BMJ

RESEARCH

Adolescents' use of purpose built shade in secondary schools: cluster randomised controlled trial

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Cite this as: *BMJ* 2009;338:b95
doi:10.1136/bmj.b95

ABSTRACT

Objective To examine whether students use or avoid newly shaded areas created by shade sails installed at schools.

Design Cluster randomised controlled trial with secondary schools as the unit of randomisation.

Setting 51 secondary schools with limited available shade, in Australia, assessed over two spring and summer terms.

Participants Students outside at lunch times.

Intervention Purpose built shade sails were installed in winter 2005 at full sun study sites to increase available shade for students in the school grounds.

Main outcome measure Mean number of students using the primary study sites during weekly observations at lunch time.

Results Over the study period the mean change in students using the primary study site from pre-test to post-test was 2.63 (95% confidence interval 0.87 to 4.39) students in intervention schools and −0.03 (−1.16 to 1.09) students in control schools. The difference in mean change between groups was 2.67 (0.65 to 4.68) students (P=0.011).

Conclusions Students used rather than avoided newly shaded areas provided by purpose built shade sails at secondary schools in this trial, suggesting a practical means of reducing adolescents' exposure to ultraviolet radiation.

Trial registration Exempt.

INTRODUCTION

Exposure to ultraviolet radiation from sunlight during childhood and adolescence is associated with an increased risk of skin cancer in later life.[1-3] In Australia, with a high incidence of skin cancer and extensive public education over many years,[4 5] the vast majority of adolescents have high levels of knowledge on the dangers of skin cancer.[6] However, adolescents are resistant to using adequate sun protective measures in their activities outdoors generally,[7 8] and typically one quarter of them are sunburnt on summer weekends.[8] This is of concern, given that history of sunburn is often linked with risk of melanoma.[1] Moreover, adolescents' exposure to ultraviolet radiation during school hours is estimated to contribute significantly to total cumulated exposure up to age 20.[9]

Few intervention studies have targeted adolescents' sun protection behaviours.[10-17] Typically, these interventions used educational strategies and had limited effect on sun protection behaviours. Two recent intervention trials in the United States have shown that some change in behaviour is possible for young adolescents (11-14 years) with a low knowledge base when messages are delivered through multiple settings and advocates or in an intensive curriculum.[18 19] However, further increasing Australian adolescents' knowledge of skin cancer alone would be unlikely to translate into behavioural change.

Schools are an important setting for prevention of skin cancer as adolescents are regularly outdoors during lunch times, when daily ultraviolet radiation levels are high.[20] Use of shade can potentially reduce the dose of ultraviolet radiation that students receive during time outdoors in schools and in pre-schools.[21 22] However, increasing shade in secondary schools is of value only if students will use it. In Australia, although primary schools have embraced the establishment of sun protective environments and primary school aged children have good sun protection behaviours,[23-25] skin cancer prevention programmes have had difficulties in engaging secondary schools in implementing strategies for students' sun protection such as wearing hats during the months when ultraviolet radiation levels are high.[26] An observational study in New Zealand found that adolescents might be attracted to using shade that was light in colour and retained warmth, was of large enough size for several students, and used an attractive design.[27] Shade sail structures have been shown to be potentially effective at reducing ultraviolet radiation levels, particularly during peak ultraviolet radiation times around solar noon, with UVR protection factors typically of 4-8.[28]

