A CROSS-SECTIONAL ANALYSIS OF THE SUN-PROTECTIVE BEHAVIOURS AND POLICIES AT PRIMARY SCHOOLS IN NORTH AND FAR NORTH QUEENSLAND

Denise Turner

BSc(Hons), Grad Dip Human Nutrition

Thesis submitted to James Cook University, in fulfilment of the requirements for the degree of Doctor of Philosophy.

College of Public Health, Medical and Veterinary Sciences
Division of Tropical Health and Medicine
James Cook University, Townsville, Queensland, AUSTRALIA 4811

Townsville, May 2017

Statement of access

I, the undersigned, the author of this thesis, understand that James Cook University will make this thesis available for use within the University Library and, via the Australian Digital Theses network (unless granted an exemption), for use elsewhere.

I understand that, as an unpublished work, a thesis has significant protection under the Copyright Act and;

I do not wish to place any further restriction on access to this work.

12th May 2017

Denise Turner date

Statement of sources

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education.

Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

12th May 2017

Denise Turner date

Electronic copy

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of the technology available

12th May 2017

Denise Turner date

Ethics declaration

The research presented and reported in this thesis was conducted in accordance with the National Statement on Ethical Conduct in Human Research, 2007. Ethical clearance was obtained from The James Cook University Human Research Ethics Committee, The Department of Education and Training, and Catholic Education. Specific ethics approval details are provided in each chapter.

12th May 2017

Denise Turner date

Acknowledgements and dedication

I would like to sincerely thank Dr Simone Harrison, Dr Madeleine Nowak and Dr Petra Buettner for their support, advice, feedback, understanding and patience during my candidature.

I would also like to acknowledge and thank the research assistants (Hilla Cohen, Michelle Sinclair and Vincent Mantio) who were employed at the JCU SCRU during 2010-2015 for their assistance with data collection and school bookings, particularly during the school shade study. I also thank Nicole Bates for her assistance with data collection while she was completing her Masters project.

I dedicate this work to my husband Aaron and children, Logan and Ivy.

Abstract

Background

Skin cancers, including both melanoma and keratinocyte carcinomas, are the most common cancers diagnosed in Australia. Solar ultraviolet radiation, sunlight, is a skin carcinogen. Geographical regions of north Queensland (Australia) are exposed to high levels of solar ultraviolet radiation year-round. For Caucasian populations, excessive exposure to solar ultraviolet radiation, especially during the childhood years, can result in sunburn and increase melanocytic naevi development. Naevi are a risk factor for melanoma and have been identified as precursor lesions in up to 60% of melanoma cases. Therefore excessive sun-exposure during the childhood years can increase naevi development and lifetime melanoma risk. The risk of developing melanoma may be especially high for individuals with numerous naevi, a history of painful blistering sunburns during childhood, fair skin (Fitzpatrick skin type I or II), fair hair colour and light eye colour. The risk of developing keratinocyte carcinoma, for example basal cell carcinoma, is linked with both intermittent and excessive sun-exposure, particularly excessive exposure that resulted in sunburn during childhood. School children should be encouraged to use multiple methods of sun-protection, including hats and shade, when outdoors at school to reduce excessive exposure to ultraviolet radiation.

The sun-protection policies of north Queensland primary schools and the sun-protective practices used by children and their adult role-models (including parents and school staff) at these schools are not regularly monitored and reported. Also, these school communities are not required to measure and report the amount of shade available at their school for children to use when they are outdoors. At the commencement of this thesis the comprehensiveness of north Queensland primary school sun-protection policies and how well these school communities followed through with sun-safety guidelines had not been documented. A remote (off-site) method to accurately measure shade at schools was also unavailable.

The aims of this thesis were to address the following research questions.

1) How comprehensive are the sun-protection policies at north Queensland primary schools in the geographical regions of Townsville (latitude 19.3˚S, longitude 146.8˚E), Cairns (latitude 16.87˚S, longitude 145.75˚E) and the Atherton Tablelands (Atherton: latitude 17.26˚S, longitude 145.48˚E) (study 1)?

2) What body surface area is covered by regulation school uniforms at primary schools in Townsville, Cairns and the Atherton Tablelands (study 2)?
3) Can a method to remotely measure shade availability at schools be developed (study 3)?
4) What proportions of Townsville primary school students and their adult-role models wear a hat to school before, during and after school hours (study 4)?
5) What proportions of Townsville primary school student spectators wear a hat and wear a shirt at inter-school swimming carnivals (study 5)?

Methodology

Participants: All north Queensland schools catering for primary school aged students (generally 5-12 year olds) from Townsville, Cairns and the Atherton Tablelands were included in studies 1 and 2 while a sample of these schools were included in studies 3 to 5. For studies 4 and 5, schools were included if they were located within a 15 km radius of Townsville's Central Business District, had at least 60 students enrolled in 2008, and predominantly educated 'day' students (not exclusively boarding schools).

Education Queensland school directory lists were used to identify eligible schools in Townsville, Cairns and the Atherton Tablelands. The SunSmart status of each school was verified through email contact with the Cancer Council Queensland since the SunSmart school program is a sun-protection campaign of the Australian Cancer Council. School characteristics (for example, school ownership, school location and student enrolment figures) were obtained from the Education Queensland website. The Australian 'My School' website was used to retrieve the 'Index of community socio-educational advantage' values and student enrolment figures for schools not listed on the Education Queensland website (non-government owned schools).

Study designs: Studies 1 and 2 were cross-sectional studies. The comprehensiveness of north Queensland primary school sun-protection policies and the body surface area covered by regulation school uniforms of these schools were assessed using publicly available school sun-protection policies and uniform documents respectively. Sun-protection policies were independently reviewed using the minimum inclusion criteria outlined in the Cancer Council's 'guide to being SunSmart' resource (study 1). A maximum score of 12 was possible and the total score determined policy comprehensiveness. Pre-determined body region percentages were used to calculate the body surface area covered by regulation uniforms (study 2). The maximum possible body surface area was 93.4% since the head region was excluded from calculations.

Study 3 was a method comparison study of two shade measurement methods. WebShade®, a shade-planning computer software, was used to measure shade at a sample of north Queensland primary schools using the on-site shade-audit method provided by the WebShade® developers. The shade-audit method required data collection at schools including building dimensions and tree heights to measure shade. WebShade® was then used to estimate shade availability at schools using a remote shade-estimation method which we had developed in conjunction with WebShade®. The remote method used a series of pre-defined height values in place of on-site data collection to measure shade. Statistics of concordance were used to assess the agreement between values calculated for 11am and 1:30pm on the 1st of December, March, June and September, respectively, using the on-site shade-audit and remote shade-estimation methods.

Studies 4 and 5 were observational studies. The proportions of students and adult role-models wearing hats were observed at Townsville primary schools (study 4). Hat use was observed before, during and after school hours. The type of hat worn by students was classified as 'gold standard hat' (broad-brimmed, legionnaire or bucket style hats) or 'other hat' (for example, cap or visor style). The proportions of student spectators wearing hats (any hat type) and wearing shirts (swim-shirts/t-shirts) were observed at inter-primary-school swimming carnivals held in Townsville (study 5).

Results

Study 1: Sun-protection policies for 112 of 116 schools (96.6% participation rate) were evaluated. Although policies of Cancer Council accredited SunSmart schools addressed more environmental, curriculum and review-related criteria than those of non-SunSmart schools, the overall median score for both groups was low at 2 from a possible 12 (SunSmart schools: [Inter-quartile range (IQR): 2.0, 9.0], and non-SunSmart schools: [IQR:2.0, 3.0], p=0.008). Most policies included a 'no hat, no play' rule (that is, a rule that students are not permitted to play outdoors without a hat on). Criteria related to shade provision at outdoor events, regular policy review and using the policy to plan outdoor events were poorly addressed by most schools. No relationships were found between sun-protection policy scores and socio-economic status, school size, school locality or region.

Study 2: Uniform policies for 114 of 116 schools (98.3% participation rate) were evaluated. The average total body surface area covered by uniforms (overall 62.4% (standard deviation (SD): 1.8%) was found to be influenced by school grouping variables, such as school ownership and socio-educational status, however the differences in terms of skin coverage were small. For example, the uniforms of non-government schools covered more skin than those of government schools (63.2% (SD: 2.7%) and 62.0% (SD: 1.0%), respectively, $p<0.001$) and the uniforms of socio-educationally advantaged schools covered more skin than those of socio-educationally disadvantaged schools (62.8% (SD: 2.7%) and 62.3% (SD: 1.4%), respectively, $p<0.001$). SunSmart and non-SunSmart school uniforms covered identical total body surface proportions (62.4% (SD: 1.6%) and 62.4% (SD: 2.2%), respectively, $p=0.084$).

Study 3: Shade-related data were compared for 22 of 27 schools (81.5% participation rate). Shade-related values calculated using the remote shade-estimation method (off-site) were usually lower than the values calculated using the shade-audit method (on-site). The average differences between shade-audit values and remote shade-estimation values were 1.3% (SD: 7.6%) for natural shade, 3.7% (SD: 4.7%) for built shade and 5.1% (SD: 6.6%) for combined shade (that is, natural shade plus built shade) for 11am 1st December values. Agreement between natural, built and combined shade-related data were poor (Lin's concordance correlation coefficient (CCC) values all below 0.90). Agreement between the remote shade-estimation and shade-audit methods was poorest for built shade. For example, built shade CCC values for 11am 1st December ranged from -0.35 (95% CI: -0.70 to 0.14) to 0.01 (95% confidence interval (CI): -0.25 to 0.26).

Study 4: Observations were based on 36 of 46 schools (78.3% participation rate). Overall, a median of 52.2% (IQR: 45.4%, 59.8%) of 28,775 students and 47.9% (IQR: 38.1%, 58.2%) of 2,954 adults were observed wearing any type of hat. A median of 22.5% (IQR: 16.8%, 33.4%), 23.4% (IQR: 15.0%, 34.6%) and 92.9% (IQR: 84.9%, 95.6%) students were observed wearing hats (any styles) before, after and during school hours, respectively. Proportions of students observed to wear hats (any style and gold-standard hat styles) at school before, after and during school hours were similar at

SunSmart and non-SunSmart schools. More students from non-government owned schools than government owned schools were usually observed wearing hats, including gold-standard hats, however the differences were not consistently significant. Most adults at SunSmart and non-SunSmart schools wore hats (any styles) during school hours (88.8% (IQR: 62.5%, 100.0%) and 80.6% (IQR: 41.7%, 94.4%), respectively, p=0.169). However fewer adults at SunSmart schools wore hats before school than adults at non-SunSmart schools (3.7% (IQR: 0.5%, 7.7%) Vs 10.2% (IQR: 5.3%, 17.1%), respectively, p=0.035). The proportions of adults who wore hats before, during and after school hours were not found to be significantly influenced by other school characteristics, including school ownership and total sun-protection policy score, considered.

Study 5: Observations were based on students from 41 of 46 schools (89.1% participation rate). Overall, a median of 30.7% (IQR: 13.2%, 46.7%) student spectators were observed wearing a hat and 77.3% (IQR: 70.0%, 85.9%) were observed wearing a shirt. Students from non-government schools were twice as likely as students from government schools to wear a hat (41% (IQR: 30.3%, 57.9%) and 18.2% (IQR: 9.8%, 37.9%), respectively, p=0.003). More students from SunSmart than non-SunSmart schools wore hats (36.3% (IQR: 13.0%, 48.8%) and 23.6% (IQR: 12.3%, 37.1%), respectively) however this difference was not significant (p=0.422). Neither the hat nor the shirt-wearing behaviours of student spectators were significantly influenced by their school's size (number of students), socio-educational advantage or the total sun-protection policy score.

Implications

The results of study 1 revealed that most primary schools in north Queensland have written sun-protection policies, however the comprehensiveness of these policies could be improved. These school communities may require support and advice to develop and implement sun-protection policies.

The results of study 2 showed that most school uniforms assessed could be modified to include longer shirt, sleeve, and pant hem lengths so that more of the body is covered by clothing. Protecting children's skin from over-exposure to ultraviolet radiation might reduce naevi development during childhood therefore sun-protective school uniforms should be worn by primary school students when outdoors.

The results of study 3 revealed that measuring shade at schools can be laborious. Future studies are needed to develop an improved remote shade-estimation method which might include contacting school communities to determine the dimensions of school buildings and trees as well as the locations of school boundaries. An improved remote shade-estimation method should be evaluated against the shade-audit method, or a gold-standard method for measuring shade when it becomes available.

The results of study 4 showed that hats are under-utilised by students and their adult role-models (including school staff and parents) when they are outdoors at school, especially before and after school hours. Children and adults, particularly parents accompanying their child to and from school, might require regular reminders to wear their hats. SunSmart status was not found to be a consistent predictor of higher student or adult hat-wearing proportions despite the ‘no hat, no play’ rule being a key element of the SunSmart school program.

