Shade as an Environmental Design Tool for Skin Cancer Prevention

Little work has been done to explore the use of shade for skin cancer prevention in the context of the built environment. In an effort to address this gap and draw attention to the intersection between architectural and public health practice, we reviewed research on shade design, use, and policies published from January 1, 1996, through December 31, 2017.

Our findings indicate that various features influence the sun-protective effects of shade, including the materials, size, shape, and position of the shade structure; the characteristics of the surrounding area; and weather conditions. Limited research suggests that shade provision in outdoor spaces may increase shade use. Shade audit and design tools are available to inform shade planning efforts. Shade policies to date have mostly been setting specific, and information on the implementation and effects of such policies is limited.

Integrating shade planning into community design, planning, and architecture may have a substantial impact and will require a multidisciplinary approach. (*Am J Public Health.* 2018;108:1607–1612. doi:10.2105/AJPH.2018.304700)

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Although a large and growing body of research describes the relationship between the built and natural environments and public health,[1] little has been done to explore the potential role of shade in this context.[2] In this article, we define shade as a built or natural intervention that provides protection from ultraviolet radiation (UV). In addition to reducing UV exposure, shade can ameliorate the urban heat island effect (a phenomenon whereby urban areas are generally warmer than surrounding suburban and rural areas owing to human activities)[3] and make outdoor spaces more comfortable, providing important benefits to public places such as parks, schools, and other spaces. However, shade planning and design are often not addressed during the development process, and sun exposure is frequently overlooked as an aspect of public health that is affected by architecture and the built environment, landscape architecture, urban design, and urban planning.

In an effort to address this gap and draw attention to the intersection between architectural and public health practice, we reviewed the literature on shade design, shade use behaviors, and shade policies. The review included both qualitative and quantitative evidence, and we describe the current state of the evidence as well as research gaps. Our aim is to help identify ways in which architects, urban designers, landscape architects, planners, and public health practitioners can work collaboratively to advance shade provision for skin cancer prevention.

METHODS

We searched PubMed for the following search string: ((shade) AND (ultraviolet OR sun OR UV OR (skin cancer))) NOT (dentis* or fluorescence or algae or genome or embryo or growth or marking or phyto* or dental or bleach* OR chlorophyll OR photosynthesis OR CO2). Use of the "NOT" term was designed to exclude irrelevant content that might otherwise be captured by the search. We limited the search to original research articles published in English from January 1, 1996, through December 31, 2017. Two of the authors (Meredith Shoemaker and Meg Watson) reviewed the titles and abstracts of all 576 articles returned in the search and retrieved the full texts of potentially relevant articles to make a final determination of their relevance.

The bibliographies of selected articles were scanned for additional relevant studies and reports, including review articles summarizing key aspects of the literature on this topic and relevant white papers, gray literature, and other documents (e.g., surveillance and policy reports) available online but not indexed in PubMed. In addition, we used our own knowledge of work done regarding shade as a tool for skin cancer prevention to ensure we had capture relevant reports that were not indexed in PubMed. We included articles and other documents that described at least 1 of the following aspects of shade: (1) characteristics of shade design that influence the level of sun protection conferred, (2) research regarding the prevalence of shade use relative to other forms of sun protection and factors that influence shade use behaviors, and (3) the prevalence, implementation, or effects of shade policies.

We classified each publication as addressing 1 or more of the categories just described (labeled in the results section as shade design, shade use behaviors, and shade policies). For each included article, one of the authors abstracted relevant information into a standardized form and a second reviewed the form to ensure

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This article was accepted August 3, 2018.

doi: 10.2105/AJPH.2018.304700

agreement, completion, and general quality control. Any discrepancies were resolved by discussions among the authors.

RESULTS

Our search identified 21 original research articles, 3 review articles, and 11 other publications (e.g., reports) of relevance (Table 1). Most of the original research articles were based on studies conducted in the United States (n = 9) or Australia (n = 8); another article described research conducted jointly in the United States and Australia. The other original research articles described work conducted in New Zealand (n = 1), Canada (n = 1), and South Africa (n = 1). In the sections to follow, we summarize the state of the science on shade according to the following topics: shade design (9 studies), shade use behaviors (10 studies), and shade policies (20 studies).

