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Rationale, Design, and Baseline Data of a Cross-national Randomized Trial on the Effect of Built Shade in Public Parks for Sun Protection

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Abstract

Environments can be structured to reduce solar ultraviolet radiation (UV) exposure to prevent skin cancer. A prospective randomized trial is being conducted to test whether introducing shade sails in passive recreation areas (PRAs) in public parks will increase use and decrease UV exposure in the shaded compared to unshaded PRAs. Shade effects will be compared between Melbourne, Australia and Denver, USA. The trial enrolled 144 public parks with PRAs suitable for shade construction and randomized parks to intervention or control in a 1:3 ratio. Use of PRAs and UV levels were recorded at each park by trained observers during 30-minute periods on four weekend days in each of two summers (pretest and posttest). Shade sails were constructed between the summers. Given low numbers of users at pretest, the outcome measure was modified to use of the PRA (use v. no use) and unit of analysis to the individual observation. Observations (n=580) occurred on average 29 days from the summer solstice and 55 minutes from solar noon in warm weather (mean=26.2°C) with some cloud cover but only slight or no wind. Typically, PRAs had benches and picnic tables and were located near playgrounds. PRAs were in use during 13.3% of observations (mean=0.41 users). UV over 30-minutes at the PRA boundary (mean=3.2 standard erythemal dose [SED]) and center (mean=3.3 SED) was high. Shade for skin cancer prevention

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has been understudied. This study will address this gap by determining whether purpose-built shade structures promote greater use of shaded areas within public parks.

Keywords

shade; sun protection; public parks; randomized trial

Introduction

Skin cancer is a significant burden in countries with high ultraviolet radiation (UV) levels and large light-skinned populations.^{1–9} Prevention involves reducing UV exposure by structuring environments to support sun safety (e.g., providing shade and altering outdoor schedules) and promoting personal protection (i.e., limiting time in the sun and wearing protective clothing^{10,11} and broad-spectrum sunscreens^{12–18}).

Shade can reduce UV exposure. Unlike other practices, shade requires little personal planning, provides a visual reminder for sun safety, and may attract individuals at high-risk or with unfavorable attitudes towards sun protection. For example, in Melbourne secondary schools, adolescents who typically were aware of skin cancer but resistant to personal protection used rather than avoided newly shaded areas.¹⁹ Permanent purpose-built shade is optimal to provide shade at desired locations, especially when warm light-colored shade of a relatively large size²⁰ is constructed that provides shade during the hours close to solar noon in seasons when UV is at its peak²¹ Some shade cloth can reduce UV levels considerably (blocking at least 94% of UV²²) at an affordable cost.²³

Our team has undertaken a randomized trial to examine prospectively the impact of built shade on use of passive recreation areas (PRAs) and potential UV exposure in public parks. Public parks are an important setting for outdoor recreation. Shade is a desirable feature in parks^{24–28} and thus should be used by park visitors. The following primary hypothesis was tested:

H1: Introduction of shade sails over PRAs will increase the number of individuals using those PRAs.

Social ecological models (SEMs) help conceptualize the potential effect of built environments on health behavior in the context of multi-level societal and environmental influences.^{29–31} Built environments are those created or significantly modified by people.³² SEMs have been employed to explain how density of tanning bed facilities is associated with youth tanning³ and to create interventions in pools³⁴ elementary schools³⁵ and communities.^{36,37} In SEMs, the physical environment, of which shade is a part, can have both direct and indirect effects on behaviors^{38–45} (see Figure 1). Direct effects may include increasing the number of individuals shaded, providing a visible cue for protection, and enabling ready access to protection. Indirect effects may occur by changing societal norms^{46–48} regarding sun protection.^{29,45} Australia and the United States have different histories of sun safety promotion that may have produced different social (i.e., sun protection norms) and physical environments (i.e., built shade) such that built shade might be used more readily in Australia than the United States. The trial also compared the use of

built shade in public parks in the United States and Australia by testing the following primary hypothesis:

H2: City will moderate use of the shade sail such that increase in number and decrease in average UV exposure of people using PRAs covered by the shade sails in the parks in Melbourne will be larger than the increase in number and decrease in average UV exposure of people in Denver.

The value of built shade for sun protection is to reduce UV in the shaded locations. To confirm this prediction, the following secondary hypothesis was evaluated:

H3: Introduction of shade sails over PRAs will reduce the average UV exposure in the PRA compared to PRAs not shaded.