The results of study 5 revealed that hats are under-utilised by student spectators at swimming carnivals. More student spectators could be encouraged to wear both hats and shirts since a single form of sun-protection will not protect an individual from both direct and indirect ultraviolet radiation at swimming events. For example, a hat alone will not protect students from both overhead sun-exposure (direct) and ultraviolet radiation which has been reflected off water surfaces and into seating areas (indirect).

Recommendations

- Investigate the SunSmart school application and renewal process since SunSmart status was not a consistent predictor of improved sun-protection policies and sun-protective behaviours.
- Use qualitative research methods, for example focus groups, to investigate why sun-protection policies at schools were under-developed.
- Work with school communities to develop their sun-protection policies, possibly by ensuring they have access to suitable sun-safety resources and incentives (for example, a reward scheme) to develop and implement thorough policies.

- Encourage school communities to use their updated (comprehensive) sun-protection policies when planning outdoor activities at school (for example, outdoor physical activity classes) and at school related events (for example, swimming carnivals).
- Investigate the practicalities of introducing a sun-protective school uniform at north Queensland primary schools. This might involve using qualitative research methods, such as focus group discussions, to investigate if school communities would be willing to introduce a sun-safe uniform and if parents would be willing to purchase a sun-safe uniform.
- Design a sun-protective school uniform (for example, garments constructed with very high ultraviolet protection factor rated materials which include longer sleeve and pant hem lengths).
- Continue to observe and report the sun-protective behaviours of north Queensland primary school students and their adult role-models at schools and at school sport events.
- Introduce and evaluate a school-based sun-protection program that includes regular unannounced observations of sun-protective behaviours and rewards school communities that demonstrate a commitment to sun-safety.
- Design an improved remote method for measuring shade at schools based on the data and knowledge accumulated during this thesis.
- Evaluate the agreement of the improved remote shade-estimation method against established methods of measuring shade.

List of abbreviations

AI – associate investigator

ARPANSA – Australian Radiation Protection and Nuclear Safety Agency

BCC – basal cell carcinoma

BSA – body surface area

CC – Cancer Council

CCC – concordance correlation coefficient

CI – confidence interval

CI – chief investigator

CM – cutaneous melanoma

EQ – Education Queensland

Gov – government

GSH – gold-standard hats

Hrs - hours

ICSEA – index of community socio-educational advantage

IQR – inter-quartile range

MN – melanocytic naevi

NMSC – non-melanocytic skin cancer

NSSS – non-SunSmart school

NQ – North Queensland

PF – protection factor

RS – remote shade-estimation

SA – shade-audit

SCC – squamous cell carcinoma

SD – standard deviation

SPF – sun protection factor

SSS – SunSmart school

UPF – ultraviolet protection factor

UV – ultraviolet

UVI – ultraviolet index

UVR – ultraviolet radiation

List of people relevant to this body of work

1. Denise Turner (nee Trapp): candidate.
2. Dr Simone Harrison: Research fellow in JCU Skin Cancer Research Group (JCU-SCRG)
3. Jane Nikles: Casual research fellow in JCU-SCRG Aug 2011 - Dec 2013.
4. Hilla Cohen: Casual research assistant in JCU-SCRG Feb 2013 - Dec 2015.
5. Vincent Mantio: Casual research assistant in JCU-SCRG June 2011- Dec 2012.
6. Michelle Sinclair: Casual research assistant in JCU-SCRG Nov 2010 - Dec 2012.
7. John Greenwood: WebShade® software developer and research collaborator.
8. Harry Greenwood: Employee of WebShade® who was also employed as a casual research assistant position with JCU-SCRG from March-Dec 2013 inclusive.
9. Nicole Bates: PhD student (College of Public Health, Medical and Veterinary Sciences).
10. Nathan Downs: JCU Adjunct Research Fellow.
11. Kendra Kamlitz: Senior medical student from University of North Dakota who completed a month of unpaid work experience in JCU-SCRG in May 2010.

Publications and presentations resulting from doctoral studies

Published manuscripts in chronological order.

1: **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "Does being a “SunSmart School” influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure." Preventive Medicine 60: 107-114.

2: **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). “School sun-protection policies – does being SunSmart make a difference?” Health Education Research 29 (3): 367-377.

3: **Turner, D.** and Harrison, S. L. (2014). “Sun protection provided by regulation school uniforms in Australian schools: an opportunity to improve personal sun protection during childhood.” Photochemistry and Photobiology 90 (6): 1439-1445.

4: **Turner, D.,** Harrison, S. L., and Bates, N. (2016). “Sun-protective behaviors of student spectators at inter-school swimming carnivals in a tropical region of high ambient solar ultraviolet radiation." Frontiers in Public Health. 4: 168. doi 10.3389/fpubh.2016.00168.

Published abstracts in chronological order.

5: **Trapp, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "An evaluation of the sun protective practices of Townsville primary school students." Annals of the ACTM 11 (2): 51-52.

6: Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and Nowak, M. (2013). "An evaluation of sun protection policies in Queensland primary schools" Annals of the ACTM 14 (1): 26.

7: Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and Nowak, M. (2013). "An evaluation of body surface area covered by school uniforms in Queensland primary schools." Annals of the ACTM 14 (1): 26.

8: **Turner, D**., Bates, N., and Harrison, S (2015). "Sun-protective behaviours of primary school students at swimming carnivals in Townsville." Annals of the ACTM 16 (2): 18.

Conference presentations.

1: **Trapp, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "An evaluation of the sun protective practices of Townsville primary school students." 100 Years of tropical medicine conference. Australian Institute of Medical Scientists. Townsville, Australia.

2: **Trapp, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "Baseline data on sun protection practices in North Queensland primary schools." Under the Queensland sun symposium. Brisbane, Australia.

Contribution statement

Project Proposal

Harrison developed the original concept for this research project. I worked with Harrison to develop the research proposal into a doctoral project.

Ethics Clearances

Harrison and I obtained ethical approval from all relevant bodies for the initial behavioural observations and shade estimations at schools in Townsville, Cairns and the Atherton Tablelands. Harrison, Nikles, Downs and Bates obtained ethic approvals for similar research to be conducted at schools in other regions (e.g. Mackay, Brisbane etc) and extended the study approval period to allow continuation of the project. The following ethics reference numbers applied to the studies presented in this thesis: James Cook University ethical approval numbers 3365 and H5279; Education Queensland ethical approval reference 11/54273; and Catholic Education ethical approval reference letter dated the 9th June 2011. Ethics approval documents can be found in Appendix 1.

Grants awarded to support this research

Harrison, Nikles and I applied for funding from numerous organisations to provide project funds (including casual salaries for the research support staff [listed above] who contributed to this research project and related projects conducted over a greater geographical area). Harrison drafted the majority of the successful funding applications mentioned below.

Successful funding:

Investigators	**Proposal title**	**Funding body**	**Funding period**	**Amount ($)**
Project funding:				
S Harrison, J Nikles.	School sun-protection intervention pilot in Townsville	Alf and Winifred Murgatroyd Perpetual Charitable Trust	August 2013 – no end date	~1,446 p.a.

S Harrison, J Nikles, M Nowak, P Buettner, D Turner.	Implementation and evaluation of a comprehensive program to improve sun-protection practices of Townsville primary schools	Rotary Club of Thuringowa	June 2013-Dec 2015	15,000
CIs: S Harrison, R Franklin, A Swinbourne, P Leggat. AIs: H Cohen.	Research support to facilitate multiple collaborative environmental health projects of particular relevance to tropical Australia.	Department of Education, Employment and Workplace Relations (Research Infrastructure Block Grants)	June – Dec 2013	15,000
CIs: S Harrison, J Nikles, A Swinbourne, R Spark, M Nowak. AIs: C Grace, V Mantio, D Turner, H Cohen.	Shared Research Support For Three Projects Using Digital And Satellite Technology To Facilitate The Expansion Of Translational Research In Rural Far North Queensland (FNQ)	Department of Education, Employment and Workplace Relations (Research Infrastructure Block Grants)	July – Dec 2012	12,500

S Harrison, D Turner, M Nowak, R Spark, V Mantio, J Greenwood, M Sinclair.	Support to assist the Skin Cancer Research Group to expand its skin cancer prevention research activities to include far NQ (Cairns, Atherton Tablelands and surrounding districts)	James Cook University (Research Infrastructure Block Grants)	July – Dec 2011	21,511
S Harrison, D Turner, M Nowak, P Buettner.	A multi-component sun protection pilot Intervention program for schools	Queensland Health	July 2010-June 2013	90,000
Dedicated salary support:				
S Harrison, M Nowak.	Three Year Step-Down Funding For Skin Cancer Research Group To Assist Cancer Research In NQ	Queensland Health step down funding	July 2011-June 2014	130,428
S Harrison, P Buttner, A Moise, B Raasch, T Woolley, M Nowak.	Cancer research in Tropical Australia, with an emphasis on skin cancer.	The Parkes Bequest, James Cook University	2010 - present	$3,200 salary support for M Nowak p.a.

Sinclair, Mantio, Nikles, Greenwood, Cohen and I received some salary support from these project grants at various times between 2010 and 2015. Harrison received some salary support from the step-down funding allocated by Queensland Health to JCU-SCRG. Sydney based shade software developers (Director and Principal Architect: John Greenwood and WebShade® consultant: Harry Greenwood) were paid for providing assistance with WebShade® data entry and assessment so I would be blinded to the WebShade® shade-audit method data.

Establishment and refinement of data collection methods

Study 1) A cross-sectional study of the comprehensiveness of primary school sun-protection policies: I (100%) developed the sun-protection policy evaluation methodology using techniques described by Reeder, Jopson et al (2009) and the policy criteria found in the Cancer Council's guide to being SunSmart resources.

Study 2) A cross-sectional study of the BSA covered by regulation uniforms at primary schools within the Townsville, Cairns and the Atherton Tableland regions: Harrison (100%) developed body maps (body images with pre-defined percentages for each body area) during her doctoral studies and these were used to establish the body surface area calculations. Harrison (10%), Kamlitz (45%) and I (45%) piloted and refined Harrison's method before all uniforms for the sample were assessed by me (100%).

Study 3) A methods comparison study. A remote, off-site, approach to shade-estimation was developed and tested at a convenience sample of north Queensland primary schools:

- WebShade® shade-audit method: The shade-audit method was developed by John Greenwood.
- Remote shade-estimation method: Initially, Harrison developed the concept of a remote shade estimation tool which could be used to monitor shade at school over time. Harrison and I then worked together to establish the goals of a remote shade-estimation method and discussed the practicalities of obtaining sufficient detail remotely (off-site) with John Greenwood. Harry Greenwood used on-site data to provide me with average height values for built structures and trees. I incorporated these values along with the advice provided by John Greenwood to develop the remote shade-estimation methodology.

Study 4) An observational study of the proportions of students and adult-role models who wore hats at Townsville primary schools: Harrison (85%) developed and piloted the hat-use observation methodology prior to me commencing this doctoral project. I (15%) further refined the methods used.

Study 5) An observational study of the proportions of student spectators at Townsville inter-primary-school swimming carnivals who hats and shirts: Harrison (90%) developed the hat-use and shirt-use observation methodologies prior to me commencing this doctoral project. I (10%) further refined the methods used.

Data collection

Study 1) School sun-protection policies: Sinclair (30%), Cohen (5%) and I (65%).

Study 2) Regulation school uniforms: Kamlitz was initially involved with collecting a sample of school uniform policies and piloting a method established by Harrison and I to estimate the proportion of the body covered by school uniforms. School uniform policies for all schools were then collected by Sinclair (25%), Kamlitz (5%) and I (70%) and assessed by me (100%).

Study 3) Shade estimation:

Shade-audit method - Sinclair (85%), Harrison (10%) and I (5%) contacted schools and arranged for Harrison (30%) and Mantio (70%) to enter school property and collect on-site measurements.

Remote assessment – was conducted by me (100%).

Study 4) Hat wearing observational data: Harrison (10%), Sinclair (10%) and I (80%).

Study 5) Sun-protective behaviours at Townsville inter-school swimming carnivals:

2009: Harrison (50%) and I (50%)

2010: Me (100%)

2011: Me (100%)

2015: Bates (100%)

Data entry into SPSS

Study 1) School sun-protection policies: Me (100%).

Study 2) Regulation school uniforms: Me (100%).

Study 3) Shade estimation:

Shade-audit - Harry Greenwood (90%) and Mantio (10%)

Remote - Me (100%).

Study 4) Hat wearing observational data: Harrison (10%) and I (90%).