Shade Design

Seeking and staying in the shade when outdoors is one strategy for reducing exposure to and harm from UV radiation.[4] Although shade does not provide complete UV protection, research findings have demonstrated its ability to reduce total UV exposure[4–6] while still possibly allowing for some UV-induced vitamin D production in the skin.[7,8] From a behavioral perspective, environments without adequate shade place greater demands on individuals to protect themselves.[4]

Shade confers variable levels of UV protection, depending on several factors.[4] One important factor is the type of material of the object casting the shade. In manmade structures, cloth, polycarbonate sheeting, and opaque building materials are often used to create shade. The level of UV protection conferred by shade cloths and sails decreases if the material is wet, stretched, or in a weathered state. Vegetation, including trees and shrubs, can also provide natural shade. A denser tree canopy provides greater protection than a less dense canopy.[4]

The height, size, and shape of the shade structure also affect the amount of UV protection. Larger shade structures offer greater protection because their size reduces the amount of diffuse UV coming through the sides of the structures.[4] An overhang or the addition of side-on protection can further reduce the amount of diffuse UV entering a shade structure.[4]

In addition to the characteristics of the shade structure itself, UV protection varies according to the amount of UV reflected from the surrounding environment, especially the albedo (i.e., reflectivity) of the ground surface. The UV albedo of the ground surface varies depending on the material.[4] Ground surfaces covered by grass, for example, can have an albedo as low as 2% to 3%, whereas a concrete surface may have an albedo of about 10% and sand an albedo of about 15% to 30%. The albedo of snow can be as high as 90%, meaning that nearly all UV is reflected back off the ground. Hard, smooth surfaces reflect more than those with varied edges. Trees and shrubs near manmade shade structures can help reduce the amount of diffuse UV, thus increasing the overall amount of UV protection.[4]

Beaches and snow-covered mountain areas are particularly high UV environments.[4] In a beach setting, an umbrella may confer very little protection, particularly if the ground is tilted rather than being completely flat, because of high levels of diffuse UV radiation from the sand and water.[4] This may give beachgoers a false sense of protection from the sun when they are using a beach umbrella, possibly resulting in greater total UV exposure.[4,9] In snowy mountain areas, the albedo of the snow and the increased altitude both increase total UV exposure, even when shade is being used.[4,9]

Weather also influences the level of protection conferred by shade because it affects the amount of UV diffusion. For example, research suggests that partly cloudy skies (less than 50% cloud cover) can lead to an increase in the diffusion of UV radiation, causing a slightly greater amount of UV exposure in the shade than would be experienced under clear skies.[10] As a rule of thumb, shade protection increases as the amount of bright sky visible under a shaded area decreases.[11]

Given the many factors that influence the UV protection conferred by shade, conducting a shade audit can help determine whether the existing shade is adequate and guide the shade planning process (for a list of shade audit tools and guidelines on shade development, see Table A, available as a supplement to the online version of this article at http://www.ajph.org). Shade audits are most informative if done during midday, a time of peak UV radiation, and during each season of the year to ensure adequate protection year-round. Shade audits can include 1 or more of the following: a visual inspection of the given area to address a set of predefined questions, interviews with potential shade users and facility managers, and the use of software to model and map the shade provided at different times of day and year.

In addition, geographical information systems can be used for audits of larger areas. One study conducted in Sydney, Australia, showed that areas of higher socioeconomic position had more total shade coverage than areas of lower socioeconomic position; they also had more well-established trees that provided shade.[12] Although it is unknown whether such patterns exist in other regions, these findings suggest the potential for disparities in availability and use of shade.

TABLE 1—Studies on Shade Design, Shade Use Behaviors, and Shade Policies Published From January 1, 1996, Through December 31, 2017, and Included in the Review

Area of Focus[a]	Type of Publication	Article Reference Numbers
Design (n = 9)	Original research (n = 7)	5–10, 12
	Review (n = 2)	4, 11
Behavior (n = 10)	Original research (n = 9)	5, 14–21
	Report (n = 1)	13
Policies (n = 20)	Original research (n = 7)	21, 26–30, 36
	Review (n = 3)	4, 11, 31
	Report (n = 9)	23–25, 32–35, 37, 38
	International agreement (n = 1)	22

Note. A total of 35 publications were included.
[a]These categories are not mutually exclusive, as some publications addressed more than 1 of the focus areas.