Materials and Methods

Experimental Design

The trial was performed in Denver, Colorado, USA and Melbourne, Victoria, Australia. A stratified, randomized pretest-posttest controlled design was employed. The protocol included 160 PRAs (80 in each city), of which 40 (20 in each city) were to be selected at random to have shade sails constructed. Parks were selected and enrolled in three annual waves to make it more feasible to manage the trial and stay within annual budgetary limits. The sample size was selected based on a priori statistical power calculations to detect an increase of 3.8 individuals on average using the shaded PRAs during each observation compared to no change in the use of control unshaded PRAs. The unequal 1:3 allocation ratio to treatment (shaded) versus control (unshaded) was adopted because of the cost of building the shade structures, limiting the number that could be built. The protocol for randomization to shade sail construction or control was stratified by wave and within each wave by the four municipalities in Melbourne and the four park maintenance areas in Denver to ensure that shade sails were distributed throughout the participating municipalities. PRAs were audited, selected, enrolled and randomized in three annual waves in each city to manage project resources. All procedures were approved by the Western Institutional Review Board and the Cancer Council Victoria Institutional Research Review Board.

Changes to Design after Commencement of the Trial

After the trial began the number of PRAs was reduced to 144 (72 in each city), with 36 (18 in each city) to be shaded, because of budget constraints. These constraints were created by unfavorable changes in foreign exchange rates between Australian and US dollars that reduced the amount of funds available to pay for shade sails in Australia. Pilot testing prior to the trial suggested that on average 4.2 individuals would be observed using PRAs during each observation period at baseline and the expected pre-post change of 3.8 was based on our secondary school study^{19,49}). However, fewer PRAs were in use during the baseline observations than expected so stratification by baseline use was not feasible but was by city and wave. In addition, it was necessary to include four municipalities in Melbourne to include sufficient parks. Given these municipalities had distinct levels of natural shade and age of housing it was decided to stratify by municipality in Melbourne, and for comparability by park maintenance areas in Denver, to distribute shade sales across them. As

discussed below, these changes required the primary outcome for the two primary hypotheses to be changed from total number of users of PRAs to any use. New power calculations were performed for the two primary hypotheses to determine whether the modified trial, with reduction to 144 PRAs and altered primary outcome, was feasible (see below). The small number of PRAs in use at baseline also made it impossible to obtain individual-level data on social norms and sun protection and tanning practices from PRA users. Thus, plans to test hypothesized moderation by these variables within the SEM framework were eliminated.

Procedures for Selecting Parks and PRAs

Denver has a population of approximately 3.4 million in the metropolitan area and encompasses 153 square miles⁵⁰ located in the western United States. At an elevation of 5,280 feet (approximately 1600 m), Denver's summer climate averages high temperatures of 30.9°C (87°F)⁵¹ and UV Index readings of 9 in July.⁵² Melbourne is a coastal city with a population of approximately 5.2 million in the metropolitan area. Its summer climate averages a high temperature of 25.9°C (78°F)⁵³ and UV Index readings of over 10 in January. Towards the commencement of the study melanoma incidence rates in both cities were relatively high. New melanoma cases in Colorado in 2009 were estimated at 1,260⁵⁴ and the cumulative lifetime risk of melanoma is 1 in 33 for males and 1 in 61 for females.⁵⁵ The incidence of melanoma in Victoria was 2,256 in 2010 and the cumulative lifetime risk of melanoma (to age 75 years) in 2009 was 1 in 28 for males and 1 in 37 for females.⁵⁶

Parks with potentially eligible PRAs were located in the City of Denver and in four municipalities within greater Melbourne (Cities of Manningham, Monash, and Whittlesea and Shire of Nillumbik). The staff from the relevant municipal departments managing the parks provided lists of potentially eligible parks. Park size, amenities, and neighborhood characteristics (e.g., SES, racial/ethnic composition) were obtained. The relevant municipal departments could designate some parks as ineligible due to their location, amenities, or scheduled construction/renovation.

PRAs were defined as areas for sitting/standing while socializing, preparing/eating a meal, watching or coaching sports, watching a concert, taking a class, or waiting, or areas where people stroll (walk slowly) for sightseeing while observing outdoor displays (e.g., festivals, gardens, zoo exhibits). Eligible PRAs within the parks were determined by a park audit. To be eligible, PRAs had to be a) located in parks containing at least two unshaded PRAs, b) be administered by the study municipalities, c) meet the definition of a PRA, and d) be in full sun (i.e. no shade) at baseline. One of the two PRAs had to e) contain a space where a shade sail could be constructed (i.e., free from underground or above ground obstructions, relatively level, and large enough to accommodate the shade sail) and f) be approved by parks department staff for shade sail construction. PRAs were excluded when major construction/redevelopment of the parks or neighborhoods were planned within the study period (5-years). Project staff visited the parks and described the PRAs (e.g., existing shade, physical features, and proximity to park features [e.g., athletic fields, pools, playgrounds, etc.]) and took photographs of the PRAs (i.e. conducted park audits).