Study 5) Sun-protective behaviours at sporting events: Cohen (10%), Bates (10%) and I (80%).

Data analysis

I analysed all data for first-author manuscripts and study 3. Harrison and her colleagues at the JCU-SCRG provided advice regarding statistical approach and data handling.

Manuscript preparation

I drafted manuscripts listed 1 through 4 along with published abstract number 5. These drafts were reviewed by Harrison for primary comment and sent to co-authors for critique. Remaining abstracts were drafted by Harrison, Nikles and Bates.

Manuscript submission

I submitted manuscripts numbered 1, 2 and 4. Harrison submitted manuscript number 3 since I was on maternity leave, checking email correspondence infrequently.

Media interviews

I presented data related to the body surface area covered by regulation school uniforms via ABC radio (Townsville) while Harrison presented data via local and national television (including ABC3 "Behind The News") in addition to local, regional, national and international print media.

Candidate's contribution to manuscripts and presentations

Chapter number	Details of publication on which chapter is based	Nature of contribution to manuscript
3	**Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "School sun-protection policies – does being SunSmart make a difference?" <u>Health Education Research</u> 29 (3): 367-377.	1. Harrison developed the research question. I analysed the data, developed the tables and wrote the first draft of the paper which was revised with editorial input from Buettner and Nowak. I submitted the manuscript.
4	**Turner, D.** and Harrison, S. L. (2014). "Sun protection provided by regulation school uniforms in Australian schools: an opportunity to improve personal sun protection during childhood." <u>Photochemistry and Photobiology</u> 90 (6): 1439-1445.	1. Harrison developed the research question. I analysed the data, developed the tables and wrote the first draft of the paper which was revised with editorial input from Harrison and her colleague. Harrison submitted the manuscript.
6	**Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure." <u>Preventive Medicine</u> 60: 107-114.	1. Harrison developed the research question. I analysed the data, developed the tables and wrote the first draft of the paper which was revised with editorial input from Buettner and Nowak. I submitted the manuscript.
7	**Turner, D.,** Harrison, S. L., and Bates, N. "Sun-protective behaviors of student spectators	1. Harrison developed the research question. I analysed the data, developed the tables and drafted the

	at inter-school swimming carnivals in a tropical region of high ambient solar ultraviolet radiation." Frontiers in Public Health. 4: 168. doi 10.3389/fpubh.2016.00168.	manuscript. Harrison and Bates provided editorial input. I submitted the manuscript.
Appendix 3	1. **Trapp, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "An evaluation of the sun protective practices of Townsville primary school students." Annals of the ACTM 11 (2): 51-51. 2. Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and Nowak, M. (2013). "An evaluation of sun protection policies in Queensland primary schools" Annals of the ACTM 14 (1): 26. 3. Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and	1. Refers to a published abstract and presentation. I analysed the data, prepared the tables and wrote the first draft of the abstract which was revised with editorial input from Harrison, Nowak and Buettner. I presented the data at the '100 Years of tropical medicine' conference; Townsville. 2. Refers to a published abstract and poster presentation. I trained Cohen to evaluate sun-protection policies using the methods described in chapter 3. Cohen collected policy data for primary schools throughout Queensland for analysis by Harrison and Nikles. Harrison and Nikles drafted the abstract with editorial input from Nowak. Nikles designed a poster for presentation at both the 'Townsville Health Research Week' symposium, Townsville, and the 'Global Controversies and Advances in Skin Cancer' conference, Brisbane. 3. Refers to a published abstract and poster presentation. I trained Cohen to

	Nowak, M. (2013). "An evaluation of body surface area covered by school uniforms in Queensland primary schools." Annals of the ACTM 14 (1): 26.	evaluate body surface area using the methods described in chapter 4. Cohen collected uniform data for primary schools throughout Queensland for analysis by Harrison and Nikles. Harrison and Nikles drafted the abstract with editorial input from Nowak. Nikles designed a poster for presentation at both the 'Medicine Symposium', Townsville, and 'Global Controversies and Advances in Skin Cancer' conference, Brisbane.
	4. **Turner, D**., Bates, N., and Harrison, S (2015). "Sun-protective behaviours of primary school students at swimming carnivals in Townsville." Annals of the ACTM 16 (2): 18.	4. Refers to a published abstract and presentation. Harrison and Bates drafted the abstract using data collected by all authors and analysed by me. Bates presented the research at 'Townsville Health Research Week' symposium, Townsville

I confirm the candidate's contribution to the papers listed above and consent to the inclusion of the paper in this thesis:

Name	Signature	Date
Simone Harrison		12 July 2016
Madeleine Nowak		12 July 2016
Petra Buettner		8 July 2016
Jane Nikles		28 July 2016
Hilla Cohen		26 July 2016
Nicole Bates		29 July 2016

Table of content

Content	Page
Statement of access	i
Statement of sources	ii
Electronic copy	iii
Ethics declaration	iv
Acknowledgements and dedication	v
Abstract	1
List of abbreviations	8
List of people relevant to this body of work	9
Publications and presentations resulting from doctoral studies	9
Contribution statement	11
Table of content	21
List of appendices	27
Chapter 1 Introduction	28
1.1 Study location	28
1.2 Setting	30
1.3 Rationale	30
1.3.1 Skin cancer epidemiology	30
1.3.2 Aetiology of skin cancer	31
1.3.3 Sun-exposure at schools	32
1.3.4 Sun-protection at schools	32
1.4 Purpose and aims of the thesis	33
1.5 List of references	36
Chapter 2 Background	42
2.1 An introduction to skin cancer	42
2.2 Skin cancer incidence rates and treatment costs in Australia	42
2.2.1 Melanoma	42
2.2.2 Keratinocyte carcinoma	43
2.3 The development of skin cancer: individual characteristics and sun-exposure behaviour	45

2.4 Solar ultraviolet radiation and the development of skin cancer **45**
2.5 Naevi and skin cancer development **46**
2.5.1 An introduction to naevi **46**
2.5.2 Solar UVR and naevi development **46**
2.5.3 The relationship between naevi and skin cancer prevention **47**
2.6 Sunscreen: MN and skin cancer prevention **48**
2.6.1 Sunscreen and MN prevention **48**
2.6.2 Sunscreen and skin cancer prevention **49**
2.7 The childhood years: role of sun-protection in the school environment **50**
2.7.1 Adult role-models at school **51**
2.8 Review of previously introduced and evaluated school sun-protection interventions **51**
2.8.1 The SunSmart school program (Australia) **53**
2.8.2 The KidSkin study (Australia) **55**
2.8.3 The 'Real Cool School' study (Australia) **58**
2.8.4 The SunWise program (America) **60**
2.8.5 The Sun protection of Florida's children study (America) **63**
2.8.6 The skin protection for kids program (America) **64**
2.8.7 The SoleSi SoleNo-GISED project (Italy) **65**
2.8.8 Living with the sun (France) **67**
2.8.9 Sunny days, healthy ways (America) **68**
2.8.10 The SolSano program (Spain) **68**
2.9 Summary **75**
2.10 Introduction to following chapter **75**
2.11 List of references **75**
Chapter 3 Study 1: A cross-sectional study of the comprehensiveness of primary school sun-protection policies **87**
3.1 Introduction **87**
3.2 Development of the research question **88**
3.3 Publication arising from study 1 **88**
3.4 Summary and future directions **100**
3.5 Introduction to following chapter **101**
3.6 List of references **101**

Chapter 4 Study 2: A cross-sectional study of the proportion of the body covered by regulation uniforms at primary schools within the Townsville, Cairns and the Atherton Tableland regions **104**
4.1 Introduction **104**
4.2 Australian clothing standard **104**
4.3 Development of the research question **105**
4.4 Publication arising from study 2 **106**
4.5 Additional data from study 2 **114**
4.6 Summary and future directions **114**
4.7 Introduction to following chapter **114**
4.8 List of references **115**
Chapter 5 Study 3: A methods comparison study of two shade-estimation methodologies **118**
5.1 Introduction **118**
5.1.1 The value of shade in the school environment **118**
5.1.2 Australian primary school shade requirement **119**
5.1.3 Previously reported attempts to quantify shade availability at schools **120**
5.1.4 Current shade estimation method for Australian schools **121**
5.1.5 WebShade® shade planning software **121**
5.2 Development of the research question and study design **126**
5.3 Methods **126**
5.3.1 Ethics statement **126**
5.3.2 Study population **126**
5.3.2.1 School descriptive information **127**
5.3.3 Potential effect-modifiers considered during study 3 **127**
5.3.3.1 The proportion of built structures which were single-storey **128**
5.3.3.2 The proportion of classroom buildings which were single-storey **128**
5.3.3.3 The total usable land area **129**
5.3.3.4 The proportion of the school area that was green-space **129**
5.3.4 Shade-audit (SA) methodology **129**
5.3.4.1 School boundary and unusable areas **130**
5.3.4.2 Built shade sources **130**
5.3.4.3 Natural shade sources **132**

5.3.4.4 WebShade® shade-related data calculations **132**
5.3.5 The development of the remote shade-estimation (RS) method **133**
5.3.6 Remote shade-estimation (RS) method **133**
5.3.6.1 School boundary and unusable areas **133**
5.3.6.2 Built shade sources **134**
5.3.6.3 Natural shade sources **134**
5.3.6.4 WebShade® shade-related data calculations **135**
5.3.7 Statistical methods **135**
5.3.7.1 Statistical comparison of the RS data against the SA data **135**
5.4 Results **136**
5.4.1 Study population **137**
5.4.2 Shade-related data for 11am, 1st December **139**
5.4.2.1 All schools considered together as one group **142**
5.4.2.2 Schools grouped according to 'the proportion of built structures that were single-storey' **149**
5.4.2.3 Schools grouped according to 'the proportion of classroom buildings that were single-storey' **152**
5.4.2.4 Schools grouped according to 'the size of their total usable area' **155**
5.4.2.5 Schools grouped according to their amount of green-space **158**
5.4.3 Additional shade-related data calculated for 11am and 1:30pm **161**
5.5 Discussion **170**
5.5.1 Summary of study 3 **170**
5.5.2 Use of shade-related data generated during study 3 **173**
5.5.3 Potential errors introduced by the RS method **173**
5.5.3.1 Natural shade calculations **174**
5.5.3.2 Built shade calculations **175**
5.5.3.3 WebShade® data entry **175**
5.5.4 Potential errors introduced by the SA method **176**
5.5.4.1 Data collection **176**
5.5.4.2 WebShade® data entry **176**
5.5.5 Study strength and limitations **176**
5.5.6 Future directions **177**
5.5.6.1 Collaborate with schools **178**

5.5.6.2 Shade-estimation software **178**
5.5.6.3 School images **179**
5.5.7 The potential value of a remote shade-estimation method **179**
5.5.8 Conclusion **180**
5.6 Introduction to the following chapter **181**
5.7 List of references **181**
Chapter 6 Study 4: An observational study of the proportions of students and adult-role models who wore their hat at Townsville primary schools **186**
6.1 Introduction **186**
6.2 Adult role-models **187**
6.3 Development of the research question **187**
6.4 Publications arising from study 4 **188**
6.5 Additional data from study 4 **197**
6.6 Summary and future directions **197**
6.7 Introduction to following chapter **198**
6.8 List of references **199**
Chapter 7 Study 5: An observational study of the proportions of student spectators who wore a hat and/or a shirt at Townsville inter-primary-school swimming carnivals **202**
7.1 Introduction **202**
7.2 Development of the research question **203**
7.3 Publications arising from study 5 **203**
7.4 Summary and future directions **215**
7.5 Introduction to following chapter **216**
7.6 List of references **216**
Chapter 8 Conclusions, future directions and recommendations **218**
8.1 Summary of studies presented in thesis **223**
8.2 Future directions **223**
8.2.1 Study designs **223**
8.2.2 School socio-educational advantage **224**
8.2.3 School size **225**
8.2.4 School ownership **225**
8.2.5 SunSmart status **226**

8.2.6 Sun-protection interventions **226**
8.3 Recommendations **228**
8.4 List of references **229**
Appendices **234**

List of appendices

Appendix	Page number
Appendix 1. Ethics approval documentation.	**234**
Appendix 2. Permission to include published materials in this thesis.	**243**
Appendix 3. Published abstracts.	**257**
Appendix 4. Additional uniform-related data from study 2.	**262**
Appendix 5.1. WebShade® fieldwork sheets.	**266**
Appendix 5.2. Scatter plots and Bland-Altman plots used during study 3.	**274**
Appendix 5.3. Additional shade-related data from study 3.	**324**
Appendix 6. Additional hat-use at school- related data from study 4.	**331**

