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INVITED REVIEW

SHADE PROVISION FOR UV MINIMISATION: A REVIEW

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Abstract

Minimising exposure to ultraviolet (UV) radiation is an essential component of skin cancer prevention. Providing and using natural and built shade is an effective protection measure against harmful UV. This article describes the factors that must be addressed to ensure quality, effective, well designed shade and recommends best practice approaches to improving the protection factor (PF) of shade structures. It identifies examples of interventions to increase shade availability and use, and examples of effective shade based on measured protection factors or measured reductions in UV exposures. Finally, this article considers examples of best practice for undertaking shade audits. The article is based on refereed papers and reviews, reports, conference papers, and shade practice and policies from reports and on web sites. Articles for the Australian setting are considered first, followed by those in an international setting.

INTRODUCTION

The World Health Organisation states that four out of five skin cancer cases can be avoided (1). The prevention of skin cancer requires the minimisation of overexposure to UV radiation.

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A multi-faceted approach based on appropriate combinations of sunscreen application, clothing, hat, minimising sunlight during the times of the day with higher UV, utilising shade, and sunglasses is essential for the minimisation of exposure to solar UV (2). These UV minimisation strategies are widely promoted by cancer prevention organisations, and are highly recommended if the UV index is three or higher (1, 2).

One important part of the prevention strategy is the use of shade as a UV minimiser. Shade is promoted for the reduction of UV exposures. For example, the increase of shade provision is a priority area for skin cancer prevention in the New South Wales (NSW) Skin Cancer Prevention Strategy 2012-15 (3). The UK National Institute for Health and Clinical Excellence (NICE) has developed recommendations (4) to increase policy and education on shade and the provision of shade environments. The Toronto Cancer Prevention Coalition (5) produced a series of guidelines for shade provision for use by a variety of professionals and city staff who are responsible for the planning and design of a range of facilities and sites. Environments that do not provide sufficient shade place great demands on individuals to protect themselves in the sun (6). An extensive amount of research has been conducted quantifying UV levels beneath different shade environments (for example, 7-28). The fact that shade is an essential component of UV minimisation means that these environments must be better designed and constructed based on research that shows how UV radiation interacts with these environments.

This paper reviews the factors influencing UV protection by shade, the protection factors of the shade provided, the provision and effectiveness of shade in different environments, and the various types of shade audits that can be used to implement shade creation.

FACTORS INFLUENCING SHADE UV PROTECTION

Protection Factors

Shade environments for public use are provided by Local Governments, schools and community organisations. These include vegetation and structures such as gazebos employing shade cloth, polycarbonate sheeting and various opaque building materials (7). Each of these provides different degrees of protection from solar UV. The reduction of the solar UV exposures is a combination of the use of shade and the amount of UV protection provided, with the amount and type of cloud cover and the anatomical site under consideration also being influential (11).

The effectiveness of shade structures is determined by their Protection Factor (PF), defined as (29):

$$PF = \frac{UVBE_{Sun}}{UVBE_{Shade}}$$

where $UVBE_{Sun}$ is the horizontal plane erythemal UV (30) in full sun and $UVBE_{Shade}$ is the erythemal UV to a horizontal plane under the shade structure. It has been recommended that a protection factor of 15 or more is required for effective shade (31). However, even a PF of 15 would be inadequate for part day or full day protection which requires a PF of 30 or 35. Furthermore, it is necessary that this PF is provided at the sites where the users are located (32). The reason for this is the shade position will change as the SZA changes with the time of day and with the day of the year. There are cases of small shade structures with no side-on protection where for large solar zenith angles, the shade is not directly below the roof structure where the seats or tables provided with the structure are located (10).

Quality, effective and well-designed shade must address a number of factors including:

- Reflected UV from the surrounding environment and materials, and the albedo of the ground surface;
- Skyview which is influenced by the height, size and shape of the structure;
- Shade characteristics that are influenced by whether it is natural or built shade.

UV Albedo and Reflectivity

The UV albedo or reflectivity of the natural and built environment contributes to the diffuse UV radiation and as a result to the UV in shade structures with a resulting reduction in the protection provided by the shade. The albedo of ground surfaces that are covered by natural ground cover are generally low and of the order of 5% or lower, with grass as low as 2-3% (33) with a report providing the erythemal UV albedo of grass as in the range of 0.5 to 1.2% (34). The albedo for erythemal UV is higher for concrete surfaces at approximately 10% (35). This is higher for gypsum sand at 15-30% and snow which can be as high as 90% (36). As a general guideline, hard smooth surfaces reflect more UV than surfaces that have varied and softer edges like grass cover (32). It has been recommended to use ground covers or grass with their lower albedo, or alternatively other low albedo surfaces under shade structures in place of concrete or concrete pavers in order to assist in reducing the diffuse UV in the shade (37).

The UV albedo of horizontal and vertical surfaces in the built environment also contributes to the diffuse UV. This albedo will depend on the solar zenith angle and azimuth (38). It also depends on the type of material and can vary between 3% for coloured metallic surfaces to approximately 30% for zinc aluminium and galvanised surfaces (38, 39). The albedo of seats and tables under the structures plays a minimal role in the diffuse UV as the surface area of these is significantly less than that of the ground cover.