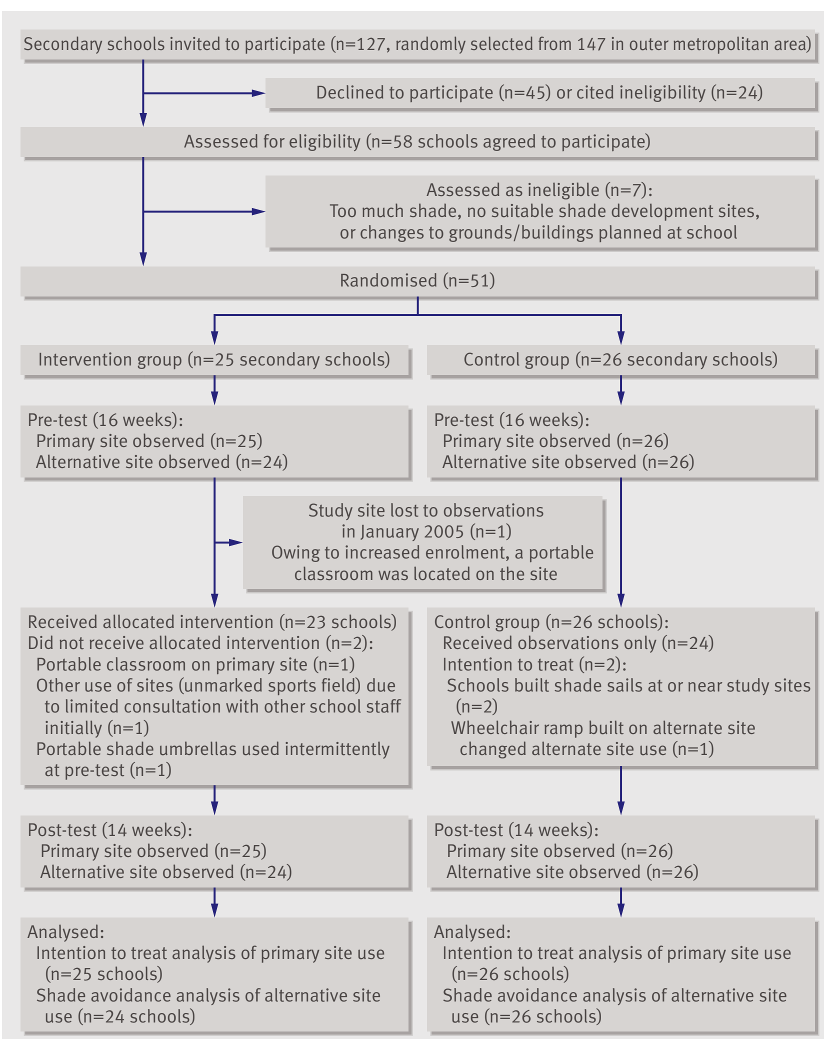
Given the substantial costs to schools in developing purpose built shade and adolescents' tendency for sun seeking,[7] we did a cluster randomised controlled trial to examine whether students would use or avoid newly shaded areas provided by a purpose built shade sail intervention in secondary schools. The intervention was delivered at the school level and required a cluster design.

METHODS

We randomly selected secondary schools from outer metropolitan areas of Melbourne and sent principals a letter of invitation outlining the study's aims and requirements. Study eligibility required enrolment of 300 or more students with all year levels 7-12 on campus, identification of two potential shade development areas, and no plans for major changes to school grounds or buildings during the study period from the start of spring 2004 to the end of summer 2006.

We approached 127 schools for participation. Of these, 31 schools did not meet the study requirements, five schools declined owing to concern about potential vandalism of shade structures or the video observations, and 40 declined with limited reasons given (such as too busy). We set the following criteria for identifying potential shade development sites: a full sun area during spring and summer terms; a large enough space for students to congregate; used regularly by students and located in a main activity area of the school; avoided existing underground services, major paths, and roadways; and approved by the principal and contact teacher as suitable for building shade for the school.

Fifty one secondary schools that met the eligibility criteria participated in the study. After shade audits and consultations with school principals, we identified two full sun areas in each school to be observed over the study period. These two sites were selected as potentially suitable for a shade development (the intervention) and located in close proximity to each other, in either adjacent or nearby areas. We considered the schools' preferred site for the shade development as the "primary" study site and the adjacent or nearby area as the "alternative" study site. We defined the boundaries of these study sites by use of both still photographs of each site with a boundary overlaid and written notes describing the features on the perimeter of the sites that were to be included or excluded. In January 2005 the study statistician (JAS) randomly assigned schools to intervention (n=25) and control (n=26) groups; she had no information about the schools. Allocation was concealed from the other researchers and the schools until randomisation occurred. Thereafter, blinding of school principals, contact teachers, researchers, and content analysts to the intervention allocation was not possible. School principals agreed to participate by September 2004, well before the school contacts were informed of the group allocation in January 2005.