Shade Use Behaviors

Shade is the most common means of sun protection in the United States, with nearly 40% of US adults usually or always seeking shade when outdoors in the sun for an hour or more.[13] Surveillance data from Australia indicate that approximately 21% of Australian adolescents and 28% of adults stay mostly in the shade during weekend outdoor activities between 10 AM and 2 PM.[14] A large survey administered in 6 provinces in Canada showed that about 41% of Canadian adults sometimes or always seek shade when in the sun between 11 AM and 4 PM.[15] An assessment of sun protection practices among workers in a large urban traditional medicine market in South Africa revealed that portable shade was the most commonly used form of sun protection among the workers.[16] In general, women are more likely to stay in the shade when outdoors than men.[13,15]

The built environment can have an important influence on individuals' shade-seeking behavior. Research has demonstrated that shade sails constructed of materials with a high UV protection factor rating can be an effective and largely sustainable intervention strategy to promote shade use in secondary school settings.[5,17] Portable shade structures can also be an inexpensive way to provide sun protection, as shown in a pilot study focusing on increasing shade use at a youth soccer camp.[18]

There has been limited research on factors that maximize shade use in outdoor settings. Designing shade to maximize comfort and convenience can serve to increase its use. In warmer temperatures, the heat relief provided by shade creates an incentive for its use.[18,19] However, ambient temperature does not correspond directly to the intensity of UV radiation, and it is possible to experience overexposure to UV in colder temperatures. In cooler climates, use of polycarbonate and laminated glass with UV protective coatings can help create "warm shade" while still providing UV protection.

Provision of facilities such as seating and tables in shaded areas may also increase shade use.[19] Moreover, provision of shade may increase use of outdoor spaces. For example, a randomized controlled trial showed that the addition of shade to passive outdoor recreation areas increased use of those spaces.[20] Pairing well-designed shaded areas with other intervention strategies to increase sun safety awareness and knowledge may help to further increase shade use. For instance, Pool Cool, a sun safety program focusing on outdoor swimming pools, incorporates both educational and environmental components, which, among other behavioral outcomes, have been shown to effectively increase shade-seeking behaviors among children.[21]

Shade Policies and Practices

The 1986 World Health Organization Ottawa Charter described the creation of healthy public policies as an essential component of disease prevention.[22] The 2010 World Health Organization Adelaide Statement on Health in All Policies promotes multisector development of policies:

> government objectives are best achieved when all sectors include health and well-being as a key component of policy development. . .because the causes of health and well-being lie outside the health sector and are socially and economically formed.[23(p1)]

These policy directions are gradually filtering down into the realm of shade for skin cancer prevention and support considering the creation of evidence-based policies in this area.

Shade policies can be divided into substantive policies (legislative programs and practices) and administrative policies, which guide the work and practices of institutions, organizations, groups, and facility owners and managers.[24] Policies can also be distinguished according to their scope and intent. Vertical policies are those developed by a specific organization or group around a specific issue, whereas horizontal policies are those that are created by 1 or more organizations or institutions around 1 or more issues and that relate to a broader number of organizations or groups.[24] Sun-safe policies directed at children in child-care settings can be considered a type of vertical policy (focusing on 1 group in 1 setting), whereas policies designed to promote shade in public places are an example of a horizontal policy (affecting a wide range of settings or groups).

Vertical shade policies. Policies regarding creation of shade for UV protection and skin cancer prevention are, for the most part, vertical policies directed at specific groups in specific settings (e.g., shade policies in settings for children and young adults). These policies, which may include incorporating shade audits into management plans and creating incentive programs to increase shade in public places, are often initiated at the local or state level and evolve from local authorities engaged in health promotion.[4]

In a 2005 study of shade policies in Australian schools, 81% of schools reported having adequate shade for passive activities such as eating lunch, and 33% reported having shade for both active and passive activities.[25] More than half (66%) reported plans to increase shade in the next 3 years. Financial support for shade was reported to come mainly from fundraising, school budget allocation, and community or government grants. The presence of adequate shade was not associated with its mention in written school policies on sun protection. Furthermore, there was no statistically significant difference in the adequacy of shade on school grounds between schools implementing and not implementing the National SunSmart Schools Program.

In 2009, a cross-sectional investigation of sun protection policies and practices in New Zealand revealed widely varying shade practices in primary schools. Among the schools assessed, 87% required students not wearing a sun-protective hat to play in allocated shade areas when outside, 13% had substantial shade available for both passive and active activities, 52% had sufficient shade for passive activities, 31% had some useful shade but insufficient shade for most activities, and 4% had inadequate shade for any activities.[26] Among schools without "substantial shade," some (21%) reported having definite plans to increase shade within the next 12 months, whereas others indicated that shade was not a priority area; 38% noted that increasing shade poses funding concerns. A formal shade assessment was not required for accreditation, and only 5% of schools had conducted a formal shade audit; however, 23% of schools had conducted

a less formal but written assessment of shade provision. Shade standards were among the least likely of sun protection standards to be met. The study authors recommended that shade be considered in development of school plans.