Skyview

Research on different sized shade structures (with a metal roof area of 32.1 m^2, 19.1 m^2 and 15.5 m^2) with no surrounding buildings, trees or vegetation around the structures has considered the influence of skyview on the PF provided. The PF was measured over a year for SZA of 13^o to 76^o (7, 9). Overall, irrespective of the size of the structure, there was a decrease in PF as the SZA increased. This is due to the higher relative proportion of diffuse UV as the SZA increases. Although, the PF dropped significantly for the SZA of 76^o, the UV irradiances at the times corresponding to these SZA are lower as it is earlier or later in the day. The other factor that lowers the PF is cloud due to the increase in the proportion of diffuse UV (27).

For these stand-alone structures the PF provided by the larger structure was nearly double that of the smaller structure for SZA smaller than 60^o due to the differences in skyview (7). This is also reported by others who recommend reducing and protecting open sides (40, 11). The amount of sky obscuration provided by the different environments can be determined with the use of upward-facing hemispherical photographs with appropriate image analysis (25, 41, 42). Additionally, for the larger SZA, the shade cast by the small structure moved away from underneath the shade where generally seating may be provided. The PF of the small and medium structures was still less than 15 at the smaller SZA. The PF of the larger shade structure reached approximately 18 for a SZA of 13^o. However, even for this larger structure, the PF dropped to below 15 as the SZA increased above approximately 20^o (9). Although, the larger shade structure provided the better protection and it is an important component of an overall protection strategy, it needs to be highlighted that the PF provided by the stand alone structure in the winter months is less due to the sun being lower in the sky, with a PF of approximately 1/3 of that considered to be effective shade.

Other types of shade structures of a shade umbrella, a covered walkway, a verandah and a covered sand pit have been measured for their PF (8). These PFs have ranged from 1.4 to 10. In all of these cases although the UV transmission of the roof material was low, the amount of diffuse UV incident through the sides was the influencing factor on the PF. Other researchers (43) have also found a low PF of the order of 1.3 to 2.5 for a shade umbrella and a sunshade.

Shade Characteristics

Some of the materials, such as shade cloth and shade sails used for the roof of a shade structure have an associated ultraviolet protection factor (UPF) that has been measured according to the Australian Standard AS/NZS 4399 (44). This is a measure of the attenuation of the direct erythemal UV for the material in a new, dry, non-stretched state and is different to the PF of a shade structure which incorporates the UPF of the roof material and the influence of the diffuse UV. The attenuation of the UV increases with increasing number and a UPF of higher than 50 is represented as 50+. A material with a UPF of 20 which is in the category of "good protection" transmits 5% of the direct erythemal UV and provides protection from 95% of the direct UV (45). Shade cloths have been reported to have a UPF of 20 to 50+ and the material of shade sails a UPF of 50+ (29, 46). Opaque materials such as metal sheets or materials that transmit only minimal UV wavelengths would have a UPF of 50+. In order to maximise the reduction of the direct component of the UV, the roofing material should provide "good protection" or better.

The UPF of most material will decrease if the material is stretched or wet or in a weathered state. Material that is aged and weathered will have a lower UPF than that when tested. The Shade Handbook (45) provides the lifetime of the most widely used roofing materials, with the lifetime of shadecloth as 5 to 10 years (45). In comparison, steel roof sheeting is given as having a long life. This information and that for the lifetimes of other materials, along with the listed properties of all the materials is a useful guide for the lifetime of the materials before they need to be replaced.

A major factor in the use of shade environments is related to the comfort of the shade users. The reduction in temperature and visible radiation is not generally indicative of UV levels, as diffuse UV can still be incident on the shaded skin and eyes (47, 27, 8). The human eye detects radiation at wavelengths that range from approximately 380 to 780 nm with a peak response at 555 nm (48), whereas the human skin detects the longer wavelength infrared radiation. While UV and visible radiation in full sun are dependent on the angle of the sun, research by Turnbull and Parisi (8) showed that while scattered UV in the shade did show a dependence on sun angle, visible radiation in the shade showed no such dependence.

The comfort of the users is a determining factor for personal UV exposure, with people using less clothing as they feel hotter due to rising ambient temperature (49). The public will generally use shade in summer due to the higher temperature, but in winter or in cooler weather people will seek locations that are warmer or 'warm shade' (50, 41). MacKay and Donn (51) found that school students preferred light and warm shade that was large enough for a group. When it is not comfortable in the shade, it will not be used; whereas, shade that is comfortable will be used by the public seeking relief from the heat (52). Visible light intensity also does not give an indication of UV levels in the shade (8).

Natural shade is an important component of shade provision and the protection factor of trees has been found to depend on a number of influences such as the foliage density of the canopy, the height of the canopy above the ground, the season, the solar zenith angle of the sun and the amount of cloud cover. A number of researchers have measured the PF of trees. The PF of trees under a number of conditions has been found to range from 2 to 20 (53). The PF of a sparse density canopy gum tree was 2-6 and 3-20 for a denser canopy she-oak (15). Protection factors of 3.5 to 5.5 were measured at noon in summer with lower PF at the higher SZA in the morning and afternoon (31). For the UV in the shade of gum trees, 60% of this has been measured as being due to the diffuse UV, with this relative amount being reasonably constant within a standard error of 10% throughout the day (16).