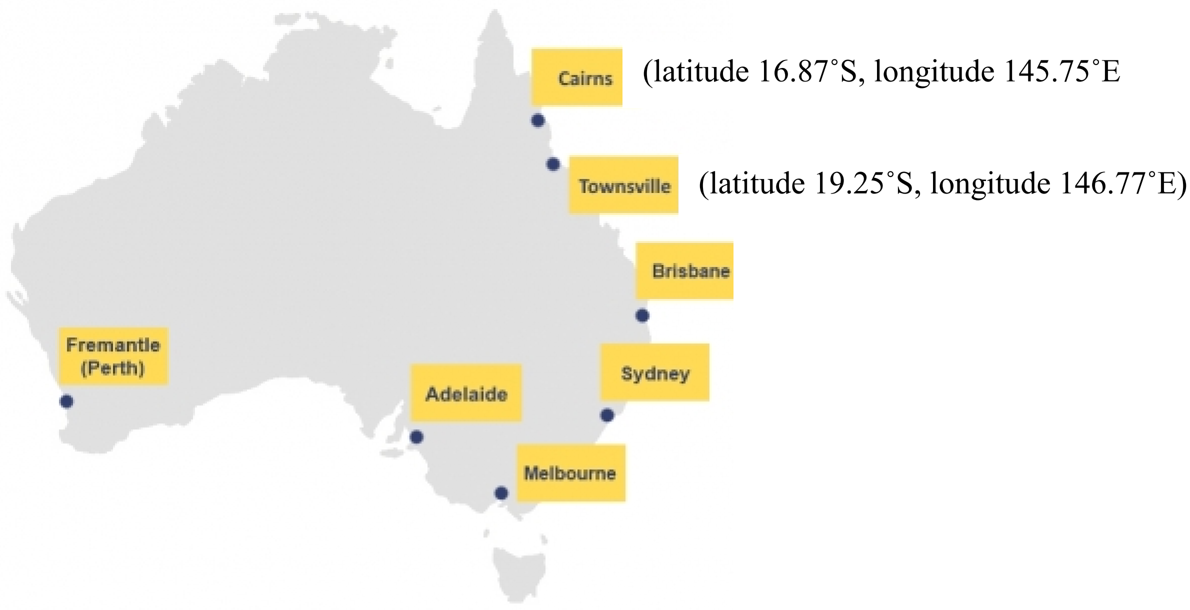
Chapter 1
Introduction

During my candidature, five studies were completed to evaluate the comprehensiveness of school sun-protection policies (study 1), investigate the body surface area covered by school uniforms (study 2), investigate if shade availability at schools could be measured without entering school property (study 3), estimate the proportion of students and their adult role-models that wear hats at school (study 4), and estimate the proportion of students that wear hats and or shirts at inter-school swimming carnivals (study 5). The purpose of chapter 1 is to describe the study location, study setting, the rationale for completing the studies included in this thesis, and the purpose and aims of this thesis.

1.1 Study location

The studies for this thesis were conducted in the north-eastern region of Queensland (latitudes 16.87˚S to 19.25˚S, longitudes 145.48˚E to 146.77˚E), which is located in the north east of Australia. The regional city of Townsville (latitude 19.25˚S, longitude 146.77˚E), the regional city of Cairns (latitude 16.87˚S, longitude 145.75˚E) and the townships located within the Atherton Tablelands region (Atherton: latitude 17.26˚S, longitude 145.48˚E) are associated with hot, humid summers and dry winters [1, 2]. Figure 1 provides an illustration of the position of the Townsville and Cairns in relation to Australia. The townships located within the Atherton Tablelands region are approximately 50km south-west of Cairns, along 'the Great Dividing Range'.

Figure 1. Illustration of the location of Townsville and Cairns in Australia



The cities of Townsville (latitude 19.25˚S, longitude 146.77˚E) and Cairns (latitude 16.87˚S, longitude 145.75˚E) are located on the east coast of north Queensland, Australia approximately 365km apart (Figure 1).

Ultraviolet radiation (UVR) is a form of energy that is produced by the sun [3]. The ultraviolet index (UVI) provides an indication of the strength of UVR that has reached the surface of the earth, at a particular place and time [4, 5]. The use of sun-protection is recommended by Australian health regulatory bodies when the UVI is three or greater [3-5]. In Townsville, the daily peak UVI is at least high (categorised by a UVI of 6 - 7.9) year-round [6, 7] (Table 1).

Table 1. Average ultraviolet index (UVI) for Townsville, 2016, for summer, autumn, winter and spring.

Season	Average ultraviolet index (UVI)
Summer	13
Autumn	9
Winter	7
Spring	11

In Townsville, during summer 2016, the average UVI was calculated to be 13 while it was calculated to be 7 during winter for the same year [8] (Table 1).

1.2 Setting

Approximately 236,000 people, most of whom are of Caucasian ancestry, reside in Townsville [9, 10]. Townsville has been described as Australia's largest garrison city [11]. Army personnel and their families represent approximately 10% of the Townsville population [11]. The Townsville campus of James Cook University educates approximately 11,500 students and more than 1,000 of these live on campus [12]. Approximately 6.4% of the working population of Townsville are employed in the mining sector (compared to 2.6% of the entire working population of Queensland who are employed in this sector) [13]. Approximately 7% of the working population of Townsville are employed in the construction industry while 4% are employed in the agriculture, forestry and fishing industries [13]. Accordingly, a considerable proportion of the Townsville workforce may encounter outdoor sun-exposure during their daily occupational duties.

A sample of primary schools in the regions of Townsville, Cairns and the Atherton Tablelands were included in studies 1, 2 and 3 presented in this thesis. For studies 4 and 5, Townsville schools were included if they educated primary school aged students (generally 5-12 years old), were located within a 15km radius of Townsville's Central Business District, had at least 60 students enrolled in 2008 and predominantly educated 'day' students (not exclusively boarding schools). The sampling criteria for studies 4 and 5 were different than studies 1, 2 and 3 because we did not have enough time or financial resources to directly observe sun-protective behaviours at all schools in all study regions.

1.3 Rationale

1.3.1 Skin cancer epidemiology

Melanoma and keratinocyte carcinoma such as basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) are Australia's most common and costly cancers [14-17]. In 2012, the Australian melanoma incidence rate was eleven times higher than the global average rate (35 cases per 100,000 inhabitants versus 3 cases per 100,000 inhabitants) and was second only to that of New Zealand (36 cases per 100,000 inhabitants) [15]. In 2016, it was estimated that since 1982, the estimated age-standardised incidence rate of melanoma in Australia had almost doubled to 49 cases per 100,000 inhabitants [15, 18]. Within Australia, the incidence of invasive melanoma is particularly high among Queenslanders with rates of up to 67 cases per 100,000 inhabitants reported for Townsville in 1996 [15, 19, 20].

Apart from Tasmania (latitude 40 to 44˚S, longitude 144 to 149˚E), an island with less than 1% of the total land mass of Australia situated off the south-eastern coast, keratinocyte carcinomas are not registrable cancers in Australia, therefore, incidence rates are difficult to quantify. The most recent keratinocyte carcinoma data presented by the Australian Institute of Health and Welfare are the 2002 data of Staples and colleagues (2006). In 2002, the Australian age-standardised incidence rate of BCC was estimated to be 884 cases per 100,000 inhabitants and the age-standardised incidence rate of SCC was estimated to be 387 cases per 100,000 inhabitants [18, 21]. In Townsville, in 1996, the age-standardised incidence rates of SCC were estimated to be 1,075.7 per 100,000 men and 517.7 per 100,000 women while for BCC they were 2,058 per 100,000 men and 1,194 per 100,000 women [19, 22]. It has been estimated that keratinocyte carcinoma will affect two-thirds of the Australian population in their lifetime [21].

Melanoma and keratinocyte carcinoma are considerable burdens to the Australian health care system [18]. Annually, the Australian government spends an estimated $367 million on treatment for keratinocyte carcinoma and $49.5 million on treatment for melanoma [18, 23, 24]. The number of keratinocyte carcinoma-related treatment medical claims submitted to the Australian health care system ‘Medicare’, increased from approximately 412,000 in 1997 to more than 767,000 in 2010 [25].

1.3.2 Aetiology of skin cancer

Over-exposure to solar UVR is the main causative agent of skin carcinogenesis [26-28]. keratinocyte carcinomas predominantly develop on chronically sun-exposed areas of the body [29, 30]. SCC development is causatively linked with accumulated lifetime sun-exposure [30-32]. Both excessive and intermittent sun-exposure, particularly excessive exposures which resulted in painful and blistering sunburn during childhood, are established risk factors for BCC development [30, 32-34].

It has been established that accumulated sun-exposure during the childhood years can lead to the proliferation of melanocytic naevi (MN) for Caucasian populations [35, 36]. For Caucasian individuals, the presence of numerous MN may be linked with both SCC development [32] and BCC development [34, 37, 38]. Naevi have been identified as precursor lesions in approximately 20-60% of melanoma cases [39, 40]. The presence of many MN, along with a fair skin colour (Fitzpatrick skin type I or II [41]), are important risk factors for melanoma development [42-46].

Children raised in geographical regions associated with high levels of ambient UVR, such as Townsville, develop more MN earlier in life than their peers [35, 47-49]. Consequently, sun-protection during the early years plays a pivotal role in reducing MN proliferation and therefore could also reduce lifetime melanoma risk and the overall risk of skin cancer.

1.3.3 Sun-exposure at schools

In Australia, children are typically at school during peak UVR exposure periods (the period of the day that the UVI is greater than 3 [50]) and they may spend prolonged periods outside for meal breaks and outdoor classes such as physical education [51]. When the UVI is very high (≥ 8), a fair-skinned individual, such as a primary school aged Caucasian child, can exceed their recommended daily UVR exposure dose in less than ten minutes if they are without sun-protection [52]. The Australian Cancer Council recommends that all individuals, including adults and children, use multiple methods of sun-protection to reduce excessive exposure to UVR [53, 54]. The Australian Cancer Council's slip (on sun-protective clothing), slop (on sunscreen), slap (on a broad-brimmed hat), seek (shade) and slide (on sunglasses) message [54] is especially pertinent for predominantly Caucasian populations that reside in northern Queensland.

1.3.4 Sun-protection at schools

The Australian Cancer Council introduced their SunSmart School program in the late 1980s to advocate the value of good sun-protective policies and behaviours at Australian primary schools [55, 56]. Australian primary schools that voluntarily apply for registration with the Australian Cancer Council's SunSmart school program are required to develop a comprehensive sun-protection policy for their school and to submit this policy to their state or territory's Cancer Council for approval [55-58]. Every Queensland government owned primary school (public school) is also expected to formulate and implement a sun-safety strategy for their school [59].

A comprehensive school sun-protection policy should stipulate that: students wear a hat when they are outdoors; students wear clothing (for example, a school uniform) that covers a substantial proportion of the body while at school; sunscreen is provided by schools for student and staff use; parents and school staff are requested to act as role-models by following the recommended sun-protection measures; students are encouraged to seek shade when they are outdoors; students are expected to wear sun-protective clothing at outdoor sporting events such as swimming carnivals and shade availability is considered when these outdoor events are planned; schools have sufficient shade or are working towards improving their shade availability; sun-protection education is incorporated into the school curriculum; sun-protection is reinforced via school assemblies/newsletters; outdoor activities are limited during peak UVR periods where possible to reduce excessive sun-exposure; and the school is responsible for regularly reviewing their sun-protection policy [55, 56, 58, 60, 61].

1.4 Purpose and aims of the thesis

The purpose of this thesis was to evaluate the sun-protection policies and sun-protective practices in place at north Queensland primary schools and to investigate the influence of school characteristics, such as SunSmart status, on these policies and practices. Additionally, as seeking shade is an important component of desirable sun-protective behaviour at schools, and measuring shade can be a time consuming and laborious activity, a comparison of two shade-estimation methods was undertaken. The use of sunscreen was intentionally not investigated in this thesis because it is difficult to observe sunscreen use inconspicuously, it is impossible to always be present when it is applied, timing of sunscreen application is important, and it has been suggested that sunscreen is often inadequately applied by children [62]. A short review of the sunscreen related literature supporting the reasons for omitting sunscreen studies from this thesis can be found in Chapter 2.

The aims of this thesis were to address five research questions.

1) How comprehensive are the sun-protection policies at north Queensland primary schools in the geographical regions of Townsville (latitude 19.3˚S, longitude 146.8˚E), Cairns (latitude 16.87˚S, longitude 145.75˚E) and The Atherton Tablelands (Atherton: latitude 17.26˚S, longitude 145.48˚E)?
2) What body surface area is covered by regulation school uniforms at primary schools in Townsville, Cairns and the Atherton Tablelands?
3) Can a method to remotely measure shade availability in schools be developed?
4) What proportions of Townsville primary school students, and their adult-role models, wear a hat to school in the morning (as they enter school property, immediately prior to school commencement time), during school hours (during recess periods) and at school dismissal time (as individuals exit the school property)?
5) What proportions of Townsville primary school student spectators wear a hat and wear a shirt at inter-school swimming carnivals?

