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Novel and promising sun safety interventions: UV photography and shade structures

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Abstract

Introduction

Ultraviolet (UV) exposure is a well-established risk factor for skin cancer. Sun protection campaigns and efforts can use a combination of educational, behavioural, and environmental interventions to address sun safety at the individual and community level. This critical review aims to investigate two novel sun safety interventions, UV photography and shade structures.

UV photography and shade structures: UV photography is an appearance-based intervention that has demonstrated efficacy in various studies focusing on children, university students, outdoor workers, and snow sport conference attendees. One study noted that phenotypic melanoma risk factors were significant predictors of sun damage severity assessed by UV photography. In addition, UV photography positively impacted sun protection intentions, perceptions of photoaging and sun protection, and increase reported sun protection behaviours. The environmental intervention of shade structures enables reduction of UV exposure and the degree of protection gained depends on numerous factors including location, surrounding environment, materials used for construction, and time of day. Certain features increase use of shaded areas such as tables and chairs and temperature greater than 27 degrees Celsius.

Discussion

UV photography has the potential to affect beliefs, opinions, and, ultimately, behaviours in a diverse range of populations. As the academic community continues to document success stories in the literature, UV photography has a unique potential for community outreach, particularly for high-risk or vulnerable populations. Alternatively, shade structures demonstrate efficacy when constructed properly with optimized features for use. The novelty with this intervention is its inherent ability to affect the environment, thus, there is no reliance on individual motivations to change behaviour.

Conclusion

Both UV photography and shade structures represent novel and promising sun safety interventions that warrant further use and investigation in the future.

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Introduction

Ultraviolet (UV) exposure is a well-established risk factor for skin cancer[1,2]. Globally, an estimated 2 to 3 million diagnoses of non-melanoma skin cancer and 132,000 diagnoses of melanoma are made each year[3]. Sun protection campaigns and efforts are directed at impacting behaviours to reduce UV exposure.

A combination of educational, behavioural, and environmental interventions is necessary to address sun protection at the individual and community level[2,4]. This review will present two novel sun safety interventions, UV photography and shade structures.

While these interventions differ in implementation and target audience, both ultimately share the common goal of UV exposure reduction. Using a UV photo and counselling, UV photography attempts to positively impact individual behaviour by increasing an individual's awareness of lifetime sun-exposure and the resulting skin damage. Shade structures, on the other hand, are environmental interventions that provide physical protection from damaging UV radiation (Table 1).

UV photography

The humble beginnings of UV photography date back to the 1903 discovery of UV light, named Wood's lamp[5]. Baltimore physicist, Robert W. Wood, first described his discovery in his 1919 "Secret communications concerning light rays," but it was two more decades before Wood's lamp use for the diagnosis of fungal hair infections was realized[6]. Over a century later, while Wood's lamp remains an invaluable tool in dermatology, the UV wavelength technology has been utilized in the development of UV cameras.

Using special filters, UV cameras emit flashes of UV light (wavelengths 400 to 750 nanometres), which are absorbed into epidermal and dermal collagen structures and are reflected back to the camera lens[7].

Non-uniform pigmentation of the skin is revealed by the resultant black and white contrast photographs. Modern innovations of this technique now provide three-dimensional, multi-spectral imaging and analysis and serve as the prototypical appearance-based intervention to impact sun protection behaviors[8]. There is mounting evidence that UV photography may be an effective intervention to impact sun behaviour.

A study involving 585 12-year old children investigated the correlation between sun damage visualized through UV photography with

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phenotypic melanoma risk factors[9]. The commercially available Visia Complexion Analysis developed by Canfield Scientific Inc. that integrates a UV camera system with sophisticated software to calculate and analyse sun damage scores was used[10]. Skin examinations were also performed to document established melanoma risk factors including full-body melanocytic nevus counts, facial freckling, eye colour, hair colour, and base skin colour.

These phenotypic risk factors were significant predictors of sun damage severity assessed by UV photography (all p values < 0.001)[9]. This study calculated UV photography mean scores that could serve as reference ranges for dermatologists that wish to compare UV scores of their own paediatric patients[9].