Six tree types were measured on sunny days over 8 months to have a PF of 5 to 10 (53). There was some variation in the PF for some trees as the canopy density changed from month to month. Other researchers have measured a PF range of 2.6 to 8.3 with changes due to the solar zenith angle (54). The variation in PF due to the difference in canopy density have also been shown in a UK setting where the PF varied from 4 for a low density canopy to 20 for a tree with a high density canopy and surrounded by other trees (55). The reduction in the UV provided by trees varies with wavelength due to the increased relative amount of diffuse UV at the shorter wavelengths (56). The improvement in PF due to trees has been modelled and shown that a PF of 10 can be obtained by a cluster of trees providing canopy cover of 90% (26). In summary, the use of trees as shade will produce a higher PF for trees with a denser canopy and also trees near other trees or structures will improve the PF.

Side-on protection in the form of vegetation and trees has been shown to also be effective in increasing the PF of a shade structure (11) and also where it is relative to other structures and buildings (57). This research measured the reduction in the UV in the shade by measurement of the UV under three similar shade structures with vegetation on various sides compared to a similar shade structure with no surrounding vegetation. The improvements in the PF ranged by a factor of 1.3 to 9 with the biggest factor at the larger solar zenith angles. Additionally, the positioning of the side-on protection needs to take into account whether the shade is going to be used in the morning or the afternoon.

The findings from the literature are that in order to improve the PF of shade settings, it is necessary to have either overhang from the roof or the addition of side-on protection in order to reduce the amount of sky that is visible from the shade and the amount of diffuse UV entering the shade (10, 27, 58). This has been shown to decrease the erythemal UV in the shade by up to 65% in summer and 57% in winter. These correspond to an improvement in the PF by factors of 2.8 and 2.3 respectively (11). MacKay (59) has reported on the importance of the use of polycarbonate and laminated glass particularly in cooler climates where it is necessary to create 'warm shade'. This is useful as research has shown that in a school setting, the preference of students is shade that provides light and warmth and is large enough to group within (51).

SHADE IN DIFFERENT ENVIRONMENTS

The creation of shade structures by the different organisations such as Councils, community groups, sporting clubs, child care centres and schools is an integral part of providing a sun safe environment. A telephone survey of 483 respondents in three different Councils (60) found that a high proportion of 93.5% placed a high priority on shade. A survey of 18 year olds and older across NSW has shown that approximately more than 60% used shade when it was available (61). The National Institute for Health and Clinical Excellence (4) reported that the main barriers to shade provision and use were: the cost of the structures; the implementation of the shade structures in various settings; and the inconvenience of having to utilise the structures when outside.

Guidelines for the provision of shade for young children and for public pools and sports fields are available (62-64). In order for the effectiveness of shade structures to be described, they need to have the PF measured or alternatively need a measure of the reduction in the UV exposures of the users. This section has a review of cases in a number of settings where the PF or reduction in UV exposures has been measured. The situations where the PF has been improved or the UV exposures reduced are provided as cases of best practice. However, the cases where the PF has been measured for the provided shade are small and it is recommended for research to be undertaken to measure the PF or reduction in UV exposures of the provided shade so that more cases of best practice can be determined.

Pre-schools

Boldemann et al. (65) compared the erythemal UV exposures of children aged 1 to 6 years in a pre-school setting over 11 days in the Northern Hemisphere summer in Sweden at one site where the playground equipment was in full sun and at another site where the playground equipment was covered by the dense canopy of trees. The UV exposures were measured with dosimeters to the shoulders. The two sites provided similar amounts of UV for the times of the day that the children were outdoors. This research found that the UV exposures to the children in the environment where the playground equipment was shaded received 19% lower erythemal UV exposures to the shoulders compared to their counterparts at the other pre-school. This adds evidence to the usefulness of shade in the reduction of solar UV exposures.

Follow up research on 197 children in 11 pre-schools measured the UV exposure to the top of the right shoulder, along with the pedometric measurement of step count during summer in Stockholm county (66). The pre-schools were classified based on the amount of outdoor shade. For the pre-schools with the higher shade cover, the average UV exposure relative to the ambient UV was lower at 14.6% compared to the 24.3% for the children in the pre-schools with less shade. Additionally, the first group with the higher levels of shade in the pre-schools had an average of 1.2 times the number of steps indicating the additional benefit of more outdoors activity (66).

Primary Schools

The erythemal UV exposures, activities and sun protective practices of 345 primary school children in 23 New Zealand schools were measured over 12 weeks (67). The erythemal UV was monitored with personal electronic UV dosimeters attached to the lapel of the outer layer of clothing. The students also completed a daily activity log with the day divided into 10 minute intervals. The average exposure of the students that used shade was 1.71 mSED/min compared to the non users of shade with 3.11 mSED/min (67). This is a reduction to almost half of the exposures of the non users of shade.

A technique to evaluate the amount of shade in a primary school setting has been developed based on the use of aerial photography and image analysis (68). The average proportion of shade in the form of trees, verandahs, covered walkways and undercover play areas compared to total school area outside of the classroom across 33 primary schools in Perth was 14.5% with a range of 3 to 26%. Polysulphone dosimeters used on the left shoulder of grade one children to measure the UV exposures for this age group suggested that the proportion of provided shade does not reflect on the amount of shade use (69). At least for this age group, the provision of shade needs to be combined with encouragement by staff and students to use the shade.