Flow of school clusters through study

Intervention

The intervention entailed building shade sail structures for students to use during passive activities such as eating lunch. The rationale was that the natural protection offered by shade would reduce adolescents' exposure to ultraviolet radiation without compromising fashion styles and peer image, which may occur with use of protective clothing, hats, and sunscreens. We used shade sail structures, as this type of built shade seemed to be popular with early childhood centres and swimming pools, offered good visual appeal, and provided visible light and warmth appropriate for a changeable climate but adequately reduced ultraviolet radiation levels by at least 94% under the sails according to shade manufacturers' advice.

A shade sail manufacturer designed and built the shade sails in the primary study sites at intervention schools during autumn and winter 2005. The shade sails were designed to accommodate the varying size of study sites; the final size was on average 74 m^2. The costs per shade sail were on average approximately $A11 500 (£5205; €5840; $7708), and the construction costs varied depending on the site conditions, with a maximum cost of $A22 000 at one school. The shade sails met all safety guidelines and planning and building approvals. The height and location of the shade sails were designed to deter access by vandals and students wanting to climb the sails, while ensuring that the study sites would be fully shaded at noon.

Hypothesis

Our main hypothesis was that the mean number of students using the primary study sites in intervention schools would increase after installation of the purpose built shade compared with students' use of equivalent unshaded sites in control schools. We monitored shade avoidance by observing changes in students' use of the unshaded alternative study site in intervention compared with control schools.

Outcome measures

The primary outcome measure used to assess the effect of the intervention was the change in the mean number of students using the primary site during lunch times in spring and summer terms before (pre-test, 2004-5) and after (post-test, 2005-6) installation of the shade sail intervention. The secondary outcome measure used to assess shade avoidance was the change from pre-test to post-test in the mean number of students using the alternative site.

Observation protocol—We observed the two defined sites weekly by using digital video cameras to monitor the number of students using the areas at lunch times. Each site was filmed for three periods of two minutes at approximately equal intervals during the main part of the lunch time for each observation date. We randomly assigned schools to the day of the week for observations after exclusion of unsuitable days (planned events or other scheduled disruptions). The day of observation was changed at only one school during the pre-test period. We informed students, parents, and school staff that the video observations were for a study of outdoor behaviour.

Content analysis of observations—Research assistants following written protocols reviewed the observation film and recorded tallies of the numbers of students "using" the sites within each two minute observation. Only one of eight coders assigned to review that set of observations analysed the film for observations at any school and date. Each coder reviewed film for both intervention and control schools. Training for the content analysis involved achieving total agreement on sample observations before each coder started the actual work of recording the numbers of students using the sites. Achieving high agreement at training is considered a valid means of ensuring agreement of coders.[29] During review of the DVD film, coders made reference to photographs and training notes that showed the boundaries of the sites. Students were defined as "using the site" and added to the tally if they were not yet counted and were within the site boundaries either playing, standing, sitting, or chatting to others in the area for more than two frames (or approximately 20 seconds). Students passing through the area were not recorded as using the study sites. The presence of teachers and a rating of cloud cover were also recorded. We also obtained the relevant noon temperature records for the closest weather stations to the schools from the Bureau of Meteorology.

Table 1 | **Description of conditions during school observations, missing data*, and schools' compliance with intervention. Values are mean (SD; range) unless stated otherwise**

Conditions	Control group (n=26)	Intervention group (n=25)
Pre-test conditions		
Temperature (°C)	19.5 (4.7; 9.7-33.7)	19.5 (4.9; 9.7-33.8)
Clear sky observations (%)	40.3	39.5
Complete observations† (%)	78.1	73.8
Total missing observations‡	3.3 (1.1; 1-6)	3.8 (1.4; 2-7)
School enrolment size (2004-5)	859 (317; 229-1371)	903 (380; 277-1876)
Post-test conditions		
Temperature (°C)	20.8 (3.9; 12.7-33.8)	20.7 (4.5; 12.2-33.8)
Clear sky observations (%)	41.0	36.4
Complete observations† (%)	88.5	86.6
Total missing observations§	1.3 (1.1; 0-4)	1.8 (1.3; 0-4)
School enrolment size (2005-2006)	862 (328; 205-1379)	888 (347; 274-1574)
Treatment implemented as intended without major changes to protocol	n=23	n=22