The research questions were addressed in the following studies (Chapters 3 to 7) of this thesis:

Study 1) A cross-sectional study of the comprehensiveness of primary school sun-protection policies. Written sun-protection policies of primary schools located at Townsville, Cairns and the Atherton Tableland regions were assessed and the influence of school characteristics such as school ownership (independently or government owned), SunSmart status, the number of students enrolled and index of community socio-educational advantage (ICSEA) score on policy comprehensiveness were evaluated (Chapter 3).

Publications:

- **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "School sun-protection policies – does being SunSmart make a difference?" Health Education Research 29 (3): 367-377.

Study 2) A cross-sectional study of the body surface area (BSA) covered by regulation uniforms at primary schools within the Townsville, Cairns and the Atherton Tableland regions. The maximum BSA which could be covered by school uniforms was determined and then the BSA covered by school uniforms was calculated and compared to this value. Schools were grouped according to characteristics to investigate any potential influence of these characteristics over the BSA covered by school uniforms (Chapter 4).

Publications:

- **Turner, D.** and Harrison, S. L. (2014). “Sun protection provided by regulation school uniforms in Australian schools: an opportunity to improve personal sun protection during childhood.” Photochemistry and Photobiology 90 (6): 1439-1445.

Study 3) A methods comparison study of two shade-estimation methodologies. A remote, off-site, approach to shade-estimation was developed and tested at a sample of north Queensland primary schools. Data obtained this way (i.e. off-site) were compared to those obtained using the WebShade® shade-audit method (i.e. on-site) method at the same schools (Chapter 5).

Study 4) An observational study of the proportions of students and adult-role models who wore a hat at Townsville primary schools. The proportions of students and adults who wore hats at school commencement time, during school hours and at school dismissal time were compared overall and at schools grouped according to school characteristics (Chapter 6).

Publications:

- **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "Does being a “SunSmart School” influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure." Preventive Medicine 60: 107-114.
- **Trapp*, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). “An evaluation of the sun protective practices of Townsville primary school students.” Annals of the ACTM 11 (2): 51-52.

Presentations:

- **Trapp*, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). “An evaluation of the sun protective practices of Townsville primary school students.” 100 Years of tropical medicine conference. Australian Institute of Medical Scientists. Townsville, Australia.

- **Trapp*, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "Baseline data on sun protection practices in North Queensland primary schools." Under the Queensland sun symposium. Brisbane, Australia.

***Turner (nee Trapp)**

Study 5) An observational study of the proportions of student spectators at Townsville inter-primary-school swimming carnivals who wore a hat and/or a shirt. The proportion of these students who wore a hat and/or a shirt was compared overall and at schools grouped according to school characteristics (Chapter 7).

Publications:

- **Turner, D.,** Harrison, S. L., and Bates, N. (2016). "Sun-protective behaviors of student spectators at inter-school swimming carnivals in a tropical region of high ambient solar ultraviolet radiation." Frontiers in Public Health. 4: 168. doi 10.3389/fpubh.2016.00168.
- **Turner, D**., Bates, N., and Harrison, S (2015). "Sun-protective behaviours of primary school students at swimming carnivals in Townsville." Annals of the ACTM 16 (2): 18.

1.5 List of references

1. Bureau of Meteorology. *Climate of Townsville*. 2015 11 June 2015]; Available from: http://www.bom.gov.au/qld/townsville/climate_Townsville.shtml.
2. Bureau of Meteorology. *Climate of Cairns*. 2016 10/09/2016]; Available from: http://www.bom.gov.au/qld/cairns/climate.shtml.
3. Cancer Council New South Wales. *What is Ultraviolet radiation (UV) radiation and the SunSmart UV alert?* 2016 04/09/16]; Available from: http://www.cancercouncil.com.au/23856/cancer-prevention/sun-protection/sunsmart-program-for-primary-schools-and-ohsc/sunsmart-information-and-news/what-is-uv-radiation/.
4. Bureau of Meteorology. *About the UV index*. 2016 17/09/2016]; Available from: http://www.bom.gov.au/uv/about_uv_index.shtml.
5. Cancer Council Australia. *UV alert*. 2016 27 June 2016]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/uv-alert/.

6. Bureau of Meteorology. *Townsville, Queensland. Daily weather observations*. 2011 May 2009 to June 2011]; Available from: http://reg.bom.gov.au/climate/dwo/IDCJDW4128.latest.shtml.
7. Australian Radiation Protection and Nuclear Safety Agency. *Townsville realtime UV index data*. 2011 May 2009 to June 2015]; http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm]. Available from: http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm.
8. Australian Radiation Protection and Nuclear Safety Agency. *UV index data*. 2017 10/04/2017]; Available from: http://www.arpansa.gov.au/uvindex.
9. Townsville Enterprise. *Economic snapshot*. 2016 10/09/2016]; Available from: http://www.movetotownsville.com.au/economic-snapshot.
10. Austalian Bureau of Statistics. *Townsville (SA4)*. 2016 16/09/2016]; Available from: http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=318&dataset=ABS_REGIONAL_ASGS&geoconcept=REGION&datasetASGS=ABS_REGIONAL_ASGS&datasetLGA=ABS_REGIONAL_LGA&regionLGA=REGION&regionASGS=REGION.
11. Townsville Enterprise. *Defence*. 2016 10/09/2016]; Available from: http://www.movetotownsville.com.au/employment-education-and-health/defence.
12. James Cook University. *Townsville*. 2016 10/09/2016]; Available from: https://www.jcu.edu.au/about-jcu/campuses/townsville.
13. Queensland Treasury. *Queensland Regaional Profiles: Workforce Profile for Townsville and North West region, Queensland*. 2016 11/09/2016]; Available from: http://rdanwq.org.au/files/regional-profiles/workforce-profile_160209.pdf.
14. Australian Institute of Health and Welfare, *Health system expenditures on cancer and other neoplasms in Australia, 2000-2001*. 2005, Australian Institute of Health and Welfare: Canberra.
15. Australian Institute of Health and Welfare, *Cancer in Australia: an overview 2014*. 2014, Australian Institute of Health and Welfare: Canberra.
16. Australian Institute of Health and Welfare and Cancer Australia, *Non-melanoma skin cancer: general practice consultations, hospitalisation and mortality*. 2008: Canberra.

17. Australian Institute of Health and Welfare & Australasian Association of Cancer Registries, *Cancer in Australia: an overview*. 2012, Australian Institute of Health and Welfare: Canberra.
18. Australian Institute of Health and Welfare, *Skin cancer in Australia*. 2016, Australian Institute of Health and Welfare: Canberra, Australia.
19. Buettner, P.G. and B.A. Raasch, *Erratum in: Buettner PG, Raash BA. Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 2001. **93**(2): p. 302-303.
20. Buettner, P.G. and R. MacLennan, *Geographical variation of incidence of cutaneous melanoma in Queensland.* Aust J Rural Health, 2008. **16**(5): p. 269-277.
21. Staples, M.P., et al., *Non-melanoma skin cancer in Australia: the 2002 national survey and trends since 1985.* Med J Austr, 2006. **184**: p. 6-10.
22. Buettner, P.G. and B.A. Raasch, *Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 1998. **78**(5): p. 587-593.
23. Australian Institute of Health and Welfare, *Health system expenditures on cancer and other neoplasms in Australia, 2000-01*. 2005, Australian Institute of Health and Welfare: Canberra.
24. Cancer Australia, *Cancer Australia submission to Inquiry into skin cancer in Australia*. 2014, Australian Government: Australia.
25. Fransen, M., et al., *Non-melanoma skin cancer in Australia.* Med J Austr, 2012. **197**: p. 565-568.
26. Bauer, J. and C. Garbe, *Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data.* Pigm Cell Res, 2003. **16**(3): p. 297-306.
27. Holman, C.D. and B.K. Armstrong, *Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: an analysis separating histogenetic types.* J Natl Cancer Inst, 1984. **73**(1): p. 75-82.
28. Shain, A.H., et al., *The genetic evolution of melanoma from precursor lesions.* N Engl J Med, 2015. **373**: p. 1926-1936.
29. Marks, R., G. Rennie, and T.S. Selwood, *Malignant transformation of solar keratoses to squamous cell carcinoma.* Lancet, 1988. **1**(8589): p. 795-797.
30. Madan, V., J.T. Lear, and R.-M. Szeimies, *Non-melanoma skin cancer.* Lancet, 2010. **375**: p. 673-685.

31. English, D.R., et al., *Case-control study of sun exposure and squamous cell carcinoma of the skin.* Int J Cancer, 1998. **77**(3): p. 347-353.
32. Iannacone, M.R., et al., *Patterns and timing of sunlight exposure and risk of basal cell and squamous cell carcinomas of the skin - a case-control study.* BMC Cancer, 2012. **12**: p. 417-428.
33. Kricker, A., et al., *Does intermittent sun exposure cause basal cell carcinoma? A case-control study in Western Australia.* Int J Cancer, 1995. **60**: p. 489-494.
34. van Dam, R.M., et al., *Risk factors for basal cell carcinoma of the skin in men: results from the health professionals follow-up study.* Am J Epidemiol, 1998. **150**(5): p. 459-468.
35. Fritschi, L., et al., *Naevi in schoolchildren in Scotland and Australia.* Br J Dermatol, 1994. **130**(5): p. 599-603.
36. Autier, P., et al., *Sunscreen use, wearing clothes, and number of nevi in 6- to 7-year-old European children.* J Natl Cancer Inst, 1998. **90**(24): p. 1873-1880.
37. Kricker, A., et al., *Pigmentary and cutaneous risk factors for non-melanocytic skin cancer - a case-control study.* Int J Cancer, 1991. **48**(5): p. 650-662.
38. Khalesi, M., et al., *A meta-analysis of pigmentary characteristics, sun sensitivity, freckling and melanocytic nevi and risk of basal cell carcinoma of the skin.* Cancer Epidemiol, 2013. **37**(5): p. 534-543.
39. Sagebiel, R.W., *Melanocytic nevi in histologic association with primary cutaneous melanoma of superficial spreading and nodular types: effect of tumor thickness.* J Invest Dermatol, 1993. **100**: p. 322S-325S.
40. Skender-Kalnenas, T.M., D.R. English, and P.J. Heenan, *Benign melanocytic lesions: risk markers or precursors of cutaneous melanoma?* J Am Acad Dermatol, 1995. **33**(6): p. 1000-1007.
41. Fitzpatrick, T.B., *The validity and practicality of sun reactive skin types I through VI.* Arch Dermatol, 1988. **124**: p. 869-871.
42. Clark, W.H., et al., *A study of tumor progression: The precursor lesions of superficial spreading and nodular melanoma.* Hum Pathol, 1984. **15**(12): p. 1147-1165.
43. Green, A.C., R. MacLennan, and V. Siskind, *Common acquired naevi and the risk of malignant melanoma.* Int J Cancer, 1985. **35**(3): p. 297-300.
44. Swerdlow, A.J., et al., *Benign melanocytic naevi as a risk factor for malignant melanoma.* Br Med J, 1986. **292**: p. 1555-1559.

45. Garbe, C., et al., *Risk factors for developing cutaneous melanoma and criteria for identifying persons at risk: multicenter case-control study of the central malignant melanoma registry of the German Dermatological Society.* J Invest Dermatol, 1994. **102**: p. 695-699.
46. English, D.R., E. Milne, and J.A. Simpson, *Sun protection and the development of melanocytic nevi in children.* Cancer Epidemiol Biomarkers Prev, 2005. **14**(12): p. 2873-2876.
47. Kelly, J.W., et al., *Sunlight: a major factor associated with the development of melanocytic naevi in Australian schoolchildren.* J Am Acad Dermatol, 1994. **30**(1): p. 40-48.
48. Harrison, S.L., R.M. MacKie, and R. MacLennan, *Development of melanocytic nevi in the first three years of life.* J Natl Cancer Inst, 2000. **92**(17): p. 1436-1438.
49. Harrison, S.L., et al., *Sun exposure and melanocytic naevi in young Australian children.* Lancet, 1994. **344**(8936): p. 1529-1532.
50. Bureau of Meteorology. *About UV and sun protection times*. 2016 6/11/2016]; Available from: http://www.bom.gov.au/uv/.
51. Moise, A.F., P.G. Buttner, and S.L. Harrison, *Sun exposure at school.* Photochem Photobiol, 1999. **70**(2): p. 269-274.
52. Downs, N.J., A.V. Parisi, and D. Igoe, *Measurements of occupational ultraviolet exposure and the implications of timetabled yard duty for school teachers in Queensland, Australia: Preliminary results.* J Photoch Photobio B, 2014. **131**: p. 84-89.
53. Cancer Council Australia. *Slip Slop Slap Seek Slide*. 2013 06/02/2015]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/campaigns-and-events/slip-slop-slap-seek-slide.html.
54. Cancer Council Victoria. *Slip, slop, slap, seek & slide: Sid Seagull*. SunSmart 2016 10/09/2016]; Available from: http://www.sunsmart.com.au/tools/videos/current-tv-campaigns/slip-slop-slap-seek-slide-sid-seagull.html.
55. Cancer Council Australia. *SunSmart schools and early childhood programs*. 2014 10/02/2015]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/sunsmart-schools/.

56. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group. *Being SunSmart - a guide for primary schools*. 2005; Available from: http://www.sunsmart.com.au.
57. Cancer Council Queensland. *SunSmart policy guidelines*. 2009 07/07/2009]; Available from: http://www.cancerqld.org.au/icms_docs/54253_SunSmart_policy_guidelines.pdf.
58. Cancer Council Queensland. *SunSmart school review form*. 2016 27/06/2016]; Available from: https://cancerqld.org.au/cancer-prevention/understanding-risk/being-sunsmart/national-sunsmart-program/sunsmart-school-review-form/.
59. Department of Education and Training. *Developing a sun safety strategy*. 2015 10/03/2015]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
60. Department of Education Training and Employment. *Sun safety*. 2012 21/08/2013]; Available from: http://education.qld.gov.au/schools/healthy/swimshirts-sunscreen.html.
61. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
62. Diaz, A., et al., *The children and sunscreen study. A crossover trial investigating children's sunscreen applicatin thickness and the influence of age and dispenser type.* Arch Dermatol, 2012. **148**(5): p. 606-612.

Chapter 2
Background

2.1 An introduction to skin cancer

Melanoma and keratinocyte carcinoma, chiefly basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) are Australia's most common and costly cancers [1-3]. Melanoma is the most aggressive form of skin cancer and has emerged as a major public health problem among Caucasian populations world-wide [3-5]. Keratinocyte carcinomas affect more Caucasian people in Australia, the United States of America, Canada and Europe than any other form of cancer [6-14]. BCCs are the most common form of keratinocyte carcinoma and while they do not typically metastasise to other organs BCCs can cause substantial damage to local tissue [15].

2.2 Skin cancer incidence rates and treatment costs in Australia

2.2.1 Melanoma

In 2012, the melanoma incidence rate in Australia was estimated to be 35 cases per 100,000 inhabitants, which was eleven times higher than the average global rate [3]. The age-standardised incidence rate of melanoma in Australia has risen from 27 cases per 100,000 inhabitants in 1982, to an estimated 49 cases per 100,000 inhabitants in 2016 [1, 3]. The estimated age-standardised incidence rate of melanoma has more than doubled for Australian males from 28 cases per 100,000 inhabitants in 1982 to approximately 60 cases per 100,000 inhabitants in 2016 [3]. The age-standardised incidence rate of melanoma for Australian females during the same period has also increased from 26 cases per 100,000 inhabitants (1982) to 39 cases per 100,000 inhabitants (2016) [3]. In Australia, invasive melanoma incidence varies with latitude, and is particularly high among Queenslanders with rates of up to 67 cases per 100,000 reported for Townsville, North Queensland (latitude 19.3˚S, longitude 146.8˚E) [1, 9, 16]. It has been estimated that more than 13,000 new cases of melanoma were diagnosed in Australia during 2016 [3].

Approximately 23,000 hospitalisations in Australia were related to melanoma in 2013-2014 compared to approximately 14,000 in 2002-2003 [3]. More males were hospitalised for reasons related to melanoma diagnoses than females for these time periods [3]. In 2013-2014 there were over 20,000 surgical procedures performed in Australian hospitals for the treatment of melanoma [3]. Approximately 15,500 of these surgical procedures were excisions while the remaining procedures were repairs [3]. Almost 5,000 chemotherapy procedures took place at Australian hospitals for melanoma treatment in 2013-2014 while approximately 2,000 chemotherapy procedures were reported during 2002-2003 [3]. The actual number of chemotherapy procedures performed in Australia might be higher than that reported since chemotherapy for melanoma treatment can be administered to individuals not admitted to public hospitals in New South Wales, South Australia and the Australian Capital Territory [3].

It has been estimated that almost 2,000 Australians died from melanoma in 2016 and this figure accounts for approximately 4% of all estimated cancer-related deaths [3]. In 2016, for Australia, the age-standardised mortality rate of melanoma was estimated to be 9.4 deaths per 100,000 male inhabitants and 3.6 deaths per 100,000 female inhabitants [3].

The most recent Australian government expenditure report which included skin cancer treatment costs presented 2008-2009 data [17]. For 2008-2009, it was estimated that the Australian government spent $49.5 million on melanoma treatment [18].

2.2.2 Keratinocyte carcinoma

Incidence rates of keratinocyte carcinoma in Australia are difficult to quantify since keratinocyte carcinomas are not registrable cancers in any state or territory. The Tasmanian Cancer Registry was an Australian cancer registry that included keratinocyte carcinoma data and more than 100,700 confirmed keratinocyte carcinoma cases were reported to the registry between 1982 and 2005 [19]. However the registry no longer registers common keratinocyte carcinomas, reportedly due to a lack of resources [3]. In 2002, Staples and colleagues surveyed more than 57,000 Australians to measure the incidence of keratinocyte carcinoma treatment for the 12 months preceding the survey date [20]. The most recent 'skin cancer in Australia' report published by the Australian Institute of Health and Welfare (2016) reported keratinocyte carcinoma incidence rates which were calculated using those 2002 study data. Staples and colleagues (2006) reported the Australian age-standardised incidence rate of BCC to be 884 cases per 100,000 inhabitants and the age-standardised incidence rate of SCC to be 387 cases per 100,000 inhabitants. Earlier research used histologically confirmed SCC and BCC cases from Townsville (latitude 19.3˚S, longitude 146.8˚E) patients to calculate the age-standardised incidence rate of SCC to be approximately 1,076 cases per 100,000 male inhabitants and approximately 518 cases per 100,000 female inhabitants [8, 9]. The age-standardised incidence rate of BCC in Townsville was calculated to be approximately 2,058 cases per 100,000 male inhabitants and 1,194 cases per 100,000 female inhabitants [8, 9].

In 2013-2014 more than 114,000 hospitalisations in Australia were related to keratinocyte carcinoma compared to 82,000 hospitalisations during 2002-2003 [3]. During 2013-2014 more than 180,000 surgical excisions and almost 70,000 surgical repair procedures were performed for keratinocyte carcinoma treatment in Australia [3]. In 2002-2003 approximately 134,000 surgical excisions and 44,000 surgical repairs took place in Australia [3]. In Australia, almost 1,600 chemotherapy procedures were performed for keratinocyte carcinoma treatment during 2013-2014 while 960 were performed during 2002-2003 [3]. Since chemotherapy for keratinocyte carcinoma treatment can also be administered to patients not admitted to public hospitals in New South Wales, South Australia and the Australian Capital Territory, the number of patients that received chemotherapy for keratinocyte carcinoma treatment could be higher than that reported [3].

It has been estimated that keratinocyte carcinoma will affect two-thirds of the Australian population in their lifetime [20]. It has also been estimated that keratinocyte carcinomas will account for more hospitalisations in Australia than any other cancer [3, 15]. In 2016 it was estimated that during that year, 560 Australians would die as a result of keratinocyte carcinoma and males would account for two thirds of these deaths [3].

During 2008-2009, the Australian government spent $367 million on treatments related to keratinocyte carcinomas [17]. Treatment for keratinocyte carcinomas for Australians aged between 25 and 64 accounted for $126.19 of the $367 million [17]. Fransen and colleagues assessed Australian Medicare system data which described keratinocyte carcinoma-related treatment costs (for example, keratinocyte carcinoma excision and liquid nitrogen cryotherapy) processed during 1997 to 2010, and estimated the cost of keratinocyte carcinoma-related treatments to the Australian health care system would approximate $700 million by 2015 [21]. In Australia, demand for keratinocyte carcinoma consultations with General Practitioners is increasing, particularly among males [15]. Approximately 950,000 consultations were expected to take place between 2005 and 2007 [15]. To my knowledge, a more recent estimate of keratinocyte carcinoma consultations with General Practitioners is not available.

2.3 The development of skin cancer: individual characteristics and sun-exposure behaviour

For Caucasian populations, fair skin (Fitzpatrick skin type I or II [22]), hair and eye colour are important risk factors for melanoma development [4, 6, 23-28]. Compared to those with dark (brown or black) hair, individuals with fair hair may be more likely to develop skin cancer during their lifetime but the risk may be higher again for those with red hair [26, 29, 30]. Similarly, individuals with light coloured eyes (blue, green or grey) and those with fair skin may be more likely to develop skin cancer than individuals with dark coloured eyes and those with darker skin (Fitzpatrick skin type III and above) [26, 30, 31]. Individuals who have a combination of light skin, fair hair and extensive freckling may fall into a particularly high risk group [26, 29, 30].

Melanoma risk is positively associated with the number of painful, blistering sunburns experienced by an individual prior to age 15 and individuals with a history of five or more sunburns may be particularly at risk [32, 33]. Additionally, a study of melanoma patients in Denmark found that individuals with more than five naevi on their arms who had also experienced at least five sunburns in their childhood were 24 times more likely to develop melanoma than those without naevi who have never been burnt [32]. Intermittent sun-exposure not resulting in sunburn also damages the skin and may increase melanoma risk [34].

Actinic keratoses are skin lesions that result from chronic solar ultraviolet radiation (UVR) exposure [35]. These lesions are common among elderly individuals with fair skin [35, 36]. The results of recent studies have revealed that actinic keratoses may be precursor lesions for SCC and BCC [35, 37].

2.4 Solar ultraviolet radiation and the development of skin cancer

Solar UVR is recognised by the International Agency for Research on Cancer as a skin carcinogen [38]. Accumulated sun-exposure throughout an individual's lifetime may be causatively linked with SCC development [6, 39, 40]. Excessive and intermittent sun-exposures, especially exposures which resulted in painful and blistering sunburns during childhood, have been identified as risk factors for BCC development [6, 40-42]. Keratinocyte carcinomas chiefly appear on chronically sun-exposed body sites such as the face and hands [6, 43, 44].

For Caucasian populations, a causal link between solar UVR exposure, for example intermittent and occupational sun-exposure, and melanoma development has been suggested [45-48]. Additionally, it has been suggested that Caucasian populations who reside closer to the equator, rather than farther away, are more likely to develop melanoma [48]. On the contrary, there is evidence to suggest that for one subtype of melanoma (acral-lentiginous melanoma) which often develops on the palms of the hand, soles of the feet and the nail beds, solar UVR exposure may not be an important risk factor [46, 49].

2.5 Naevi and skin cancer development

2.5.1 An introduction to naevi

Melanocytic naevi (MN) are classified as benign tumours of melanocytes [28]. Melanocytes are skin cells located in the skin, hair and eyes that primarily function to synthesise pigment [28]. MN develop when melanocytes proliferate within the skin layers [23, 28]. The development of common acquired MN (the type of naevi developed by many Caucasians) begins during the childhood years [23-28, 31, 50-54]. The terms atypical naevi and dysplastic naevi are often used interchangeably to describe acquired MN which may mimic the clinical presentation of melanoma [55]. Congenital MN are described as naevi which are present at birth or develop during the newborn stage [28]. The melanocytes of congenital MN usually penetrate deeper into the dermis than the cells of common acquired MN [28].

2.5.2 Solar UVR and naevi development

It has been suggested that solar UVR exposure is causatively linked with MN development [24, 26, 29, 34, 50, 56-61]. For Caucasian populations, excessive sun-exposure during the childhood years may intensify the proliferation of MN [26, 27, 32, 58]. A German study found that, children who holiday at sunny locations or spend more than two hours per day playing outdoors at home were more likely to develop greater numbers of MN than their peers [50]. Also, fair-skinned children may be more likely to develop more MN if they reside in geographical regions associated with high, rather than low, ambient UVR levels [51, 62].

Adults may be more likely to have more MN if naevi development began between birth and their first birthday [63]. A Townsville study found that children who spent approximately four hours per day playing outside developed more MN during their younger years than children who spent less than an hour per day outdoors [58]. Additionally, Harrison and colleagues (1994) found that these MN tended to accumulate on sun-exposed skin.