Two PRAs in each park were selected for inclusion in the trial through a review by the project investigators and parks department staff. One eligible PRA was selected per park to be the study PRA. Selecting a single study PRA for full assessment avoided bias in statistical tests due to clustering of PRAs within the same park. A second unshaded PRA was selected in each park and project staff recorded whether it was in use or not during the data collection periods to provide an indication of how extensively PRAs in the parks were being used. Decisions by park users to use the shade/unshaded study PRA may be affected by whether other PRAs in the same park were unoccupied and available for use.

Shade Sail Design and Construction

Shade sails were constructed between baseline and posttest assessments at PRAs randomized to intervention, working with parks department staff and a shade sail vendor. Shade sails were built to similar designs in both cities, with some variation to fit the site requirements and city/municipalities' preferences. They were designed to create attractive shade structures that maximized available shade from 11 am to 3 pm in the summer. They had powder-coated or gout galvanized steel poles and a lighter colored shade cloth to transmit visual light. The shade cloth met Ultraviolet Protection Factor (UPF) ratings to reduce UV under the shade cloth by 94%. The final shade sail designs and sizes were determined with input from parks department staff and complied with all local engineering, building, and planning codes. Project staff recommended that the shade sail be the largest size acceptable to City'/council' parks staff to cover the maximum amount of the sky. Shade sails exceeded the minimum safety requirements for strength (for wind and snow load), resistance to light degradation, and UV transmission. The design minimized climbing access points and hazards to adjacent activities. Shade sails cost approximately US\$13,000 to US \$22,000 each in Denver (mean=US\$15,563) and AU\$13,700 to AU\$20,500 each (mean=AU \$16,135, excluding 10% GST and cost of shade sail cloth which was donated by a shade cloth manufacturer). Ownership of the shade sails was transferred to the city and local governments once built and thereby compensated them for government staff time spent on the project. Construction planning commenced in the fall after the pretest, with engineered plans approved in the winter, permits obtained in the early spring, and construction completed at the beginning of the summer posttesting period (May/June in Denver and November/December in Melbourne). Vendors for the shade sail construction were selected who had worked in the past with these local governments. Construction took about two weeks for each shade sail. Prior to installation, city/council staff located underground utilities, irrigation, and other obstructions.

Outcomes: Definitions and Ascertainment

The planned primary outcome was the number of adults using each PRA, assessed by observing each PRA for 30 minutes, although this was changed to any use by an individual of any age following the pretest observations. The secondary outcome was the average potential UV exposure for a user of the PRA based on measurements from a handheld UV meter. Both outcomes were assessed by trained research assistants (RAs) at the study PRAs. Theoretic moderators and mediators from the SEM were collected in a park audit and from public records. Baseline and posttest observations were performed in 20-week periods over

two summers (June–September in Denver; December–March in Melbourne); the same data collection methods were used in both cities.

Assessment Visits to Parks—Assessments were performed between 11 am and 3 pm (± 2 hours of solar noon) on four weekend days throughout the summer months during each test-period (8 observations in total per PRA). The four observation times at pretest and again at posttest were scheduled at random to the extent possible given weather (eligible weekend days had forecast high temperature between 72°F/22°C and 95°F/35°C; observations were suspended during rain) and staff availability and avoided major national holidays. They were alternated across the two weekend days and within two halves of the four-hour observation periods on Saturday (early and late) and on Sunday (early and late). Weekend days were selected because parks department staff reported that park usage would be higher on weekend than week days. Observations were anonymous; adults were identified by park.

Observation of Sun Protection Practices—The observation protocol was modified from a measure employed previously in Australia⁵⁷ to record park details and neckline and collar on shirts. Also, the record of whether the PRA users were in the shade was revised into 2 variables to provide more detail. The age measure had two categories, 18–49 and 50+ years. RAs were trained to unobtrusively count the number of adults who were present in the PRA during a 30-minute observation period, recording their sex (male/female), age (18–49/50 or older), and time of arrival and departure (arrival time = start of observation period for individuals already present in the PRA; departure time = end of observation period for individuals who remain in the PRA when the period ends). They also counted the number of individuals under age 18 in the PRAs. RAs recorded the other sun protection practices of each adult observed: head covering (no hat/visor/narrow hat/peaked [baseball] cap/legionnaire hat/broad hat [i.e., wide brim]); sunglasses (yes/no); shirts (yes/no); sleeve length (sleeveless/ $\frac{1}{4}$ length/elbow length/ $\frac{3}{4}$ length/wrist length); collar (yes/no); neckline (low/mid/high); midriff coverage (covered/partially exposed/exposed); leg covering (none/mid-thigh/knee length/ $\frac{3}{4}$ cover/ankle length); socks (no socks/ankle length/long tube socks); and shoes (no shoes/thongs or flip flops/sandals/shoes). RAs recorded whether each adult is in the shade while in the PRA by indicating type of shade (not using shade/using portable shade/using permanent shade) and shade coverage (full shade/partial shade/full sun/can't say). The type of activity in which the adult is engaged also was recorded (lying, sitting, standing, walking, exercising, or other). For each observation period, RAs recorded the park name, PRA, date, and time of observation.