The Cancer Council Qld (70) has provided an instructional video for UV minimisation. One component of this is the provision of shade through the building of shelters and planting of trees. This has to be incorporated with the encouragement to use the shade during break times and at sporting events.

The horizontal plane and vertical plane reduction in UV exposure under shade structures in New Zealand primary schools has been reported (28, 71). Twenty nine shade structures were investigated across ten schools and only six were found to provide a PF of greater than 15, with the majority providing a PF of 4 to 8. The structures that were verandahs that faced north or north east onto large open areas had protection factors that were affected by the diffuse UV in this environment. Any improvement of the protection factor of verandahs or awnings requires the lowering of the roof edge or some form of screening with possibly trees and plants.

Secondary Schools

A questionnaire of 70 grade 8 school students at the tropical site of Townsville (19^{o} S) showed that 24.2% spent time under a shade cloth structure during morning and midday breaks (72). A more recent study in secondary schools in Melbourne compared the use of areas of each school by adolescents prior to and post the installation of shade sails (73). There was an increase between the intervention school and the control school of a mean of 2.67 more students per school using the area with the provided shade. Although not a large increase, it is statistically significant in this population group that is recognised as a difficult group to influence with respect to sun safety.

Community Environments

A survey of 2,338 non-hispanic white adults in the US has shown that for this population group, the use of shade and long sleeves may be more effective than sun screen in the reduction of UV exposures (74). In an urban setting, the erythemal UV exposures were measured with an electronic dosimeter to the chest on clear summer days in Vienna (75). The subjects wore the dosimeters in the settings of both sunlight and urban shade while walking, sightseeing, sitting at a sidewalk cafe, cycling, shopping along sidewalk shops and at an open air swimming pool. All of these activities, except for shopping resulted in less than an hour in exposures of 1 MED for skin types I and II on the six point Fitzpatrick scale (76). The PF mainly ranged from 1.4 to 5 with the highest value of 33 for the sidewalk shops.

In a similar manner, erythemal UV exposures in the setting of the metropolis of Paris were measured on four sunny spring days (77) in both sun and shade settings. These measurements were both static measurements at eight pre-selected tourist sites where the UV index was measured in the sun and directly afterwards in the shade and along two walks where the UV was measured during intervals of shade and sun. The resulting PF due to this urban shade ranged from 2 to 33.

Workplace Environments

There are an estimated 1.2 million outdoor workers across Australia (70), with resultant high levels of UV exposures to these outdoor workers due to the nature of the work. The Cancer Council Qld (70) provides an information resource in the form of a short online video containing strategies for the minimisation of UV exposures to outdoor workers. One of the strategies recommended is the provision of shade and the relocation of work to shaded areas.

A comparison of the erythemal UV exposures to electronic dosimeters worn on the wrist relative to ambient for 31 Irish gardeners and 22 Danish gardeners showed that the Irish gardeners received 4.5% of the ambient UV compared to 8.1% for the Danish gardeners (78). The reason for this was two-fold in that the Irish gardeners had their indoor lunch breaks during times of higher ambient UV and that they were working in older parks with trees having larger and more dense canopies. This emphases the importance of shade in the workplace to reduce UV exposures.

The UV exposures of 77 outdoor workers in building, horticulture and roads in Central Otago, New Zealand were measured with time stamped electronic dosimeters (79). The seeking of shade during their lunch break was employed by only a minority of these workers. This is a different finding to that of outdoor workers across 107 building and construction sites over Queensland where although only 12% were working in shade, 91% chose to take their breaks either in shade or indoors (80). This difference in shade seeking behaviour between the groups in the different locations could possibly be due to the difference in ambient temperatures where the hotter temperatures in Queensland are more conducive for the workers to seek shade for thermal comfort.

Recreational Environments

Thirty recreational environments of swimming pools, beaches, sports grounds and skate parks in the three NSW Local Government areas of Gosford, Sutherland and Shoalhaven have been audited for shade provision (81). There was insufficient shade at a large proportion of the audited sites with insufficient shade at 58% of the sports grounds, 49% of the surveyed areas at beaches and 40% of skate parks. There was shade in the pool areas, but no shade over the main outdoor pools or the main skate ramps. Although all of the pools had UV minimisation strategies, only two of the pool sites had any form of signage. These findings illustrate the shade provision is relatively low at beaches, skate parks and pools and needs to be increased. In parallel with this, UV minimisation policies need to be implemented at recreational settings with related signage at the sites (81).

Observations of 753 children at New Zealand beaches and playgrounds in Dunedin and Hawkes Bay were made to evaluate the amount of sun protection employed (82). It was found that in these settings, the opportunities to employ shade were limited and considered by the authors as the next stage in improving sun protection.

An audit of shade at 203 outdoor Victorian swimming pools in the 2000/2001 summer has found that the shade over the main pool areas was more limited than the shade over other pool facilities (83). Only 52% of the pools had any form of shade over the main pool areas. The types of shade were in the form of permanent shade comprising of fixed structures with covers such as sails, portable shade comprising of umbrellas or other forms of portable shade and shade provided by existing walls and trees or vegetation. The number of pools with signs and messages promoting UV minimisation were low with only 21% of the swimming centres having any form of sun protection message and only 16% had signs that included the SunSmart logo.