2.5.3 The relationship between naevi and skin cancer prevention

The presence of many MN may be linked with both SCC development [40] and BCC development [42, 64, 65]. When MN do not differentiate and disappear via normal pathways, they may become melanocytic dysplasia and these potentially advance to melanoma [23, 28, 56]. For Caucasian individuals with many MN, especially MN with irregular edges and colour variations, the risk of developing melanoma during their lifetime might be higher [28, 66].

It has been estimated that acquired naevi may be precursor lesions for approximately 40% of both superficial spreading melanoma cases and nodular melanoma cases [54, 56, 67]. A review of the literature conducted by Farber and colleagues (2012) suggested that while dysplastic naevi may be associated with an increased melanoma risk, the majority of these naevi did not develop into melanoma. On the other hand, an Australian study of 289 melanoma cases suggested that dysplastic naevi were precursor lesions for 56% of the cases [67]. Congenital MN, particularly those which are categorised as large or giant in size, may develop into melanoma [28, 68].

In a large German study, individuals with 50 to 100 common naevi were four times more likely to develop melanoma and the risk was higher again (>7 times) for those with more than 100 naevi [26]. In the same study, the risk of melanoma was increased two fold for those who had a few lentigines (sun spots, liver spots or brown spots) but was increased three fold when many lentigines were present [26]. It was estimated that a Caucasian individual who had 50 or more common naevi, actinic lentigines and five or more atypical naevi was 121 times more likely to develop melanoma [26]. Garbe and colleagues (1994) noted that the melanoma risk may have been different if it was reported for individuals who resided in a different geographical location to Germany that was associated with higher or lower ambient UVR levels.

2.6 Sunscreen: MN and skin cancer prevention

The Australian Cancer Council advocates the use of sunscreen as a valuable method of personal sun-protection [69]. It is recommended that an individual apply sunscreen 15 to 30 minutes before sun-exposure, reapply sunscreen within the first hour of sun-exposure and then regularly reapply sunscreen for the duration of sun-exposure [70-72]. The Australian Cancer Council also recommends that sunscreen with a sun protection factor (SPF) of at least 30 be applied [71, 72]. SPF is a measure of how well and for how long a sunscreen can protect the skin from sunburn [71]. It has been suggested that adults and children do not apply adequate quantities of sunscreen to benefit from the advertised SPF rating [73-76]. In particular, a Queensland study that investigated sunscreen use by Queensland primary school students showed that primary school aged children may apply as little as one quarter of the required amount of sunscreen to achieve the advertised efficacy [73].

2.6.1 Sunscreen and MN prevention

Studies which have investigated the relationship between sunscreen use and MN development have revealed conflicting results [77-83]. For instance, an Israeli study of primary school aged children, most of whom were described to have fair skin, reported that regular sunscreen use was not associated with reduced naevi development for their study population [80]. Azizi and colleagues (2000) retrospectively assessed sun-exposure and sunscreen use among their study population of approximately 970 participants however the researchers did not measure the adequacy of sunscreen application by participants. Lee and colleagues (2005) surmised that regular sunscreen use could reduce the development of MN for fair-skinned individuals. The Canadian study presented by Lee and colleagues (2005) involved the randomisation of 309 fair skinned primary school aged students to either a sunscreen intervention or control group for a three-year period. Students in the intervention group were provided with a SPF 30 sunscreen and instructed how to use it effectively while students in the control group did not receive sunscreen or instructions for sunscreen use [82]. At study completion, the intervention group children had developed fewer naevi on their back than the control group children [82].

2.6.2 Sunscreen and skin cancer prevention

The relationship between sunscreen use and skin cancer development risk may also be considered controversial [77, 78, 81]. The results of a longitudinal trial conducted in Nambour, Australia, during which approximately 1,600 participants, mostly Caucasian, were randomised either to the intervention or control group revealed that regular sunscreen application may have a preventative role for SCC development but not for BCC development [78]. In the study described by van der Pols et al (2006), participants in the intervention group were instructed to apply sunscreen to their head, neck, arms and hands every morning while the participants in the control group were instructed to use sunscreen at their usual frequency [78]. Participants in this study were followed from 1992 to 2000 and full skin checks were conducted by dermatologists in 1992, 1994, 1996 and 2000 [78]. Green and colleagues (2010) investigated the relationship between sunscreen application and melanoma development in the study population that participated in the intervention described by van der Pols (2006). Green and colleagues (2010) reported that more control participants than intervention participants had developed melanoma ten years post-intervention which led the researchers to suggest that regular sunscreen use by adults may have a role for melanoma prevention. However, some medical experts argued that the results presented by Green and colleagues (2010) did not provide sufficient evidence that sunscreen use can prevent melanoma [81]. Goldenhersh and Koslowsky (2011) proposed that a prospective and double-blinded study design was needed to show a cause-effect relationship between sunscreen use and melanoma development.

Summary of sections 2.1 to 2.6

Skin cancers (keratinocyte carcinomas and melanoma) are Australia's most common and costly cancers.

Solar UVR is causatively linked with skin cancer development for Caucasian populations.

Solar UVR, especially during childhood, may increase naevi development for Caucasian populations.

Naevi have been identified as precursor lesions in melanoma cases.

The presence of many naevi along with fair skin, hair and eye colour may increase melanoma risk.

Regular sunscreen may or may not reduce the risk of MN and skin cancer development.

2.7 The childhood years: role of sun-protection in the school environment

Among Caucasian populations, it has been shown that there may be a causative link between excessive sun-exposure during the childhood years and MN development [27, 34, 57, 63, 79, 84-87]. Also, for Caucasian populations, a causal link between the presence of many MN and skin cancer development has been suggested [24, 26, 54, 56, 66, 67, 87, 88]. Accordingly, one might infer that it is important to reduce excessive sun-exposure during the childhood years.

Most Australian primary school aged children attend school five days a week, which accumulates to approximately 200 days per year [89, 90]. Most Queensland primary school lessons commence at approximately 9am and conclude at approximately 3pm [91]. The Australian Cancer Council recommends that individuals use sun-protection when the ultraviolet index (UVI), a measure of ambient UVR levels, is greater than 3 [92, 93]. For geographical regions associated with high ambient UVR levels, such as Townsville, the UVI can be greater than 3 for the majority of a school day [94].

At Queensland schools, individual sun-exposure can be substantial during school hours on a typical day since students and staff may spend prolonged periods outside [95-97]. It has been shown that Queensland school teachers can exceed the daily occupational UVR exposure limit recommended by the International Non-Ionizing Radiation Committee in less than ten minutes on a clear day during Summer and Spring [95, 96]. Accordingly, one could surmise that Queensland school students receive similarly high amounts of UVR whilst at school.

Schools provide an ideal environment for the introduction of sun-protection programs since school hours typically include the peak UVR exposure period of the day and children and staff may spend a considerable amount of time outside for recess breaks and/or physical activity classes [95, 96]. At school, students and their adult role models (for example, school staff members and parents) should be encouraged to wear sun-protective clothing, wear a hat, use sunscreen and seek shade [98, 99].

2.7.1 Adult role-models at school

The behaviours of adults, such as parents and care-givers, might influence the same behaviours of children [100]. For example, adult sports coaches have been shown to facilitate positive changes in the sun-protective behaviours of children in their sporting teams [101]. Similarly, at a pool setting, the sun-protective behaviours of children and adult patrons were shown to improve when lifeguards wore a hat, sun-safe shirt and used shade where possible [102]. Therefore the role of school staff and parents as sun-protective behaviour role-models in the school environment may be important. For example, at school, sun-safety behaviours could be emphasised by teachers during class and then role-modelled by school staff during outdoor activities.

2.8 Review of previously introduced and evaluated school sun-protection interventions

The following discussion presents a review of sun-protection interventions that have been introduced to primary schools in Australia and elsewhere. The following search terms were entered into the James Cook University Library one search database which comprised biomedical literature from MEDLINE, life science journals and online books [103]: ‘primary school’, ‘sun protection intervention’, ‘sun protection’, ‘sun-safety’, and ‘sun safety’. Studies were included if the intervention included only primary school aged children (approximately 5 to 12 years of age) at a primary school setting. Studies were excluded if they were not completed at primary schools (for example, pools, ski areas, work places, pre-schools, high schools etc.) and/or if they did not include primary school children. Only peer-reviewed studies published as journal articles were included (Figure 1).

Figure 1. Flow chart to illustrate the search protocol used to find literature published as journal articles related to sun-protection interventions at primary school settings.

Search terms:

'primary school', 'sun protection intervention', 'sun protection', 'sun-safety', and 'sun safety'

Search dates:

January 1990 to October 2016

248 results (peer-reviewed, full-text journal articles) were found (newspaper articles, newsletters, book reviews, book chapters etc. were excluded) to be potentially related to the search topic.

93 articles were excluded because they described studies which were completed at settings other than primary schools (for example, at pre-schools, high schools, work places etc) and/or because the study participants were not primary school students (for example, high school students, adults at a work place, etc.).

139 articles were excluded because they were reviews or their content was not appropriate for the search terms. For example, articles were excluded if they described a health model and not an intervention completed at a primary school.

16 articles were included in the literature review.

Figure 1 shows that 248 results were displayed when the search terms 'primary school', 'sun protection intervention', 'sun protection', 'sun-safety', and 'sun safety' were entered into the James Cook University one search database. Sixteen articles from these results were included in the literature review of sun-protection interventions introduced to primary school aged children at primary school settings.

2.8.1 The SunSmart school program (Australia)

In 1981, the Australian Cancer Council introduced the now internationally recognised 'Slip, Slop, Slap' sun-safety campaign to encourage Australians to slip on a shirt, slop on some sunscreen and slap on a hat [104]. At a time when melanoma rates were increasing and the causative link between solar UVR exposure and skin cancer development was becoming clearer, this campaign delivered a catchy message designed to improve the sun-safety practices of Australians [104]. The Victorian Cancer Council credits the SunSmart program with positively influencing the public's attitudes towards sun-protection [105]. Specifically, the Cancer Council credits the SunSmart program with encouraging more Australians to wear hats, more parents to purchase sun-safe swim clothing for their children and with reducing the appeal of a sun-tan [105].

In 1988, the Cancer Council established the "SunSmart School (SSS)" program to promote sun-safety in the school environment since sun-exposure during the childhood years had emerged as a risk factor for skin cancer development later in life [106, 107]. SSSs are expected to develop and adhere to the following sun-protection related guidelines (Table 1). Since the SSS program was introduced, it has been suggested that more Australian schools have written sun-protection policies which mention that students are expected to wear broad-brimmed and/or wide brimmed hats when outside and sun-safety education is incorporated into the school curriculum [108, 109].

Table 1. Description of the sun-protection guidelines that school sun-safety policies must address to be accredited as a SunSmart school by the Australian Cancer Council.

Aspect of sun-protection policy	Description of guidelines
Behaviour	1. All staff and students at the school wear a broad brimmed, legionnaire or a bucket style hat (with a deep crown and brim width of at least 6 cm) whenever they are outdoors. 2. Clothing that covers as much skin as possible is provided as part of the school uniform/dress code: for example, midriff and singlet tops are not appropriate. 3. Children are encouraged to use available areas of shade for outdoor activities.

	4. Staff are requested and parents are encouraged to act as role models by following sun-protection measures. 5. The use of SPF 30+ broad-spectrum, water resistant sunscreen is encouraged with time for application allowed.
Environment	6. The school has enough shade or is trying to increase the number of trees and shade structures to provide shady areas in the school grounds. 7. Shade is considered when organising outdoor activities, such as physical education and sports carnivals.
Curriculum	8. Outdoor activities are rescheduled to minimize sun exposure during peak UV times. 9. SunSmart behaviour is regularly reinforced and promoted to the whole school community, for example by newsletters or assemblies. 10. Curriculum information and activities about sun-protection are included in at least three year levels. 11. The sun-protection policy is used when planning all outdoor events: for example, camps, fairs, excursions and sporting events.
Review	12. The school is responsible for regularly reviewing its sun-protection policy. The school will participate in The Cancer Council's regular review process.

Table 1 was adapted from the Cancer Council Australia's 'Being SunSmart – a guide for primary schools' handbook [110].

To my knowledge, Australian SunSmart policies and practices are not objectively assessed despite key stakeholders being present at the 'Advances towards a SunSmart state: sun-protection in schools' workshop highlighting the value of behavioural audits to determine policy compliance [111]. It has also been reported that intermittent monitoring of compliance with SSS policies were planned when the program was developed [109]. Despite this potential shortfall, the SSS program has gained popularity worldwide and many schools and kindergartens in Germany, New Zealand, Spain, South Africa, the United Kingdom and America have adopted the principles of the Australian SSS program [112-117].