An observation location was selected for each PRA that provided unobstructed viewing of the PRA while making the staff less obvious to PRA users. Photographs of the PRA were provided to the RA to assist in counting users of the PRA. RAs used a customized mobile app with the observation assessment running on an Android tablet computer to record observations. The mobile app recorded date and time of the observation period. The RAs used a paper record sheet as a backup if needed. RAs were trained to perform the observation by classroom instruction and field practice in a PRA in a non-study park or other location outdoors. RAs were required to achieve inter-rater reliabilities of ≥ 0.70 for all assessments, prior to performing observations of study PRAs.

UV Measures and Environmental Data—At the end of each observation period, the RAs obtained UV levels (on a UV Index scale from 0 to 12), using a Solarmeter 6.5 handheld meter. RAs performed the readings standing outside the PRA and in the middle of the PRA. All the measurements at pretest were in full sun. At posttest, both measures at the control PRA center and boundary were in full sun. At the intervention PRAs, the measurement at the boundary of the PRA was in full sun but the measurement in the center of the PRA was under the shade sail. See Dobbins et al. (2016) for data on the performance of the handheld meter.⁵⁸ The UV Index measurements were converted to Standard Erythemal Dose (SED), using standard algorithms: $SED^{59,60} = ((\text{measured UVI units at PRA} \times 0.025 \text{ W.m}^{-2}) \times \text{number of seconds exposure}) / 100 \text{ J.m}^{-2} \text{ per SED}$. At the end of the observation period, RAs recorded the temperature and wind (none/slight/moderate/strong/very strong) and estimated cloud fraction by recording if the sky was clear, had high thin clouds, was partly cloudy, or was overcast. Cloud fraction was calculated as 0% for clear sky and 100% for overcast. For high thin clouds or partly cloudy conditions, RAs estimated the amount of sky covered by clouds in 10% increments (10% to 90%).⁶¹ Additionally, records of temperature data from city meteorological stations were obtained, using the records for the hour closest to the observation times in the analyses.

Assessment of PRA Availability—Use of the comparison PRA (in use/not in use) was recorded by observers during each data collection visit. It measured the availability of other PRAs in the park (i.e., extent to which PRAs in the park were in use during the observation periods). It is recognized that this is an imprecise measure of PRA availability because steps were not taken to ensure that the comparison PRAs were similar to the study PRA, except that they were in the same park and unshaded.

Sample Size

Hypothesis 1: Introduction of shade will increase PRA use—The original outcome for the primary hypotheses was changed to use of the PRA by any individual of any age during each observation period (i.e., use vs. no use) because the number of adults using the PRAs at baseline was low. Only 12.0% of PRAs had any adult using them at baseline (mean=0.75 users; range=0 to 15) in Waves 1 and 2. Further, unfavorable foreign exchange rate movements meant that fewer shade sails could be constructed in Melbourne than planned, reducing the number from 40 to 36 total (18 per city). Therefore, the primary analysis and the power calculations were revised. It was assumed based on pretest observations that: (a) the pre-test probability (and the post-test probability for a control PRA) that a PRA is in use is 0.12 and (b) the within PRA correlation in use of a PRA is 0.17. To estimate power, it was assumed that each PRA was observed one time at pretest and again at posttest and 5000 simulations of two logistic regression models of posttest use were performed, adjusted for pretest use. One model included a term for the intervention while the other did not. The power was estimated by the proportion of simulations in which the likelihood ratio test p-value comparing the two models was < 0.05 (two-sided). These calculations showed the power would be 81% to test Hypothesis 1 if the proportion of PRAs in use increased from 12% to 33.5% pre to post (change=+21.5%) in the intervention PRAs (79% if use increased to 33%).

Hypothesis 2: City will moderate the effect of introduction of shade on use of PRAs

The same simulation approach was used to estimate the revised power for Hypothesis 2. The simulation involved testing an interaction between city and condition. To achieve 80% power would require a pre-post change of 12% to 66% of PRAs in use in Melbourne (change= +54.0%) and no pre-post change in Denver (change=0.0%). The magnitude of difference between the two cities seemed implausible, but because this moderation by city was predicted a priori, it will be tested.

