCC; there is reasonably consistent observational evidence that early-life sun exposure is more important than cumulative exposure in the aetiology of BCC.<sup>20</sup> There are also reports that sunscreen use prior to age 25, but not after, is associated with reduced risks of BCC.<sup>21</sup>

The evidence base for melanoma is limited; only 33 participants developed melanoma during and after the sunscreen intervention in the Nambour Trial.<sup>19</sup> While the findings for melanoma were of borderline statistical significance, the number of people who developed melanoma in the intervention group was half that of the control group, suggesting a protective effect of sunscreen.

Models based on the effect estimates for SCC and melanoma generated by the Nambour Trial and the prevalence of frequent sunscreen use from the 2010 NSW Population Health Survey<sup>22</sup> estimated that 9.3% of

#### Box 2: When to apply sunscreen.

Skin cancers are predominantly caused by over-exposure to the sun's UV radiation:

- During everyday activities which add up over time (e.g. travelling to and from work; doing household chores; shopping etc)
- During any planned or prolonged outdoor activities (e.g. doing outdoor work; gardening; playing or watching sport; going to the pool or beach; exercising outdoors etc)

When applied correctly and used regularly, sunscreen is effective in reducing the incidence of skin cancer.

In the statement below, "sunscreen" means sunscreen with an SPF of 30 or more and compliant with Australian/New Zealand Sunscreen Standard AS/NZS 2604:2012.

#### Sunscreen for everyday activities

When the UV index is forecast to reach 3 or above, it is recommended that sunscreen is applied every day to the face, ears, scalp if uncovered, neck and all parts of the body not covered by clothing. Ideally, this would form part of the morning routine. This protects the skin from the harmful effects of everyday sun exposure.

#### Sunscreen for planned or prolonged outdoor activities

During planned or prolonged outdoor activities, for the best protection it is recommended that sunscreen is used along with other sun protection measures (i.e. clothing to cover as much of the skin as possible; hats; sunglasses; shade and scheduling outdoor activities to avoid the middle part of the day).

When the UV index is forecast to reach 3 or above, sunscreen should be applied to the face, ears, scalp if uncovered, neck and all parts of the body not covered by clothing.

Sunscreen should be re-applied every 2 hours or more frequently if swimming, sweating or towel drying.

Sunscreens should not be used to promote tanning, but rather as one of five strategies (along with shade, hats, clothing, sunglasses) to reduce exposure to harmful UV radiation.

SCCs and 14.0% of melanomas that would have otherwise occurred in 2010 had been prevented by sunscreen.<sup>8</sup> Further modelling suggests that intervening to incrementally increase sunscreen use over a 10-year period would prevent 10% of melanomas in Australia and the US between 2012 and 2031.<sup>23</sup>

### Harms of sunscreen application

The Policy Group considered the following known or potential harms of sunscreen use: 1) contact dermatitis; 2) increased risk of vitamin D deficiency; 3) harms of nanoparticles; 4) hormone-disrupting effects of some sunscreen ingredients; 5) risks to the environment.

**Dermatitis:** Sunscreens can cause irritant or allergic contact dermatitis and, more rarely, photo-contact dermatitis. There is a dearth of data regarding the prevalence of these reactions in the general population, but fewer than 2% of participants in the Nambour Trial reported skin reactions.<sup>12</sup> Reactions to sunscreens account for a small proportion of adults<sup>24</sup> and children<sup>25</sup> undergoing patch testing. Sunscreen-induced dermatitis does not have long-term consequences and is mitigated by ceasing use of the particular agent or product.

**Vitamin D deficiency:** Sunscreens are manufactured primarily to prevent erythema. The action spectra for erythema and pre-vitamin D production overlap<sup>26</sup> so, in theory, sunscreen use could increase the risk of vitamin D deficiency. A systematic review presented at the Sunscreen Summit found consistent evidence in experimental studies that sunscreen applied to human volunteers prior to artificial UVR exposure abrogated vitamin D production (Presented by R. E. Neale at the Sunscreen Summit 19/03/2018; manuscript under review).<sup>27-31</sup> The observational studies have considerable limitations, but most (65%) found no association between sunscreen and 25 hydroxy vitamin D (25(OH)D) concentration. The most compelling data come from the two Australian randomised-controlled trials of sunscreen (SPF~16) for prevention of actinic keratosis and skin cancer, in which there was no difference in the 25(OH)D concentration between the daily sunscreen and discretionary sunscreen use/placebo groups.<sup>32,33</sup> There are no trials examining the impact on vitamin D of the high SPF sunscreens that are currently recommended, but findings from the existing trials suggest that any influence on 25(OH)D concentration

is likely to be small. We will continue to monitor this issue.