*Missed observations occurred as a result of filming difficulties, heavy rain, and school or public holidays.
†Three observations per school per date.
‡Aggregate mean number of missing dates per school at 16 weeks pre-test.
§Aggregate mean number of missing dates per school at 14 weeks post-test.

Sample size and randomisation

We calculated the sample size on the basis of a sign test for comparison of matched pairs.[30 31] Cohen's power tables suggested that we needed 30 matched pairs for 80% power to detect a large intervention effect (g=0.25).[32] Before randomisation, we revised the design and primary analysis. We considered randomisation without matching or stratification to be a better control of potential confounding,[33] given the multiple features of study sites that might vary and the feasibility of matching schools by only a few features, and we chose an unpaired t test comparing mean change in students' use from pre-test to post-test at the school level for the primary analysis. The unmatched design increases the degrees of freedom from 29 (matched pairs design) to 58, and the comparison of means is more statistically powerful than a simple comparison of the number of schools that did or did not increase in students' usage.

Statistical methods

A preliminary analysis examined group differences in weather conditions, missing observation data, and school enrolment size. We excluded observation dates with only one of the three lunch time observations at the school recorded for a given date from further analyses. For dates with two or three lunch time observations we calculated the mean to represent students' use for the observation date. Missing observations occurred as a result of difficulties with filming or access, whole school events, and public holidays.

For both the primary and alternative study sites of each school, we aggregated observations of students' use by calculating the mean value. We did this separately for the pre-test (16 weeks of observation) and post-test (14 weeks) periods. We then calculated the difference to describe the mean change in students' use from pre-test to post-test for each school study site.

The primary analysis compared these school specific differences in students' use at the primary site between the intervention and control schools by using an

Table 2 | Intention to treat analysis, comparing mean change in numbers of students observed to use primary site from pre-test to post-test by group

	Control schools (n=26)	Intervention schools (n=25)	Group difference (95% CI)	P value
Pre-test				
Mean (SD) use*	3.49 (2.82)	3.24 (2.83)	−0.25	
Range of use	0-59	0-30		
Intra-school correlation coefficient	0.30	0.40		
Post-test				
Mean (SD) use†	3.46 (2.69)	5.87 (4.70)	2.41	
Range of use	0-34	0-47		
Intra-school correlation coefficient	0.34	0.52		
Change from pre-test to post-test				
Mean change‡	−0.03 (2.78)	2.63 (4.26)	2.67 (0.65 to 4.68)	0.011

*Aggregate mean of observations on 16 days.
†Aggregate mean of observations on 14 days.
‡Difference calculated as post-test mean use minus pre-test mean use.

unpaired *t* test and on an intention to treat basis. The secondary analysis included the school specific differences in students' use for both the primary and alternative study sites, resulting in two outcome measures per school. We fitted generalised estimating equations with robust standard errors to the data, allowing for an interaction between group and site. In addition, we fitted linear mixed models to the non-aggregated data to determine intra-school correlation coefficients. The statistician (KMJ) was blinded to group assignment. We used Stata version 8 for all analyses.

RESULTS

The figure shows the flow of schools through each stage of the study. The shade sails were not built at two intervention schools where unforeseen demands required different use of the areas. Two control schools built shade sails near or on the study sites before the end of the study. One intervention school used portable shade umbrellas at pre-test, and one control school built a wheelchair ramp on the alternative study site, which probably disturbed observations.

Group differences in potential confounders

Temperature, cloud cover, school enrolments, and the numbers of missed observations were similar for the two groups at both pre-test and post-test (table 1).