UV photography interventions have also been investigated in teenage and university-age individuals who are at particular risk for tanning behaviours and associated societal pressures. A randomized controlled trial of 146 university students measured the impact of an intervention consisting of a UV facial photograph and a 12-minute educational videotape regarding photoaging[11]. Participants were surveyed regarding their sun protection intentions immediately after the intervention and one month later. The intervention resulted in significantly stronger sun protection intentions ($p<0.01$), perceptions of photo-aging and sun protection ($p<0.01$), and greater reported sun protection behaviours ($p<0.05$)[11]. In addition, 61% of participants reported that they told at least one friend or family member about what they had learned from the study[11].

Another study by the same investigators targeting groups of college students and beachgoers demonstrated a similar positive impact of a photo aging video, UV photography, and combination of the two on future intentions to use sunscreen, as well as increased intentions to use sunscreen and reduce incidental direct sun exposure[12]. In addition to the predominantly female, intentional

Table: 1 Table 1. Summary of key points regarding ultraviolet photography and shade structures.

Key points	
Ultraviolet photography	1. UV photography is an appearance-based sun safety intervention that reveals non-uniform pigmentation of the skin that may not be visible with the naked eye. 2. Phenotypic melanoma risk factors were significant predictors of sun damage severity assessed by UV photography. 3. UV photography can positively impact sun protection intentions, perceptions of photoaging and sun protection, and increase reported sun protection behaviors.
Shade structures	1. Factors that impact degree of protection offered by shade structures include size, location, surrounding environment, materials used for construction, and time of day. 2. Certain features that optimize use of shade structures are tables and chairs, temperature greater than 27 degrees Celsius, aesthetically pleasing designs, and light colored shade. 3. Socioeconomic status of a geographic region was linked with less shade at playgrounds.

tanning population, the effectiveness of UV photography in other high-risk groups has been investigated. Outdoor workers are at particular risk for chronic sun exposure and the morbidity and mortality from skin cancer. In addition, outdoor workers are predominantly male and receive very little motivation to use sun protection. The long-term efficacy of a UV photography intervention was studied in a randomized trial of 148 male highway workers of which 81% reported never or only occasional sunscreen use and 90% reported spending at least five to six hours in the sun each day[13].

A single component intervention (education video) was compared with a dual component intervention consisting of education video plus UV photo. Participants were assessed prior to the interventions, immediately post-intervention, and at two month and one year assessments. Highway workers that received UV photographs of their faces in addition to the skin cancer educational video had significantly greater reported sun protection behaviours and decreases in skin colour objectively measured by reflectance spectrophotometry at one year ($p<0.001$)[13].

Of note, the educational video intervention by itself without UV photography was not associated with a significant impact on long-term sun protection, highlighting once again the power of personal UV photos to motivate behavioural change[13].

Another population at high risk for chronic sun exposure includes those who participate in snow sports such as skiing and snowboarding. The high altitude of mountain resorts combined with UV ray reflection from the snow creates an environment with significant direct UV exposure. Snow sport enthusiasts attending the Snow Sports Industries America (SIA) Snow Show in Denver, Colorado were recruited to receive a UV photograph and complete pre-intervention and follow-up post-intervention surveys[14]. The UV photographs influenced reported sun protection opinions in 78% of male and 62% of female participants. The most frequently modified behaviour, reported by 53% of participants, was increased sunscreen use[14].

UV photography has the ability to influence significant behavioural change and is now also entering the retail scene. A skin care company from Louisville, Colorado uses UV photography in a novel way to objectively assess the effectiveness of their skin care products for potential customers[15].

Joining forces with Whole Foods Market, MyChelle Dermaceuticals uses UV photography to engage in community-wide public health education and promote products. The company has UV camera programs in 47 locations across the United States,

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three in the United Kingdom, and future plans for global expansion including Norway and Australia. The Visia machines are typically placed in the Whole Body skin care section of Whole Foods Markets and are staffed by trained company employees. Potential clients receive a complementary UV photograph and tailored product recommendation[15].