The Policy Group concluded that for the purposes of forming policy, the 'pragmatic' findings of field trials (showing that daily sunscreen is effective in preventing skin cancer yet with no measurable reduction in Vitamin D levels) outweigh the largely 'theoretical' effects of diminished vitamin D synthesis observed under laboratory conditions.

**Harms of nanoparticles:** Inorganic UV filters, zinc oxide and titanium dioxide are used in sunscreens in their nanoparticle form. Concerns have been raised that these could be absorbed and cause harm such as by producing reactive oxygen species. The Policy Group noted the recently updated evidence statement from the Australian Therapeutic Goods Administration (2017) that concluded that nanoparticles only minimally penetrate the stratum corneum and that these products are unlikely to cause harm.<sup>34</sup>

**Hormonal effects:** Some have expressed concern that oxybenzone (also called benzophenone-3), a phenolic compound used as an organic sunscreen agent, has the potential to cause hormonal disruption. The Policy Group noted the recent systematic review that found little evidence to suggest significant harms of these compounds,<sup>35</sup> although the body of evidence is limited. Rodent studies (n=7) yielded inconsistent findings; harms were generally observed only at very high exposures. A total of 11 human studies investigated possible hormonal effects of sunscreens. Four studies reported positive associations between urinary oxybenzone or total phenol concentration and some reproductive outcomes (increased male birth weight, decreased female birthweight, decreased gestational age). There were no associations with other outcomes such as semen quality, fecundity, spontaneous abortion or male genital abnormalities. A randomised-controlled trial using a cream containing oxybenzone found no effect on any reproductive hormones.<sup>36</sup>

**Potential environmental harms:** Active ingredients of sunscreens (or their by-products) have been detected in freshwater, coastal and marine ecosystems. These compounds can impair the development of corals,<sup>37</sup> sea urchins,<sup>38</sup> and fish.<sup>39</sup> Concentrations can be particularly high near swimming beaches.<sup>40</sup> In light of this, the US state of Hawaii legislated

to ban the sale of sunscreens containing oxybenzone and octinoxate. Other legislation has been submitted to the European Union calling for a similar ban. New sunscreens are being developed currently to mitigate any environmental risks.

### Prevalence of sunscreen use and consumer concerns

The Policy Group reviewed the most recent survey data regarding the use of sunscreens in Australia, and consumer perceptions and concerns about sunscreen. The 2010-2011 Australian National Sun Survey found that 37% of adolescents (12–17 years) and 36% of adults (18–69 years) wore sunscreen when outdoors on summer weekends; the 2016-18 survey (not yet published) found that sunscreen use has increased among adults and stayed the same among adolescents (Presented by S. Dobbins at the Sunscreen Summit on 19/03/2018 and confirmed by email on 26/09/2018). Importantly, 40% of respondents were confused about which weather factors caused sunburn, resulting in a risk of unprotected exposure.

Consumer surveys conducted by Choice Australia found that while there were some concerns about chemicals, nanoparticles and vitamin D deficiency, the reason most frequently cited for not using sunscreen was forgetfulness.<sup>41</sup> Nine per cent of people from the nationally representative survey listed price as a barrier.

### Economic considerations

The Policy Group reviewed the findings of health economics research. Based on the findings of the Nambour Trial, daily sunscreen use produced substantial cost savings to government over a five-year period,<sup>42</sup> and long-term modelling confirmed that regular sunscreen use is cost-effective.<sup>43</sup> Investments in skin cancer prevention programs, which promote sunscreen use alongside other sun protection measures, bring strong returns on investment.<sup>9</sup> In Australia, for every dollar spent on skin cancer prevention programs/campaigns, there is an expected \$3.20 return with a net social benefit of \$1.43 billion.<sup>44</sup> The Policy Group concluded that using sunscreen regularly will likely reduce future health care spending, patient medical expenses and other societal costs.

## Discussion and recommendations

The Policy Group concluded that the experimental studies and randomised trials provide strong evidence that daily sunscreen use reduces the risk of skin cancer, and that there is consistent and compelling evidence that sunscreens are safe. Adverse events are rare and are almost always minor and transitory.