Students' use of primary study sites at pre-test

Use of the primary study site varied widely across schools and observation days. Many observations of the primary sites had no students present during the two minute observation periods. However, although the minimum use of the primary site was zero students, a maximum of 59 students at control schools and 30 students at intervention schools were observed to use the primary site at pre-test in a given two minute period. Table 2 shows that the aggregated mean students' use of the primary site over the 16 weeks of pre-test was similar for control and intervention schools.

Effect of building shade sails at intervention study sites

The mean change in use of the primary site from pre-test to post-test was −0.03 (95% confidence interval −1.16 to 1.09) students for control schools and 2.63 (0.87 to 4.39) students for intervention schools. An unpaired *t* test comparing these mean changes showed evidence of an intervention effect (mean change 2.67, 0.65 to 4.68; P=0.011) (table 2). The intra-school correlation increased from pre-test to post-test in the intervention group, indicating more similarity in the number of students using the intervention site across days after the installation of the shade compared with control schools.

Analysis of shade avoidance

Table 3 shows that the mean change from pre-test to post-test in use of the alternative sites was relatively stable for each group. Furthermore, we found evidence that at intervention schools the mean change was greater for the primary sites than for the alternative sites (difference in mean change between sites 2.70, 0.75 to 4.64; P=0.007 from the generalised estimating equation), so the shaded area was not being avoided. In contrast, we found little evidence that the mean change in use of the primary and alternative sites differed at control schools (difference in mean change −0.90, −2.03 to 0.23; P=0.119 from the generalised estimating equation).

Table 3 | Mean change in numbers of students observed to use alternative sites from pre-test to post-test by group

Change from pre-test to post-test	Control schools (n=26)	Intervention schools (n=24)*	Group difference
Mean change (95% CI)	0.87 (−0.22 to 1.95)	−0.03 (−1.09 to 1.02)	0.90

*Excludes one intervention school where observations of the alternative site were not possible.

WHAT IS ALREADY KNOWN ON THIS TOPIC

Reducing exposure to harmful ultraviolet radiation during childhood and adolescence is important for skin cancer prevention

Despite good knowledge and awareness of skin cancer, Australian adolescents are resistant to use of hats and clothing for sun protection

No quality studies on the effects of increasing available shade alone for adolescent skin cancer prevention have been done

WHAT THIS STUDY ADDS

A purpose built shade sail intervention increased students' use of newly shaded areas at schools

Building shade is an effective practical option for protecting students against ultraviolet radiation during lunch times

Adverse events

None of the schools reported any vandalism to the shade sails or injuries resulting from building the sails.

DISCUSSION

We found this shade sail intervention to be effective, with greater use of the newly shaded areas by students at intervention schools compared with full sun areas at control schools. Furthermore, we found no evidence of shade avoidance. The study was implemented with no drop out of schools.

The mean change in use of the primary study sites between control and intervention schools was relatively small; an average of approximately three more students used the shaded sites at intervention schools compared with unshaded primary sites at control schools. Nevertheless, we believe the findings are important because no other rigorous studies of the effects of environmental approaches alone for skin cancer prevention have been done.[17] Moreover, adolescents have been intransigent in their use of sun protection,[7 8] and this is one of the few interventions that has had an effect on adolescents' sun protective behaviours. Researchers have been pessimistic about succeeding in this area.[7 10 11] To highlight how challenging producing positive change in sun protection behaviour among adolescents is, one of the two other successful intervention trials for adolescents described positive outcomes in terms of stalling the decline in sun protection after two years of intervention.[18] The other successful study found that relatively small improvements in use of sunscreen and long sleeved clothing were possible for young adolescents after a one year intensive curriculum.[19]

Context

The findings from our study suggest that among a population of adolescents with good knowledge about the dangers of skin cancer and the need for sun protection, providing attractive purpose built shade in secondary schools is sufficient on its own to increase use of shade by students. However, given the relatively small increase in the number of students using the shade structure, more research is needed to determine the circumstances that maximise this effect. If this can be done successfully, the installation of permanent shade at secondary schools has an added advantage over educational interventions for adolescents' sun protection, in that the benefits may be sustained over months and years with small maintenance costs.