The Visia Complexion Analysis UV camera plus software technology assigns a quantitative, age and ethnicity-matched score across eight dimensions: visible spots, wrinkles and fine lines, texture, pores, UV spots, brown spots, vascular areas, and porphyrins and bacterial secretions. Clients are given a copy of their photo, counselled on a recommended skin care regimen, and encouraged to return for a follow-up scan in three to six months to assess the regimen effectiveness[15].

Shade Structures

Shade structures offer a unique opportunity to affect the environment in which people work and play. With appropriate implementation, this physical intervention makes the environment intrinsically safer from the sun. Much of the information available regarding shade structures focuses on regions of Australia and New Zealand where skin cancer incidence and mortality rank amongst the highest in the world[16, 17]. Overall, much of the literature demonstrates that shade structures offer protection from UV rays; however, the degree of protection is dependent on a variety of factors including but not limited to location, surrounding environment, materials used for construction, and time of day[18].

Of note, shade structures in isolation are not the definitive solution to sun protection[19,20]. Used in conjunction with other sun protection practices such as sunscreen use, wearing protective clothing, and avoiding peak UV exposure hours, shade structures offer an additional barrier against UV exposure[21]. Not only is there no harm incurred by this intervention, shade structures circumvent issues of fashion trends and peer image that are more prevalent with sun protection clothing[22]. Therefore, it is a worthwhile solution to maximize sun protection and use by the public.

Much of the literature surrounding shade structures involve settings that aim to impact children and adolescents, including schools and outdoor recreational areas such as parks and pools. One such study examined the use of newly constructed shade sails at 51 Australian secondary schools for students in grades 7 to 12 during the lunch hour[22]. No shade avoidance was noted and there was an increase in student utilization of the shaded areas. On average, an estimated increase of three students was noted in the shaded areas of intervention schools when compared to control schools ($p=0.011$)[22]. The results from this study demonstrate that behavioural change can be elicited via environmental change and that shade structures can serve as an avenue to reduce UV exposure in the student population[22]. This is in accordance with behavioural health promotion models and theories that highlight the positive influence of supportive environments and organizational alterations on behavior modification[22, 23, 24].

What can be done to maximize public utilization of shade structures [22, 25]? A follow-up study was conducted to determine how physical characteristics and weather conditions impacted use of shade structures at intervention schools.

Interestingly, lunchtime use was largely dictated by age demographics, in addition to habitual use and perceived ownership of designated areas[25]. These were the predominant factors identified, rather than need or consideration for UV protection.

Tables with seats were the feature most predictive of usage, associated with an average increase of seven students using the shaded area compared to shaded areas without this feature. Temperatures greater than 27 degrees Celsius increased use, while grass was linked with decreased use of shade[25]. These findings are in the absence of simultaneous sun protection education or coercion for use of the shaded areas. Hence, this study suggests that careful location selection and providing tables and chairs increase use of the shaded areas[25]. In addition, an observational study in New Zealand discovered features that may increase the appeal of shaded areas to teens include shade that was light in colour, retained warmth, provision of adequate area for several students to congregate, and use of an aesthetically pleasing design[26].

A sun protection study determined the sun safety practices and the prevalence of shade at United States schools[27]. It was determined that 73% of the schools had shade available, however 67% of those with shade covered less than one fifth of the grounds. On a positive note, 76% of the principals surveyed were receptive to increasing the number of shade structures[27]. It was noted that the low incidence of sun protection policies and shade structures warrant efforts to implement and reform these issues at schools in the United States. In addition, the efficacy of these changes would need to be assessed.

Perhaps an inventory of the amount, usability, and reflection of current shade areas would aid schools to implement construction of more shaded areas, especially those in high traffic zones such as walkways and playground equipment[27].

A study in New Zealand assessed the efficacy of 29 shade structures providing sun protection in 10 schools. Only 6 structures provided the recommended UV protection factor of 15 or greater for all day protection[19, 28]. Another investigation demonstrated that degree of sun protection over swimming centre toddler pools in Melbourne varied based on position allocation underneath a shade structure and time of day[21]. Larger shade areas and those with extra shade provided by neighboring structures had greater protection factors. In particular, this study highlighted that protection factors decreased as height from the water decreased, indicating that, compared to adults, the shorter stature of young children results in less protection under the same structure[21].