Hypothesis 3: Introduction of shade will decrease the average UV exposure in the PRA

As a secondary hypothesis, no sample size calculations were made for Hypothesis 3. We will not adjust the alpha levels for any of the hypotheses because a) Hypotheses 1 and 2 are hierarchical and Hypothesis 2 is only relevant if Hypothesis 1 is confirmed and b) Hypothesis 3 relates to ambient UV exposure and not to people observed using the PRAs.

Randomization Procedure

After the pretest observations were complete for each stratum (e.g., Denver Wave 1, Melbourne Wave 2), an independent biostatistician generated the allocation sequence for that stratum using the random number generator in Stata (StataCorp, College Station, TX). To conceal the allocation sequence, each PRA was identified to the biostatistician by a code number only. The allocation sequence was then forwarded to the study coordinator in the relevant city for implementation of the randomization.

Statistical Methods

All statistical analyses will be performed using Stata version 14. Descriptive analyses will be presented for the primary and secondary outcomes and the covariates. Baseline data, blind to allocation status, will be used to determine the most appropriate categorizations of covariates. Equivalent measures of socio-economic status for the neighborhoods surrounding the PRAs were not available for the cities. Instead in Denver U.S. Census annual household income and in Melbourne Australian Bureau of Statistics socio-economic indexes[SEIFA] were used (identifying the areas, or fraction of areas, within 1 km distance from the park boundary closest to the PRA location (latitude and longitude). The mean scores for these variables were classified into income tertiles based on the distribution of annual income/ SEIFA score for each metropolitan area to allow between city comparisons. Randomization was checked by comparing baseline measures between the intervention and control PRAs to present group equivalence.

Hypothesis 1: Introduction of shade will increase use of PRAs—All analyses of the effect of the intervention will be by intention-to-treat. The unit of analysis will be an individual observation for a PRA (i.e., there will be 1152 units – 144 PRAs × 8 observations each. The data will be analyzed using logistic regression with generalized estimating equations (GEEs) to account for the correlation among observations for each PRA. An exchangeable correlation will be assumed. Wald tests will be used to calculate p-values; tests will be two-sided with an alpha level of 0.05. GEEs, which give population-averaged estimators, will be used rather than random effects because for logistic regression, the odds

ratio from the mixed effects regression is a within cluster (PRA) measure rather than a population-averaged estimator. The population-averaged estimator enables inferences about use of the “average” PRA following introduction of shade and therefore facilitates presentation of results as estimates of the probability (together with the 95% confidence interval) that a treatment (shaded) or control (unshaded) PRA is in use at pretest and posttest. To estimate these probabilities, all covariates in the model will be set at their respective means.

The model will include main effects for condition (shade versus control), time (pretest versus posttest) and pre-specified covariates. The intervention effect will be assessed by fitting an interaction between condition and time. To allow for the stratified design, the stratum will be included as a covariate. Other covariates to be included were nominated because they are likely predictors of the primary outcome measure (PRA in use/not in use). These consist of environmental characteristics at the time of each observation (proximity to solar noon, observed PRA temperature (meteorological records), cloud cover and wind), setting features for PRAs and parks (comparison PRA in use, the type of amenity contiguous to each study PRA; the type of amenities contiguous to each comparison PRA), and characteristics of residents in the neighborhood (average age of residents; ancestry/race of residents).

Hypothesis 2: City (Denver versus Melbourne) will moderate the effect of introduction of shade on use of PRAs—A three-way interaction between condition, city and time will be added to the model for Hypothesis 1 to explore whether city moderates the effect of constructing shade as predicted in Hypothesis 2. As for Hypothesis 1, the results will be presented as the change in the probability that intervention and control PRAs are in use pretest to posttest separately for Melbourne and Denver.

Hypothesis 3: The introduction of shade will reduce potential UV exposure—Separate models will be used to test Hypothesis 3 for SEDs at the center and boundary of the PRA. We assume that SEDs are normally distributed and will perform mixed effects linear regression with a random effect for PRA. The same covariates will be used as for Hypothesis 1. From the models, we will estimate the mean SEDs for 30-minutes exposure of a potential user at the center and boundary of the PRA, with all covariates (other than condition) fixed at their means.

Results

Table 1 displays the characteristics of the PRAs for the baseline observations and comparison by experimental condition and city. Overall, observations of PRAs were performed in 145 parks, 72 in Melbourne and 73 in Denver. The 1:3 randomization ratio resulted in 109 parks being assigned to the control condition, remaining unshaded, and in 36 parks to the treatment condition in which a shade sail was built. A total of 580 observations of PRAs were conducted (n=4 per PRA).