A 1998 study of 1000 US public elementary schools showed that very few schools (3.4%) had a sun protection policy in place.[27] Although most school principals said that students were outdoors during midday hours and almost three quarters of schools surveyed had shade structures, the majority reportedly covered less than one fifth of the grounds. In the abstract of their article, the authors concluded that

> the low frequency of sun protection policies and shade structures calls for national efforts to change policies and environments to increase sun protection at US schools, with the need for further research to demonstrate the efficacy of these changes.[27(p771)]

Similar deficiencies were found for US secondary schools.[28]

Several studies of school ground use during periods of high UV exposure have explored the shade-seeking behaviors of users and concomitant policies. A study on skin cancer prevention policies and curricula in Massachusetts elementary schools indicated that none of the 18 schools in the 9 districts assessed had any sun protection policies in place at either the school or the district level. The study revealed a low level of receptivity to the introduction of sun safety policies because of lack of funding and worry about uptake. Most participants agreed that they were open to adopting best practices rather than policies.[29] Factors influencing lack of development of sun protection policies included sun safety being a low priority, limited time spent outdoors, and lack of funding for health classes. The study authors concluded that schools' communication infrastructures could be key portals for disseminating sun protection information.[29]

Results from a randomized controlled trial conducted in Colorado and Southern California to evaluate a program (Sun Safe Schools) aimed at convincing public school districts to adopt policies to reduce student sun exposure indicated that intervention districts adopted stronger policies for provision of outdoor shade than control districts.[30] The intervention involved providing policy information, tools, and technical assistance through printed materials, a Web site, meetings with school administrators, and presentations to school boards. Policy adoption was promoted over a 2-year period.

Researchers have also examined the impact of sun protection in recreational settings. For example, the Pool Cool program includes a guide for pool managers about how to make the pool environment and policies more sun safe.[21] Evaluations of the program's effects at swimming pools in a diverse sample of communities have shown improvements in sun protection policies and environments, although the reports do not distinguish between the program's effects on shade policies and its effects on other relevant pool policies.

Horizontal shade policies. Horizontal shade policies have extended beyond specific users and policy requirements but have remained mostly settings based. An Australian review discussed legislative and environmental changes regarding the Australian standards for sun protection, including materials used for shade structures such as shade cloth, plastics, glass, windscreens, and applicable tints.[31] A joint series of studies developed by the University of Queensland outlined guidelines for shade in a variety of settings, including sports fields, public pools, and public facilities.[32–35]

Both Australia and New Zealand have implemented multifaceted national sun safety programs that incorporate components related to shade. Examples of these efforts include promoting the development of new shade structures, planting shade trees, adding shade structures to playgrounds and outdoor work sites, and linking shade manufacturers to local governments.[36] The SunSmart program in Australia is particularly unique with regard to the degree of consistency and continuity with which the program has been implemented over several decades.[36]

In 2007, Toronto became the first jurisdiction in North America to adopt a comprehensive shade policy, integrating shade guidelines into the larger scope of municipal planning efforts to influence a wide range of settings and users. According to the policy, developed by Toronto Public Health:

> The provision of shade, either natural or constructed, should be an essential element when planning for and developing new City facilities such as parks or public spaces, and in refurbishing existing City-owned and operated facilities and sites. Increasing shade in Toronto contributes to a healthier and more sustainable City.[37]

Since the establishment of the policy, a number of city departments have implemented shade provisions into their policies and activities.[11]

In the United States in 2014, the US surgeon general issued the *Call to Action to Prevent Skin Cancer*, which addressed the importance of shade in 3 of the 5 strategic goals outlined.[38] Strategic planning for and use of shade was identified in goal 1 as a way to increase opportunities for sun protection in outdoor settings, including outdoor recreational settings, school settings, and outdoor work settings. Goal 3 encouraged promotion of policies advancing the national goal of preventing skin cancer, including shade planning policies in schools and policies supporting shade planning in land use development. Goal 5 addressed the need to strengthen research, surveillance, monitoring, and evaluation related to skin cancer prevention, including evaluating the effects of community shade policies. Although not tied directly to legislation, the *Call to Action* raised awareness about skin cancer as a major public health concern and provided a roadmap for the public health community at the national, state, and local levels to work together strategically with partners in all sectors to advance skin cancer prevention in the United States.

DISCUSSION

Scientific evidence clearly demonstrates that shade can be an effective means of UV protection. Shade can also provide other important benefits, such as ameliorating the heat island effect and providing more comfortable outdoor areas, thus encouraging use of outdoor spaces. Taking advantage of natural elements such as shade provided by trees may confer additional health and environmental benefits.[39]

(Images of both natural and manmade shade are provided as examples in supplements to the online version of this article at http://www.ajph.org.)