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Additional characteristics influence the efficacy of shade structures. Cloud coverage increases the amount of scattered UV radiation, which can be reduced by decreasing the amount of unobstructed sky visible[19,28]. Use of side screens to decrease angled UV rays as well as decreased use of reflective surfaces, such as sand, concrete, and snow, in the structure and surrounding environment help to decrease UV radiation[28].

Shade lacking these characteristics may create a false sense of sun protection. In addition, shade lacking utility and appeal in colder months risks being under-used[19]. Careful consideration of construction and materials as well as proper maintenance to replace aged and worn materials are critical for the successful creation and continued efficacy of shade structures[20,28].

Finally, the relationship between metropolitan playground shade and socio-economic status of the surrounding geographic region has been investigated. Increased shade was significantly associated with more affluent areas ($p<0.001$)[29]. These wealthier communities had greater utilization of natural providers of shade, such as large and mature trees. Within a playground environment, eating areas provided 35% more shade coverage than playing areas ($p<0.001$)[29]. Based on these findings of significant disparity, it is suggested that local governments prioritize policy efforts to increase natural and man-made shade at playgrounds, regardless of socio-economic status[29].

Discussion

UV photography has the potential to affect beliefs, opinions, and, ultimately, behaviours in a diverse range of populations. As the academic community continues to document success stories in the literature, UV photography has a unique potential for community outreach, particularly for high-risk or vulnerable populations. However, a limitation of most available studies investigating UV photography as an intervention is the reliance on self-reported surveys to measure behavioural change. While this method is entirely appropriate for the study populations, objective analysis is difficult to obtain and lacking. Use of objective measures to document the effectiveness of UV photography will be very valuable. As an example, the above-mentioned use of UV photography by MyChelle Dermaceuticals utilizes camera software technology to assign clients with a numerical age and ethnicity-matched score in eight areas. One of the eight areas, UV spots, could serve as a particularly objective value to assess change in sun habits motivated by the UV photograph.

Alternatively, shade structures demonstrate efficacy when constructed properly with optimized features for use. The novelty with this intervention is its inherent ability to affect the environment, thus, there is no reliance on individual motivations to change behaviour.

Most studies investigating shade structure interventions are conducted in particular geographic regions and settings, such as Australia and New Zealand where skin cancer is a significant cause of morbidity and mortality. However, further analysis outside these realms will be important and may reveal key discoveries for successful implementation.

A final mention will be made to the cost of these two interventions. The Canfield Visia UV camera costs approximately $20,000, which is a significant investment. However, the cost-effectiveness of this intervention is manifest in the hopeful prevention of skin cancer. The total cost of non-melanoma skin cancer in Australia, including diagnosis, treatment, and pathology, was estimated at $511 million in 2010, with a 2015 projection of $703 million[30].

The investment in an effective UV photography intervention is minimal compared to this significant economic burden. In addition, a range of lower cost UV photography system alternatives is available[31]. Similar to UV photography, shade structures require an initial upfront investment.

An Australian study investigating effective shade structures identified cost as a major concern to most schools, often resulting in compromise with smaller and less efficient structures. As an example, a basic 10 square meter shade sail starts at $500 but would triple in price with the addition of one square meter since this would require a building permit[32].

The American Academy of Dermatology has established a Shade Structure Grant Program to help offset the costs for installing permanent shade structures[33]. Grants valued up $8,000 are awarded to public schools and non-profit organizations and include the cost for the shade structure, installation, and an adjacent permanent sign[33].

Conclusion

Effective sun protection requires a multi-faceted approach. Impacting behaviours and beliefs of individuals through UV photography and counselling is an important educational and impressionable tool.

Environmental efforts such as shade structures establish sun protection at a community-level and require no intentional behaviour change by individuals. Both UV photography and shade structures represent novel and promising sun safety interventions that warrant further use and investigation in the future.

Certainly, as the medical community continues to learn about the positive correlation between UV radiation and skin cancer, the significant economic burden, morbidity, and mortality of skin cancer warrant continual investigation into the most effective protective mechanisms.

Abbreviations list

UV = Ultraviolet.

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