Baseline Use of PRAs

Use of the PRAs at baseline was low. Individuals were observed using the PRAs in 13.3% of the observations at baseline, with averages for number of days in use and number of individuals using the PRAs less than 1.0 (Table 1). PRAs assigned to the control condition appeared to have slightly higher use than treatment PRAs, but use in both conditions remained low. Baseline use of the PRAs was also slightly higher, but still low, in Denver than Melbourne.

Use of the PRAs selected as comparisons also was low (7.1%) and appeared to be lower than use of the study PRAs (Table 1). Slightly more comparison PRAs were in use in the treatment than control conditions but the differences between the cities was very small. Average number of days in use was also less than 1.0 for comparison PRAs.

Ambient UV in the PRAs

Ambient UV levels at the PRAs averaged over 3 SED in a 30-minute period across all of the baseline observations when measured at either the center or boundary of the PRAs (Table 1). Average SEDs were very similar in treatment and control conditions and in the two cities.

Features of the Observation Period

Observations were conducted throughout the summer months at midday and averaged 29 days from the summer solstice and 55 minutes from solar noon (approximately 13:00) (Table 10). There was little difference in the timing of the observations by treatment group. Observations in Denver were slightly farther from the summer solstice than in Melbourne but proximity to solar noon was similar across the cities.

Overall, the weather during the observations was warm (mean=26.2°C) and had some cloud cover but only slight or no wind. Weather conditions were similar across the two experimental conditions but the weather was cooler, cloudier, and windier in Melbourne than Denver during the observations.

Setting Features of the PRAs

The most common amenities in the study PRAs were benches and picnic tables, while benches were most common in the comparison PRAs (Table 1). Playgrounds were the single most frequent amenity close to the study and comparison PRAs, occurring at nearly half of these PRAs, with more playgrounds next to the Melbourne PRAs. The amenities within the study PRAs were very similar between the two experimental conditions but benches were more frequent in Melbourne and picnic tables more frequent in Denver for both the study and comparison PRAs. Also, only Denver PRAs contained bleachers.

Neighborhood Characteristics Surrounding Parks

The parks were located in diverse neighborhoods in the two cities. On average, neighborhood residents were 36.6 years old, half were white, 23% were under age 18, and 67% were employed (Table 1). Income of neighborhood residents was distributed evenly across the three income tertiles. Neighborhood characteristics were the same between experimental conditions except that more parks with experimental PRAs were in low income

neighborhoods and more parks with control PRAs were in high income neighborhoods. These characteristics were also similar across the two cities.

Discussion

Identifying features of built environments amenable to change that can affect health behaviors holds considerable potential for improving population health.^{32,62–65} This trial will address important gaps in our understanding of effective sun protection interventions, specifically whether purpose-built shade structure will promote greater use of shaded areas within public parks. Shade use has been relatively understudied and this trial will contribute some of the first evidence from an experimental design that examines built shade separate from other sun protection practices. It will advance beyond our previous shade intervention study in secondary schools¹⁹ by examining the behavior of adults in public spaces.

It has been challenging to acquire evidence on how built environments influence behavior.^{45,66} Most studies have used cross-sectional designs which cannot establish causality.⁶⁷ For instance, past cross-sectional studies of shade use^{57,68–73} have described the prevalence and trends in shade use,^{69,74} demographic and attitudinal correlates of shade use,^{75–80} and association of shade use with temperature and sunburn incidence.⁸¹ Prospective sun protection intervention studies have promoted shade use.^{82–84} However, only a few actually increased shade levels⁸² and the effects of changing shade could not be separated from other concurrently promoted precautions.¹⁹ For example, an evaluation of an intervention at swimming pools found that the pools with the highest intervention effects on sunscreen use were those with good shade provision,⁸⁵ while an evaluation of a sun protection campaign for outdoor workers suggested that educating workers about using shade was insufficient to motivate actual shade use (shirt use was improved instead).⁸⁶ Our recent shade study in Melbourne secondary schools remains the only example of a rigorous, randomized trial of the effects of modifying the built environment to provide newly shaded areas on sun protection behavior (i.e., shade use).^{19,49} It showed that students used rather than avoided built shade on the school grounds at intervention schools, with an increase in the number of students using the shaded areas relative to unshaded areas at control schools. These findings suggest that providing built shade where individuals are outdoors in the sun is useful for encouraging increased use of shade and reducing UV exposure, but this prediction needs to be tested in other locations where extended UV exposure may occur such as public parks. The baseline observations showed that use of the unshaded PRAs was low, meaning that the introduction of a shade sail had plenty of room to increase use. However, the low number of users initially means that we are likely to have several zero observations at posttest which may require further adjustments to our statistical models.