The effectiveness of shade provision at 16 toddler pools in Melbourne was assessed in mid-summer to early autumn with the use of handheld UV meters and UV dosimeters based on polysulphone that can be calibrated to measure erythemal UV exposures (29). The PF of the structures depended on the size of the structure, materials used and the location with respect to other structures or trees in the vicinity. This study found that the PF mainly ranged from 2 to 10, with only one structure with a PF of 16. This higher PF was partly due to the structure being near a larger structure over another pool. The PF varied during the day with lower values on the northern side compared to the southern side (29). Additionally, the PF changed by up to three points as the sun moved from east to west. The research suggested the dissemination of the information on shade guidelines to pool owners and managers.

A suggestion to increase the PF is to not rely on shade structures alone and use multiple methods of shading (29). Specifically, natural shade in the form of trees can be used in combination with shade structures around pools to increase the PF provided. Previous research has shown that an increase in protection is provided when there is 10% tree cover compared to no cover (26), providing evidence for the need for trees in UV protection. Guidelines for the combination of natural and built shade have been published (45). However, for natural shade there may be time taken for the trees to mature and in this case either temporary shade structures are required till the trees mature, or alternatively a trellis with quick growing vegetation (32).

In a cooler climate, the use of shade structures with laminated glass as the roofing material has been employed in a swimming pool in New Zealand (84). A PF of 4 to 6 has been measured for the shade structures. The laminated glass transmits only a minimal amount of the UV (85-87) while transmitting the visible and infrared wavebands. The UPF of the material is good, but the protection provided by the material in a shade structure is low due to the coverage. The lamination of the glass prevents any scattering of the glass fragments if there is any breakage of the glass. The use of a questionnaire of the swimming pool users showed that after being told they provided a UV protection factor of 4-6, 69% indicated they would sit under the structures (84).

High UV Risk Environments

The two high UV risk geographical environments considered are a tourist resort in a snow covered mountain area and a beach setting. The snow covered mountain area is a high risk factor setting due to the high albedo of the snow and also the increased UV due to the higher altitude. The beach setting is a high risk setting due to potentially longer periods of time being spent at the beach on summer holidays and also the lower amount of the body covered in clothing, along with the high albedo of the sand.

In the beach environment, the UV protection provided by a beach umbrella was found to be reasonably uniform for a horizontal surface at approximately 14 (88). However, for surfaces tilted at other angles, the PF varied with the sun's position and the orientation of the surface and in the worst case was as low as approximately 1.4. In this environment, the user under a beach umbrella may not be aware of the high levels of diffuse UV radiation. The situation may arise where a user could spend longer than they normally would due to feeling cooler in the shade of the umbrella and obtaining the false impression of being protected. This requires signage at the beach settings to warn users of the presence and dangers of diffuse UV radiation.

In the mountain area, a shade umbrella was used to reproduce shade in early spring with snow covered ground and in summer when the ground cover was grass (89). The albedo of the ground cover was found to influence the UV exposures to vertical and tilted surfaces with less protection provided by the shade over the high albedo snow covered surfaces. Over the snow covered areas the PF for vertical surfaces dropped to approximately two. Similar results have been found by Utrillas et al. (90) where the PF of an umbrella dropped to approximately 1.3 over snow covered ground in comparison to a PF of 3 to 6 over grass covered surfaces.

Interventions to Increase Availability and Use of Shade

The report on Environmental Design and Public Health in Victoria, Australia provides as one of its recommendations that there is collaboration between the Health Department and SunSmart for shade measures to be included in Municipal Public Health and Wellbeing Plans (91). Recommendations are also provided to New South Wales (NSW) Local Governments in Australia to take action by incorporating shade audits and natural and built shade initiatives in management plans (92).

A number of schemes have been initiated to increase the amount of shade provision. These have ranged from grants to community organisations, loans to borrow shade structures and awards to Local Governments who have developed measures to improve UV protection. The SunSmart grant scheme last run in 2012 in Australia was a partnership between Queensland Health and Cancer Council Queensland (93). This scheme has provided grants to community organisations who are involved with children aged 12 years and younger to improve UV minimisation measures, with grants to over 350 organisations. The Cancer Society of New Zealand has a free Shade Loan scheme that loans shade structures such as gazebos and beach umbrellas to eligible groups (94).

At various times, awards have been provided for organisations using innovative shade provision measures. The Cancer Council Victoria offered these in 2008 (95). In a similar manner, the North Queensland Skin Cancer Network conducted a pilot program in 2005 to provide an award to Local Governments who developed quality sun safety initiatives (96, 97). There were only seven entries from six Councils for the prize of $2,500. A review of the pilot found that the monetary amount was not enough to make it financially viable for Local Councils to commit the time to developing an entry. The primary barrier to involvement was that Councils had other priorities that took precedence over skin cancer prevention. It was concluded that any future initiatives should be opened to a broader range of organisations such as community groups, schools and clubs.

SUNbusters was an initiative funded by Queensland Health to provide seeding grants of $500 to community and sporting non-profit organisations to build shade for children (98). Although the quality of the shade provided was relatively poor, a review of the project found that there were additional benefits for UV minimisation from the project. A significant outcome is that at the time of the review, 74% of the grant recipients were developing or had already adopted policies for UV minimisation (98). In addition to the shade provided, this project increased the community awareness and action for the prevention of skin cancer.