The study schools were a mix of types and enrolment sizes. We anticipate that the intervention might be disseminated effectively to other secondary schools with limited shade across Australia, with careful choice of appropriate locations and using the same shade sail design principles. The intervention was effective despite the varied weather conditions of the study. The intervention may not be as effective in very cool climates or where students spend most of their lunch times indoors. Furthermore, the study sites were mainly for seated recreation, and the effects may not be the same for more active recreation areas. A pilot test of the intervention assessed the feasibility of developing shade in areas of more active recreation; this tended to have more constraints, such as safety concerns in placement of the poles and the need for a larger sized sail to be beneficial.

The results of this study suggest that environmental change alone can produce behavioural change. The findings are not unexpected given that health promotion frameworks and theoretical models of behaviour underline the role that supportive environments and organisational change can have in influencing behaviours.[34 35] Moreover, sun protective behaviours are considered to be strongly environmentally cued. Further research is needed to examine whether increasing shade can be beneficial for prevention of skin cancer in adolescents in settings other than schools.

Strengths and limitations

Our study has several strengths. The distribution of potential confounding variables was similar between groups. We minimised bias from seasonal effects and school events by making the observations over several weeks, and repeated measurements during lunch time minimised varied patterns of use across the lunch break between schools. Because two intervention schools did not receive a shade sail, the intention to treat analysis may have underestimated the effect if the intervention was implemented in all schools.

One limitation was that many study sites were underused for at least part of the lunch time, which may reflect several factors. A major criterion for selecting study sites was that they were well used areas in the main activity centres of the schools. However, we selected the sites in winter and patterns of use may have been different in the warmer months. Further research is needed to establish what type of areas in schools are well used and attractive to students for passive recreation where shade sails might be built. The intervention sites included a range of features that might be more or less attractive to students and, for example, included seating or tables; grass, bitumen, or paving ground surfaces; and nearby garden beds and sports fields. That the effects were found despite this variation in features of sites was encouraging. The findings that students' use of the shaded sites at intervention schools increased whereas use of the alternative full sun sites was steady implies that at least some attraction of students from other areas in the schools to at least one study site occurred. We recruited schools with limited shade, so we expect that migration of students to these sites would mainly be from other unshaded areas in the schools. If migration occurred from pre-existing shaded areas it would highlight that the type of shade provided by shade sails was more attractive than other shade provided by trees and buildings.

Moreover, although the shade sails were relatively large (46-120 m^2), on average only six students used them. Friendship groups might avoid encroaching on other students' space, limiting the optimal use of shade sails. Further research might examine whether factors such as seating arrangements, as well as size of sails, might maximise use. If friendship groups were limiting, building multiple shade sails within a school would be valuable.

Conclusions

This study provides clear evidence that secondary school students will use rather than avoid shade sails in schools when location and shade design have been carefully selected. Although more research is needed to identify factors that will maximise students' use of shade sails, these findings suggest that investing in shade in schools has potential for reducing students' exposure to ultraviolet radiation during school hours.

We thank the school staff and students who participated in this study. We also thank the shade sail manufacturer and the research assistants without whom this study would not have been possible.

Contributors: SJD developed the original study idea, was principal investigator, and, with MAW, Victoria White, PML, and DRE, developed the trial design and protocols and directed the conduct of the study. Vanessa White helped to refine the study protocols, recruited the schools, and coordinated the intervention and collection of outcome measures. KMJ did the statistical analysis with direction from JAS and DRE. SJD, MAW, and Victoria White assisted with interpretation of results. SJD, MAW, and KMJ drafted the manuscript. All authors critically reviewed the article and approved the submitted manuscript. SJD is the guarantor.

Funding: The study was funded by a research project grant (ID 265902) from the Australian National Health and Medical Research Council. The building of the shade sails was covered by the research grant, and the manufacturer did not provide any funding to this study.

Competing interests: None declared.

Ethics approval: The Cancer Council Victoria's Human Research Ethics Committee approved the research (HREC 0402), as did the education authorities.

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Accepted: 30 October 2008