Park and PRA selection procedures resulted in a sample of parks for the trial in diverse areas, although the PRAs were generally of two types, ones with benches or picnic tables which provided a focus for the passive recreation. As expected, UV levels were high during the midday observation periods, high enough to sunburn light-skinned individuals with short exposure (i.e., less than 30 minutes). Thus, sun protection, including the use of shade provided by a shade sail, was advisable during the midday observation periods in the public parks in Melbourne and Denver. Fortunately, randomization appeared to largely balance the

PRAs between condition on baseline PRA use, PRA amenities, UV levels and weather, and neighborhood characteristics, suggesting that potential covariates should result in only minimal adjustments of any treatment effect at posttest.

The trial will also prospectively test predictions from the SEM about the interplay among the built environment and environmental and setting features. There appear to be diverse social norms for sun protection and tan motivations in Denver and Melbourne, likely produced by longstanding community-wide skin cancer prevention campaigns in Melbourne^{87–96} and more recent, less comprehensive campaigns in Denver.^{97,98} SEM predicts that these social norms will differentially affect local-level interventions, such as purpose-built shade. This will be similar to research that established the effectiveness of building walking trails for increasing physical activity and described how and who used the trails, which helped to create effective strategies encouraging increased use of the trails.⁹⁹ While it may seem intuitive that people will use shade if it is convenient and practical, there is very little evidence to show that investments in built shade will reduce people's UV exposure. There appeared to be only a small number of differences between the PRAs enrolled in the two cities (e.g., more benches in Melbourne and picnic tables in Denver), suggesting that that two cities provide reasonably good comparators. However, it will be important to control for weather conditions because the weather overall was more inclement in Melbourne (cooler, cloudier, and windier) than in Denver during the observations.

The focus on public parks is important because parks have been venues for interventions to improve physical activity.^{24,100–102} As individuals are convinced to be more physically active, many light-skinned individuals may have more high-risk sun exposure in outdoor settings,^{103,104} especially the youngest and oldest cohorts.¹⁰⁵ Shaded areas could be used when taking breaks from or viewing such activities and some physical activities could be performed in the shade. Also, public parks may be important leisure activity areas for residents who have limited outdoor private spaces such as those living in multi-family housing units (e.g., apartment buildings and condominiums). Purpose-built shade in parks also could remind high-risk individuals, regardless of how they are using the parks, to take precautions when in the sun.

Conclusions

In the end, the trial results will have important implications for governments, planners, architects, landscapers and private organizations considering environmental strategies to improve sun safety. A number of childcare centers^{106,107} and schools and swimming pools in Australia^{108–110} and the United States^{111–113} have policies that encourage increasing shade and considerable funds have been invested in shade-sails in childcare centers' playgrounds and over outdoor toddler pools in Melbourne¹¹⁰ and in public parks in Victoria. However, such investment is usually not trivial, with the cost of building each shade sail in this trial exceeding \$15,000 (in both currencies). Evidence that the public will use shade will provide a practical reason to further invest in improving shade infrastructure.

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FIGURE 1.
Social Ecological Model Applied to Influence of Built Shade

Trial outcome measures and features of observation periods and passive recreation areas (PRAs) at baseline by experimental group and city

Table 1

	City		Experimental Condition		Total
	Melbourne	Denver	Treatment (shade)	Control (unshaded)	
N of parks	72	73	36	109	145
N of observation days	288	292	144	436	580
Trial Outcome Measures at Baseline					
<i>Study Passive Recreation Area (PRA) Use</i>					
Study PRA in Use, n (%)	32 (11.1%)	45 (15.4%)	14 (9.7%)	63 (14.4%)	77 (13.3%)
Number of days in use, mean (SD)	0.4 (0.7)	0.6 (0.8)	0.4 (0.7)	0.6 (0.8)	0.5 (0.8)
Number of users, mean (SD)	0.31 (1.41)	0.50 (1.65)	0.33 (1.31)	0.43 (1.61)	0.41 (1.54)
Number of users under 18, mean (SD)	0.14 (0.98)	0.23 (0.81)	0.22 (1.35)	0.17 (0.69)	0.18 (0.90)
<i>Use of Comparison PRA</i>					
Comparison PRA in Use, n (%)	19 (6.6%)	22 (7.5%)	13 (9.0%)	28 (6.4%)	41 (7.1%)
Number of days in use, mean (SD)	0.3 (0.4)	0.3 (0.6)	0.4 (0.6)	0.3 (0.5)	0.3 (0.5)
<i>Ambient UV Level (SEDs in J.m⁻²)</i>					
Standard Erythral Dose ^a (SED) at PRA Center over 30 min, mean (SD)	3.1 (1.5)	3.4 (1.2)	3.4 (1.3)	3.2 (1.4)	3.3 (1.4)
SED at PRA boundary over 30 min, mean (SD)	3.1 (1.5)	3.4 (1.2)	3.3 (1.3)	3.2 (1.4)	3.2 (1.4)
Features of Observation Period					
Proximity to summer solstice in days, mean (SD)	27 (21)	31 (23)	28 (21)	29 (22)	29 (22)
Proximity to solar noon in minutes, mean (SD)	54 (34)	55 (36)	55 (35)	54 (35)	55 (35)
Temperature, degrees Celsius, mean (SD)	23.9 (4.1)	28.5 (4.2)	26.5 (4.9)	26.1 (4.7)	26.2 (4.7)
<i>Observed Cloud Cover</i>					
Clear sky, n (%)	54 (18.8%)	111 (38.3%)	44 (30.6%)	121 (27.9%)	165 (28.5%)
Any cloud cover, n (%)	234 (81.3%)	179 (61.7%)	100 (69.4%)	313 (72.1%)	413 (71.5%)
<i>Observed Wind</i>					
None to slight, n (%)	165 (57.3%)	234 (81.0%)	103 (71.5%)	296 (68.4%)	399 (69.2%)
Moderate to very strong, n (%)	123 (42.7%)	55 (19.0%)	41 (28.5%)	137 (31.6%)	178 (30.8%)
Setting Features of Study PRA					