The SUNbusters initiative increased shade availability and community awareness on skin cancer prevention, however only very few structures constructed under the program provided high quality shade. If such an initiative were to be repeated, it is recommended that it be expanded to provide a greater financial incentive and also include a shade audit to ensure that shade structures are planned, designed and built following best practice guidelines. A strong evaluative aspect would also need to be incorporated in order to demonstrate the programs ability to produce effective shade

A similar grants program currently being run in the USA is funded by the American Academy of Dermatology and provides $8,000 to each successful applicant for shade provision projects. Shade structures built under the program must satisfy stringent specifications as set out in the program guidelines. For example, shade structures must be permanent, with a roof constructed of metal, wood or shade cloth. Documentation is required to demonstrate that any shade cloth used has a UPF of 30 or higher. Eligible applicants are non-profit organisations that provide services to young people of 18 year old and under and the application must be sponsored by a dermatologist (99). The provision of strong and specific criteria on the quality of shade structures built under the program is a good model for future initiatives seeking to produce highly effective shade structures.

In NSW, there are a number of grant initiatives that are more broadly aimed at facilities improvement or health promotion projects, but which have provided funding for shade. For example, NSW Sport and Recreation (Department of Education and Communities) offer two funding rounds per year through the Participation and Facility Grants Program to local sporting organisations and Councils. Shade structures are available and have been funded through this program (100). In Queensland, the Office of Liquor and Gaming Regulations offers a number of community benefit funds. For example, the Gambling Community Benefit Fund has four rounds per year and there have been successful applicants for shade provision (101).

The 2005/06 Healthy Local Government Grants Program funded by NSW Health and administered by Local Government NSW provided a number of grants for skin cancer prevention in Local Government through shade provision and other sun protection strategies. The aim of the projects focussing on skin cancer was for prevention in the community and council staff, with a particular focus on sun protection for children and young people. Cancer Council NSW advice was sought for the skin cancer prevention focussed applications during the judging phase of the grants program. Successful Councils were also requested to meet the requirements of the NSW Cancer Council publication, *Under Cover: Guidelines for Shade Planning and Design*, in undertaking this project (100).

TYPES OF SHADE AUDITS

Determining the adequacy of existing shade and whether there is enough shade at a particular site can be achieved through the use of a shade audit. The Guidelines to Shade (102) recommend a shade audit in the shade planning process. Shade audits are an essential step in creating highly effective shade environments to protect children and adults from over-exposure to UV radiation. This type of assessment helps to find ways of creating shade that is appropriately located, of proper size, and provides suitable protection. Cancer Councils throughout Australia promote conducting shade audits. SunSmart highly recommends that a shade audit be undertaken to assess existing shade and identify additional shade requirements as part of best practice planning for outdoor locations (2).

The Centre for Disease Control and Prevention in America has produced an extensive document on shade planning in schools (103). The majority of international guidelines reference specific Australian documents: The Shade Handbook (45); Creating Effective Shade (2); and Under Cover (104).

Generally, a shade audit should be done at high UV irradiance times, namely 10 am to 3 pm. It is also recommended to reassess at the same times in winter to ensure that the shade provided is adequate year round. Apart from one review of shade audits in eight New Zealand schools, no reviews of shade audits have been found. To overcome this, the authors of this review have separated the types of shade audits into three categories depending on their approach to undertaking the shade audit. The three categories are:

- Visual shade audits based on inspection of the site utilising a series of pre-defined questions;
- Larger shade audits where the usage pattern of shade is determined by interview of potential users, along with investigation of the site;
- Shade audits with mapping that use software to model and map the site and provide information on the shade provided at different times of the day and dates of the year.

Visual Shade Audits

These are based on inspection of the site and the use of a template. There are a number of visual shade audits with general guidelines provided for these. The information on these is provided in Table 1. The pros and cons of each method are provided after the table.

Table 1: Various types of visual shade audits

Organisation	**Name**	**Web page**	**Comments**
SunSmart	Creating effective shade	http://www.sunsmart.com.au/parta	Involves interviewing the users of the space; observing the outdoor area (including the UV block out of the roofing material, shade structure condition, safety aspects and nearby reflective surfaces, quantity and accessibility of existing shade); options for reducing UV exposure.
Cancer Council NSW	Guidelines to Shade	http://www.cancercouncil.com.au/reduce-risks/sun-protection/shade/	Similar to the previous entry.
Queensland Government	Sun safety in the shade	www.sunsafety.qld.gov.au/intheshade/shadeaudit.aspx	Provides a simple visual shade audit.
OZSUN Shade Systems	How to do a simple shade audit	http://www.alloutcool.com/shade-audit.html	This is more applicable for home settings.
SunSafe Nova Scotia	Summer Sun Safety Program - How to Conduct a Shade Audit	http://www.cancercare.ns.ca/site-cc/media/cancercare/Shade_Audit_Guide.doc	Considers the shade usage of the group. Involves providing the options for improving the shade. Provides an interview tool and a site fieldwork tool.
SunSafe Nova Scotia	Play it Safe - Enhancing Shade in	http://www.cancercare.ns.ca/site-	Provides general guidelines with sample checklists to assist with the

	Licensed Child Care Centres	cc/media/cancercare/ShadeAudit%20childcare.pdf	shade audit.