The human field trials of sunscreen use were mostly conducted either at a time of year or location where the average maximum UV index was at least 3, so the findings are not necessarily generalisable to times or places where the UV index is lower than this. The Policy Group debated whether or not to extend the recommendation to routinely apply sunscreen even when the UV index is forecast to be less than 3. On balance, it was felt that such a position would be challenged on the grounds of credibility. Moreover, maintaining the threshold for application at the UV index of 3 accords with existing advice about protecting the skin before planned exposures (see Supplementary Table 2 for links to policies from participating organisations). To assist consumers, the new position statement includes a table displaying the average monthly maximum UV index at major locations in Australia and New Zealand (Table 1).

The Policy Group also considered the ramifications for subgroups of the population, including people with darker skin types and children. Current policies are essentially silent on the matter of skin type, with the exception

of stating that darker-skinned people may need more time outdoors to optimise vitamin D. The new recommendation to use sunscreen routinely is intended to be incorporated into existing policies, so the Policy Group concluded that the current practice of providing advice that is not specific to particular skin types should be continued.

There are very few data relating specifically to children, apart from one randomised trial that found that children randomised to receive regular sunscreen had fewer naevi at follow-up than those receiving 'usual care'.<sup>17</sup> The Policy Group determined that the advice to use sunscreen routinely when the UV index is 3 or greater should also apply to children.

The Policy Group considered issues of equity. Sunscreen products vary in price, although Australia's regulatory environment ensures that more and less expensive sunscreens are equally effective. Nevertheless, the Policy Group recognised that the cost of applying sunscreen every day would be a barrier for some. This issue needs to be considered in implementation of the policy but should not preclude organisations from providing evidence-based advice.

Sunscreen cannot substitute for other forms of protection during prolonged exposure. The Nambour Trial found no evidence that instructing people to apply sunscreen every day reduced their use of other protective behaviours. However, to ensure that the recommendation to apply sunscreen routinely does not lead to declines in other protective behaviours, the Policy Group intentionally separated incidental from

planned sun exposures and provided specific, tailored advice for each circumstance.

This change in policy has set the stage for advising people in Australia and New Zealand to apply sunscreen daily when the UV index is forecast to reach 3 or greater. The government and non-government organisations tasked with implementing this policy have a long history of delivering sun protection messages to the general public and will be guided by their knowledge of the barriers to, and enablers of, sunscreen use. Future planned meetings of the working group will explore the impact of the new policy, issues related to implementation, and consider any modifications in light of consumer feedback and/or new research.

## Acknowledgements

David C. Whiteman and Rachel E. Neale contributed equally to this report and should be considered joint first authors.

DCW and REN receive salary support from the National Health and Medical Research Council. The Sunscreen Summit received support from the Australian Skin and Skin Cancer Research Centre (a joint venture of the QIMR Berghofer Medical Research Institute and the University of Queensland).

## The Sunscreen Summit Policy Group

Sunscreen Summit Organising Committee and Jodie Antrobus, Sanchia Aranda, Victoria Beedle, Linda Buxton, Megan Chapman, Anita Dessaix, Georgina Long, Cheryl McRae, Victoria Mar, Keith Monnington, Stephen Shumack, Craig Sinclair, Terry Slevin, Mark Strickland, Mei Tam, Heather Walker, Dallas English.

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Table 1: Average daily maximum UV index for Australia and New Zealand, by month and city

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Australia												
Darwin	12	13	13	11	9	8	9	10	12	13	12	12
Brisbane	12	11	10	7	5	4	4	5	7	9	11	11
Perth	12	11	9	6	4	3	3	4	6	8	10	11
Sydney	11	10	8	5	3	2	3	4	5	7	9	10
Canberra	11	8	7	5	3	2	2	3	5	7	9	11
Adelaide	11	10	8	5	3	2	2	3	5	7	9	11
Melbourne	10	9	7	4	2	2	2	3	4	6	8	10
Hobart	8	7	4	3	1	1	1	2	3	4	6	7
New Zealand												
Auckland	10	8	7	4	2	1	2	2	3	6	8	9
Wellington	9	8	6	3	1	1	1	2	2	5	7	8
Christchurch	8	7	5	2	1	1	1	1	2	4	7	8
Invercargill	7	6	4	2	1	0	0	1	2	3	5	6

Notes:

Sunscreen should be applied to exposed body sites daily when the maximum UV index is forecast to reach 3 or more. Shaded cells show months when the average maximum UV index does not reach 3.

Data Credit: Dr Richard MacKenzie, NIWA (New Zealand).<sup>45</sup>

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## Supporting Information

Additional supporting information may be found in the online version of this article:

**Supplementary Table 1:** Randomised-controlled trials of sunscreen for prevention of premalignant or malignant lesions.

**Supplementary Table 2:** Sunscreen policies and position statements from participating organisations.