In general, the benefits of shade seem to drive individuals to take advantage of its presence. A limited body of research suggests that people will use shade structures if they are available.[17–19] Additional research on shade use behaviors among various demographic groups could yield more nuanced insights into ways to maximize the appeal and, ultimately, use of shade. Such research would benefit from the input of multiple fields, including urban planning and design, urban forestry, and behavioral science.

Despite shade's many benefits, shade planning is not regularly included in the design phase of community development projects and is often overlooked as one of the many aspects of public health affected by architecture and planning. One potential misconception about shade is that it can simply be added to a space with little need for expert guidance or attention to detail. However, the existing literature on shade characteristics indicates that to maximize the benefits of future shade development, many factors that influence the amount of UV protection conferred by shade need to be taken into consideration. This includes considering the materials used to create shade; the characteristics of the surrounding area (e.g., the materials and corresponding albedo); the size, shape, and position of the shade structure; and typical weather conditions for the area. Currently, there is not a standard metric to evaluate the effectiveness of shade, another area of research that, if examined, might benefit future shade development.[9]

Efforts to take a comprehensive, population-based approach to skin cancer prevention will inherently require shade planning and design as a component. A settings-based approach to shade development appears to be the most common means of effecting shade, particularly in settings involving children.[2] Similarly, other existing community settings and spaces can be examined for opportunities to create or improve shade. Establishment of comprehensive shade policies may benefit from the participation of a broad group of stakeholders and could be incorporated into the process for municipal planning, design, and development. Evaluation of shade policies may be beneficial, as the effects of such policies could range from changes in health behaviors (e.g., sun protection behaviors) and health outcomes (e.g., sunburn) to economic effects (which could potentially be examined via cost–benefit analyses).

Efforts to promote shade as a skin cancer prevention tool may be most successful if they also address other benefits of shade such as aesthetic benefits, improved comfort in spaces designed for active transportation, reductions in the heat island effect, and energy conservation. Future work summarizing the latest research on shade, not only for UV protection but also regarding these other aspects of the built environment, could help to bolster understanding of the benefits of shade. Furthermore, research on the cost of creating and maintaining shade in outdoor spaces could help community leaders and other stakeholders make informed decisions about the addition of shade to community spaces.[40]

Limitations

Our review of the literature is subject to limitations. Given our focus on shade as a tool for skin cancer prevention, our search methods primarily focused on articles indexed in PubMed, with some complementary information pulled from relevant surveillance and policy reports available online. The health focus of PubMed limited the content included from relevant fields such as urban planning and design and architecture. However, we have identified these areas as important for future exploration and literature reviews. In addition, our decision to include English-language articles only resulted in a body of research based exclusively out of the United States, Australia, New Zealand, and Canada, which may limit the relevance of our findings to other countries.

Conclusions

Shade is well recognized as a key component of population sun safety and skin cancer prevention efforts and is also relevant to countering heat island and other heat-related bodily challenges. Integrating shade planning into community design, planning, and architecture can maximize the benefits provided by shade. Additional research on how to improve use of shade, along with evaluations of shade policies and practices (including cost–benefit analyses), could inform future efforts to include shade provision as part of comprehensive strategies to reduce skin cancer risk at the population level. Such efforts will require a multidisciplinary approach. AJPH

CONTRIBUTORS

D. M. Holman, M. Shoemaker, and M. Watson conducted searches of the peer-reviewed literature, identified relevant articles, and abstracted key information into a standardized form. All of the authors contributed to the design and concept for the article, analysis and interpretation of information abstracted from the peer-reviewed literature, and drafting and critical revisions of the article.

ACKNOWLEDGMENTS

This research was supported in part by an appointment (Meredith Shoemaker) to the Research Participation Program at the Centers for Disease Control and Prevention (CDC) administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the US Department of Energy and the CDC. Support was also provided by the Ryerson University Faculty of Engineering and Architectural Science (George Thomas Kapelos). Dawn M. Holman and Meg Watson are federal employees, and their work on this article was performed as part of their official duties.

We thank Cate Townley of the Colorado Department of Public Health and Environment for allowing us to include her photo of shade trees lining a Colorado sidewalk. Also, we thank Craig Sinclair of the Cancer Council Victoria and the World Health Organization's Collaborative Centre for UV Radiation for helping us obtain additional photographic examples of shade.

Note. The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the CDC or Ryerson University.

HUMAN PARTICIPANT PROTECTION

No protocol approval was needed for this study because no human participants were involved.

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