The SunSmart Creating Effective Shade resource has a user friendly two page table that allows the user to undertake an audit of existing shade including the location of the shade, the level of shade provided and the location of nearby reflective surfaces. The resource also provides possible shade solutions and highlights particular priority areas.

The Cancer Council NSW's Guidelines to Shade includes a template for establishing priority sites for the provision of shade (based on the age of users, the time of use, the duration of use, the level of use and the type of activity). For sites identified as being a priority, a five part shade audit can be undertaken to determine the use of the site, the amount of existing shade and its use and the amount of reflected UV. The audit also allows for assessment of the need for the shade and the identification of possible shade options. There are a number of considerations to address under each of these.

The Queensland Government Sun Safety in the Shade resource provides a simple to use shade auditing tool, but it is not as comprehensive as the SunSmart or Guidelines to Shade audits described above. The OZSUN Shade Systems shade audit provides general information on the issues to consider, but does not provide an easy to use list of items or a table. Both of the SunSafe NovaScotia audits provide a series of questions and items to consider, along with a means to categorise the existing shade and provide an inventory of natural shade. Whilst these audits are suitable tools for shade auditing in this category, the recommendation is to use either of the more concise and comprehensive SunSmart or Cancer Council NSW audits listed above, with the one in the Cancer Council NSW's Guidelines to Shade being more user friendly and providing the information required.

Larger Scale Shade Audits

Larger scale shade audits include determination of the usage pattern of shade, along with investigation of the site. A larger scale shade audit may include a series of interviews with shade users along with a series of behavioural and environmental observations (103). This provides example questions for school principals, teachers, students and neighbours, a template for an inventory of the type of trees and types of buildings in the area, along with a shade planning matrix template to aid in determining the cost effectiveness of the different options for shade provision.

Similarly, the Waterloo Wellington Regional Cancer Program provides a shade audit tool that has been employed to implement shade (105). This document provides a simple step by step outline of how to conduct a shade audit as well as providing a shade audit tool to fill out. General examples for housing, parks and schools are also provided along with lists of resources for mapping and modelling shade. Options for natural shade creation are also presented. The guide is easy to use and provides enough background information for anyone to make an informed decision about shade creation.

Another example of a larger scale audit is provided in ‘Creating shade at public facilities’ (106) funded by the Queensland Health Promotion Council. The document provides a series of guidelines for Local Government, an extensive series of questions and templates for shade auditing and a template to assess priority areas for the shade provision. One advantage of this document is that it also provides recommendations and technical guidelines for shade provision in thirteen different kinds of public facilities (e.g. beaches, parks, bikeways). The information is presented in an easy to follow table format.

An important consideration in regards to the first two shade auditing tools above (provided by the Centre for Disease Control and the Waterloo Wellington Regional Cancer Program) is that they are designed for the Northern Hemisphere with any references that are made to the shade being cast is to the north side of a structure, whereas in the Southern Hemisphere, the shadow is cast to the south side of a structure.

All three larger scale shade audits described are suitable for a lay person to undertake, with the proviso that for the first two the position of the sun for the Southern Hemisphere is taken into account. The ‘Creating shade at public facilities’ shade audit tool is recommended as best practice for a shade audit that can be undertaken by a layperson for settings such as schools and sporting grounds and parks. However the Northern Hemisphere larger scale shade audits are also suitable with a minor modification for the position of the sun.

Shade Audits with Mapping

In recent years, there have been some examples of shade audits with mapping. WebShade is an Australian supplier of an interactive, web-based tool designed to help assess sun protection needs and assist with shade planning in a range of settings. The WebShade program can be used to model shade patterns that proposed buildings and plants will cast under different conditions (58). The program is available for purchase online. The software requires users to be quite technically proficient and hence WebShade (http://www.webshade.com.au/contact.html) also offers the services of professional auditors at an extra cost. The cost of an auditor to undertake a shade audit depends on the size and type of the site, as well as the location (personal communication, 2013).

In 2008, shade audits were undertaken in eight New Zealand schools by specialists trained in the use of WebShade and an evaluation was undertaken (107). The audits identified a number of options, including some low cost options to increase shade, improve shade and make better use of existing shade in all schools. The review found that the shade auditing process was an effective planning tool and recommended the adoption of shade audits in all New Zealand schools as a step towards achieving the objectives of the New Zealand Cancer Control Strategy developed by the New Zealand Ministry of Health.

Another shade audit described in "How to Conduct a Shade Audit" utilises mapping software MapMaker Pro and GPS mapping software OziExplorer for mapping shade patterns at different times of the day and year (108). The goal of this initiative, developed in collaboration with the City of Toronto, Division of Parks, Forestry and Recreation, was to develop an efficient and cost effective shade audit protocol. The protocol is applied in shade audits of two city parks. The document provides detailed information that is very useful for a shade audit. However, it does require knowledge of the mapping software to produce the maps.

A poster has presented the use of Geographical Information Systems (GIS) for a shade audit of a park in the City of Peterborough, Canada. Although there is little detail provided, it reports on the use of aerial photographs of the park to provide a shade audit with classification of the amount of shade use, type of ground cover and type and amount of tree cover (109). The usage of different parts of the park based on observations was also mapped. In this poster, Google SketchUp was employed to provide a visualisation tool of the park shade. The results provided a mapping of the ground surface type, the areas with low use, medium use and high use and a mapping and classification of the trees as deciduous or coniferous and a mapping of the tree species composition. The advantage of this audit is the comprehensive mapping provided, with the disadvantage being the need for a specialist with the knowledge to use the software to analyse the aerial photographs and to produce the maps.