		City		Experimental Condition		Total
		Melbourne	Denver	Treatment (shade)	Control (unshaded)	
Main Amenity within Study PRA						
Bench, n (%)		45 (62.5%)	23 (31.5%)	17 (47.2%)	51 (46.8%)	68 (46.9%)
Picnic table, n(%)		27 (37.5%)	44 (60.3%)	18 (50.0%)	53 (48.6%)	71 (49.0%)
Bleachers, n (%)		0 (0.0%)	6 (8.2%)	1 (2.8%)	5 (4.6%)	6 (4.1%)
Main Amenity Contiguous to Study PRA						
Playground, n (%)		48 (66.7%)	36 (49.3%)	21 (58.3%)	63 (57.8%)	84 (57.9%)
All others, n (%)		24 (33.3%)	37 (50.7%)	15 (41.7%)	46 (42.2%)	61 (42.1%)
Setting Features of Comparison PRA						
Main Amenity within Comparison PRA						
Bench, n (%)		59 (81.9%)	38 (52.1%)	20 (55.6%)	77 (70.6%)	97 (66.9%)
Picnic table, n(%)		13 (18.1%)	29 (39.7%)	15 (41.7%)	27 (24.8%)	42 (29.0%)
Bleachers, n (%)		0 (0.0%)	6 (8.2%)	1 (2.8%)	5 (4.6%)	6 (4.1%)
Main Amenity Contiguous to Comparison PRA						
Playground, n (%)		38 (52.8%)	28 (38.4%)	16 (44.4%)	50 (45.9%)	66 (45.5%)
All others, n (%)		34 (47.2%)	45 (61.6%)	20 (55.6%)	59 (54.1%)	79 (54.5%)
Neighborhood Characteristics, within 1.0 km of Study PRA						
Mean age of residents in years, mean (SD)		37.4 (4.7)	35.8 (4.0)	36.4 (4.3)	36.7 (4.5)	36.6 (4.4)
Proportion of residents who are white, mean (SD)		0.52 (0.20)	0.48 (0.24)	0.49 (0.23)	0.51 (0.22)	0.50 (0.22)
Proportion of residents who are under 18 years, mean (SD)		0.23 (0.04)	0.24 (0.07)	0.23 (0.07)	0.23 (0.06)	0.23 (0.06)
Proportion of residents employed, mean (SD)		0.63 (0.08)	0.71 (0.05)	0.67 (0.08)	0.67 (0.07)	0.67 (0.08)
Socioeconomic status tertiles; ^b						
Low, n (%)		24 (33.3%)	24 (32.9%)	16 (44.4%)	32 (29.4%)	48 (33.1%)
Middle, n (%)		24 (33.3%)	24 (32.9%)	11 (30.6%)	37 (33.9%)	48 (33.1%)
High, n (%)		24 (33.3%)	25 (34.2%)	9 (25.0%)	40 (36.7%)	49 (33.8%)

^a SED = ((measured UVI units at PRA $\times 0.025 \text{ W.m}^{-2}$) $\times$ number of seconds exposure) / 100 J.m^{-2}

^b Socioeconomic status tertiles based on tertiles for distribution of socioeconomic status in the entire metropolitan areas (i.e., SEIFA score for Melbourne and annual income for Denver).