Shade audits with mapping are recommended for complex shade provision projects that have a built in budget component for a shade audit. In Australia, WebShade is recommended as it is the most readily accessible in the Australian context and user support is available.

SUMMARY AND CONCLUSIONS

Minimising exposure to ultraviolet radiation is an essential component of skin cancer prevention. Providing and using natural and built shade is an effective protection measure against harmful UV. Quality, effective and well-designed shade must provide a protection factor of at least 15 or as high as possible. Key factors to be addressed include the UV albedo and reflectivity, amount of skyview and the shade characteristics to reduce the diffuse UV as well as direct UV. The main recommendations to improve the protection factor and useability of shade structures are to: minimise the amount of unobstructed sky visible from the shade; use low albedo ground covers or surfaces under shade structures that have a lower albedo than concrete or sand; avoid locating shade structures near high albedo vertical or horizontal surfaces or use extra side-on UV mitigation strategies; ensure the shade provided is over the sites where the users are located, and specifically over picnic tables, sandpits or other playground equipment; provide side-on protection in the form of vegetation, trees or UV blocking material; ensure stand-alone structures with no side-on protection have shade structures with larger overall covered roof area; use roofing material with a low UV transmission that provides an UPF of 20 or better; and replace aged or weathered roofing materials to maintain the UPF.

Trees are an important part of shade provision strategies. Trees with higher canopy density and trees near other trees or structures need to form a component of shade provision. This includes both single trees in open areas, groups of trees, and trees near other structures.

There have been a number of initiatives in the form of awards and seeding grants to increase the availability of shade. One program found that in addition to the extra shade provided, there was an increase in community awareness and action for the prevention of skin cancer. Recommendations to inform the planning and development of future shade initiatives are to: expanding grant programs to offer greater financial incentives and availability to a larger number of applicants; use shade auditing to ensure that shade structures are planned using best practice guidelines and achieve the greatest level of UV protection possible; provide program guidelines with specific criteria on the quality of shade structures; and to implement natural and built shade initiatives at the local government level.

Best practice in shade provision is dependent on a number of factors. To establish if shade provides quality effective protection requires measurement of the protection factor or the reduction in users' UV exposure with UV sensitive dosimeter film or electronic dosimeters, attached to the body or clothing of potential shade users. However, this review identified only a small number of cases where this had been done, and further research is recommended to measure these elements so that more case studies of the provision of quality effective shade can be determined.

This report reviewed shade in the different environments of pre-schools, primary schools, secondary schools, community settings, workplaces and recreational settings. A small number of cases in each setting where the PF or the reduction in users' UV exposure have been measured were found. These found that locating the equipment or area of highest usage under either natural or built shade, and increasing the overhang from the roof edge of the structure or adding side on protection or some form of screening, increases the PF. Building large structures near existing structures, and multiple methods of shading in the form of built shade, portable shade, or trees with wide dense canopies planted away from the area of use, will also increase the PF.

Shade audits need to be undertaken wherever possible in order to improve options for shade, by assessing the existing shade and identifying additional shade requirements. Best practice in shade auditing is dependent on a number of factors including the budget and scale of the proposed shade project. This review classified shade audits into three categories: visual shade audits, larger scale audits, and shade audits with mapping. The visual shade audit is based on inspection of the site utilising a series of pre-defined questions. The larger shade audit identifies the usage pattern of shade by interviewing potential users, along with investigation of the site. Shade audit with mapping requires software to model and map the site, and gives information on the shade provided at different times of the day throughout the year. The shade audits recommended in each category are:

- Visual shade audit: Where no funding is available to employ a specialist to undertake the audit, or where the project is small, the technique described in the Cancer Council NSW's Guidelines to Shade is recommended as best practice. This audit can be undertaken by a lay person. http://www.cancercouncil.com.au/reduce-risks/sun-protection/shade/
- Larger scale shade audits: The 'Creating shade at public facilities' shade auditing tool provided by the Queensland Health Promotion Council is recommended as best practice for a shade audit that can be undertaken by a layperson for settings such as schools and sporting grounds and parks. www.health.qld.gov.au/ph/documents/hpu/20267.pdf
- Shade audits with mapping: This kind of shade audit is recommended for complex shade provision projects that have a built in budget component for shade auditing. In

Australia, WebShade, a shade planning software program, is recommended for this kind of project as it is the most readily accessible in the Australian context and user support is available. http://www.webshade.com.au/contact.html

Further research is required to review shade audits and to review the resulting shade provided. The review of the shade needs to be based on measurement, with UV film dosimeters or electronic dosimeters or handheld UV meters of the protection factors provided and the amount of use of the shade.

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David Turnbull studied UV radiation physics at the University of Southern Queensland. In 2005 he completed his PhD on UV radiation and shade environments. In 2007 he obtained a grant from the Cancer Council QLD to study UV and vitamin D exposures in shade environments. His research has also ranged from the development of photosensitive polymers to storage dam evaporation mitigation. Current research interests include human exposures to wavelengths across the entire non-ionising spectrum.

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