2.8.2 The KidSkin study (Australia)

Milne and colleagues developed then trialled the 'KidSkin' intervention at West Australian primary schools (n=33) from 1995-1998 [118-121]. The 'KidSkin' intervention was introduced to year one students and incorporated school and home based education sessions and activities. The key outcome measure of KidSkin was the number of new naevi developed on each child's back post-intervention [120]. Control schools received the usual Western Australian health education curriculum while schools in the 'moderate' and 'high' intervention groups received school and home based activities aimed to discourage excessive sun-exposure during peak UVR periods and to encourage children to use multiple methods of personal sun-protection when outdoors [120]. Chief aims of the KidSkin intervention were to encourage schools to introduce a 'no hat, no play' policy that enforced their students to wear broad brim or legionnaire style hats when they were outside, encourage students to use shade, and encourage schools to improve their shade availability [119, 120]. Children participating in the 'high level' intervention received educational materials throughout their summer holidays and they were offered sun-protective swimwear for purchase at a reduced cost [120].

To my knowledge, the cost of the sun-protective swimwear was not stated nor was an image of the clothing provided. The swimwear was described to cover the trunk, upper arms and thighs therefore it was possibly a t-shirt and pants option (two items of clothing) or an all-in-one swim-suit covering a similar amount of skin. It could be suggested that garment comfort and design are important factors considered by parents when they purchase clothing for their child. For example, a parent may have been less inclined to purchase the sun-protective swimwear that was offered during KidSkin if they did not think that their child would wear the garment. Additionally, it could be suggested that if the 'low-cost' clothing was still more expensive than clothing typically purchased by parents, the garments may not have been bought. No data were provided about the number of these garments purchased.

At baseline, Milne and colleagues (1999) recorded the number of naevi on children's backs, face, arms, chest and abdomen along with the degree of freckling on the face and arms. The baseline measurements were compared to those repeated at the conclusion of the study. When these data were compared, it was found that children in the control group developed more naevi than those who attended schools which received the 'high' or 'moderate' intervention material [122]. However, the differences in naevi counts between the control and intervention groups failed to reach statistical significance [122].

Milne and colleagues (1999) also observed the proportion of teachers and students who wore hats during school recess periods at baseline by reviewing video footage of play areas (which they recorded). The mean proportion of students that were observed to wear hats during recess periods for all schools was reported to be 87%, however only 14% of these children wore gold-standard hat styles (broad-brim, bucket or legionnaire style) [120, 123]. Approximately half of the teachers observed wore broad-brimmed hat styles however almost a third of teachers failed to wear any hats [123].

One might suggest that a potential weakness of the method used by Milne and colleagues (1999) to assess the proportion of children who wore hats might be that all students present in the filmed play area were included in the observation. That is, the KidSkin intervention was introduced to year one students only, however, the use of hats by all students who were outside at the time of filming was reported. While school staff members were not told the exact purpose of the observations, it might be possible that school employees inferred the purpose of filming students at recess. For instance, it is possible that schools were aware that the KidSkin intervention aimed to improve the use of gold-standard hats at school and as a consequence of this knowledge, the teachers may have encouraged the students to wear these hats. However it is likely that the researchers were ethically obliged to inform school staff members of the study purpose because they chose to film students on school property then calculate hat-wearing proportions retrospectively. On the other hand, it could be suggested that the results of this research were strengthened by the use of video footage to calculate the proportions of students and teachers who wore hats since the video footage could have been meticulously viewed to ensure each individual, and the type of hat that they wore, was accounted for.

Milne and colleagues used aerial photographs to estimate shade availability at all schools [123]. The services of a pilot and a photographer were employed to capture the photographs between noon and 1pm [123]. Researchers met with school staff to ascertain the areas available and unavailable for student use on each aerial photograph and marked the areas accordingly [123]. Buildings, trees, under-cover play areas, covered walkways, balconies and school boundaries were identified on these aerial photographs and the proportion of the school area that was shaded was calculated [123]. On average, approximately 15% of a school's usable area was shaded however more shade was available at some older schools, possibly because older schools had more large established trees with broad canopies that provided more shade than younger trees with smaller canopies [123]. One might suggest that the shade calculations presented by Milne and colleagues (1999) represented shade availability for only the time and date that the photographs were taken.

At baseline (1995), during the second year of the intervention (1997) and at the completion of the 'KidSkin' intervention (1999), parents completed questionnaires estimating their child's sun-exposure during the previous summer [118, 122]. For example, parents were asked how many days their child spent at the beach or at an outdoor swimming pool (and how much time was spent there), how much time their children spent outdoors between 8am and 4pm, how much time their child spent playing outdoors at home, how often their child wore a hat, used sunscreen and/or wore clothing that covered the torso, and parents were also asked to describe the type of swim garments, clothing and hats typically worn by their child [118]. At baseline, children in the control and high intervention groups reportedly spent similar amounts of time outdoors during 11am and 2pm [118]. At year two, parental questionnaires revealed that 'high' level intervention children spent considerably less time outdoors from 11am to 2pm compared to children in the control group [118]. However the reported slight changes to the wording of the sun-exposure questions may have accounted for this change [118]. Control group children were reported to be more likely to use multiple methods of sun-protection at baseline compared to their peers from the intervention groups however follow-up questionnaires (year two) revealed improvements in shade and clothing use among the intervention groups [118]. Sun-protective swim-wear styles were favoured by the intervention groups at baseline and at follow-up [118]. Data presented during the follow-up report did not include observational hat-wearing data collected during school recess breaks and instead relied on self-report data. Consequently, measurement bias may have been present (self-report bias, social-desirability bias and recall bias), and this may have resulted in under- or over-reporting.

The positive behavioural changes reported at year two (1997) by the intervention groups were not sustained in the final year of the program (1999) nor were they evident two years post-completion (2001) [121]. While the 'KidSkin' intervention was not credited with sustained improvements in school student's sun-protective behaviours post-intervention, it represents an important study in the history of Australia's school sun-protection interventions since it was, to my knowledge, the first longitudinal sun-protection intervention study completed at Australian schools.

To further improve upon the KidSkin design, it might have been advantageous to have introduced the intervention to the whole school rather than to one year level only. It is plausible that more students and teachers may have complied with the sun-protective behavioural aspects of the KidSkin intervention or may have been more willing to make positive sun-protective behavioural changes if they were actively involved in the intervention. It could be suggested that if a whole school approach was taken, the younger children may have seen the older children (possible role models) wearing their hats outdoors and this may have encouraged the younger children to wear their hats also. However, KidSkin was likely introduced to one year level only because a sizeable increase in resources may have been required to complete the intervention at a whole school level at numerous schools. For instance, Milne and colleagues counted the number of naevi on each year one student and it may not have been feasible to repeat this process for every student if KidSkin was introduced to every year level at numerous schools. It could be suggested that the provision of low-cost sun-protective clothing encouraged schools to participate in the KidSkin intervention. Also, it may be possible that the provision of such clothing resulted in more children having access to sun-protective clothing that they otherwise may not have had access to. One could assume that the clothing option was a costly component of the intervention, however the benefit of the clothing to the students in terms of reduced sun-exposure should not be under-estimated.

2.8.3 The 'Real Cool School' study (Australia)

Real Cool School was another Australian sun-protection initiative and it was piloted at 15 New South Wales primary schools (estimated number of students at these schools: 3,700) from 1997-1998 [124]. Unlike 'KidSkin', this program was introduced on a whole school level however less schools were involved (Real Cool School: n=15 versus KidSkin: n=33). Real Cool School was chiefly designed to encourage schools to formulate comprehensive sun-safety policies and to make environmental changes that increased shade provision at their school [124]. Schools were encouraged to nominate themselves for awards, and prizes of up to $2500 were offered as incentives to participate [124]. To apply for an award, schools were required to meet specific sun-protection policy criteria (such as reschedule outdoor classes to before 10am or after 3pm, regularly remind parents to be sun-safe and include sun-protection education in the curriculum) [124]. The highest monetary award was associated with the most comprehensive policy along with additional commitments from the school to not only improve their policy but also to be proactive in their community regarding sun-safety awareness and behaviour [124]. For example, it was suggested that schools could be proactive in their community if they urged local council to increase shade availability at outdoor events [124]. The program was launched publicly since a key objective of the Real Cool School program was to enhance community awareness of sun-safety.

Fifteen schools participated in the Real Cool School program however it is not stated if more were asked or if this number of schools was chosen for other reasons. For example, these schools may have been invited to participate because they were in a convenient location for study staff to attend. School demographic characteristics were not disclosed therefore it is not known if the 15 schools were representative of other schools in the area. Research staff met with school staff throughout the study period to collect observational data and assess sun-protection policies. Since each sun-protection policy criterion could be met in various ways, research staff noted numerous strategies by which schools could do so and asked open-ended questions to determine if sun-protective policies and associated behaviours had improved [124]. Unlike ‘KidSkin’, behavioural observations were conducted on unannounced days prior to, during and at the completion of the intervention to assess compliance with school sun-protection policies. However, these observational data were not presented by the researchers [124]. Instead, it was intimated that the judges considered the observational data during the award process [124].

Maher and colleagues (2002) recognised the importance of providing support to schools while they developed their sun-protection policies. During the study, a paid project officer worked with school staff and parents to develop sun-safety policies and discussed different aspects of sun-protection. By the completion of the study, the sun-safety policies of all participating schools had improved, most schools had either planted trees or built shade structures to increase shade availability and most schools had rescheduled outdoor activities to avoid peak UVR exposure periods [124]. KidSkin and Real Cool School ran concurrently while the latter was piloted however the geographical distance between the two studies (approximately 3,300 km) likely resulted in little interference. It is unknown if Real Cool School progressed past the pilot phase since additional reports were not found.

2.8.4 The SunWise program (America)

SunWise was the first sun-safety program introduced at American schools (that cater for students in kindergarten through to grade eight), and it is now coordinated by the National Environmental Education Foundation [125, 126]. Introduced in 1999, SunWise promotes the necessity of effective personal sun-protection methods and aims to improve environmental awareness of solar UVR among children [126]. Schools, individual classes, recreation groups, education organisations and childcare providers can participate in the SunWise program if they agree to do at least one of the following: adopt cross-curricular classroom lessons; measure and report UV information on the internet; enhance school infrastructure (make changes to school policy or sun-protection structures); engage with the community; or promote school-wide sun-safety activities [126, 127]. Participating schools/classes/groups etc. are given educational resources and a UVR sensitive frisbee to encourage sun-safe physical fitness [126]. However since care providers need only agree to do one of the activities listed above, it seems that schools can apply to be SunWise without necessarily having a sun-protection policy.

From September 1999 to June 2000, 130 schools participated in the SunWise school program [128]. Schools were given resources to develop classroom lessons that explained the effects of solar UVR, risk factors associated with over-exposure to UVR and sun-protection habits [128]. Teachers were encouraged to incorporate classroom learning with developmentally appropriate activities to further enhance student learning. In 1999, students from 65 randomly chosen schools were asked to complete pre-test surveys before the introduction of the SunWise intervention. At the conclusion of the study period (2000), 40 schools returned post-test surveys which were completed by students. A control group of schools from another school district (n=7 schools) returned student-completed surveys to which the intervention results were compared. Students who completed the questionnaires were aged between five and 12 and almost half of respondents were aged between ten and 12. At intervention schools, the number of students who completed pre-tests was 1,894 and the number that completed post-test surveys was 1,815 [128]. The number of students from control schools that completed surveys was not reported.

An aim of the study presented by Geller and colleagues (2002) was to evaluate the impact of the SunWise program since the number of American schools which were applying to enlist in the program was increasing. The pre-test survey (1999) and post-test survey (2000) included a variety of questions related to sun-safety (for example, UV index knowledge), sun-protection attitudes (for example, sun-tan appeal), sun-protection practices (for example, sunscreen and clothing use) and intended sun-safety practices (for example, intention to use sunscreen) [128]. Surveys collected by Geller and colleagues (2002) indicated that students who received the SunWise intervention were more likely to demonstrate improvements in sun-related knowledge [128]. For intervention children aged between five and 12, their responses to the 'intended sun-safety practices' related questions revealed that they were more likely to know that they should wear a hat and shirt when outdoors, use sunscreen with a sun-protection factor of at least 15, and not associate a sun-tan with being 'healthier' [128]. However, the responses from these same students to the survey questions related to 'practiced sun-protective behaviours' revealed students did not wear sunscreen, a hat or sunglasses more often post-intervention than pre-intervention [128].

It could be suggested that the inclusion of various year levels in the survey component of the study presented by Geller and colleagues (2002) be considered both a strength and a weakness of this study. For example, the completion of the survey by various year levels may have provided responses from a variety of age groups and this could have provided insight of the sun-protective knowledge and intended sun-protective practices for different age groups. However, some questions might have been interpreted differently by younger, compared to older, students therefore responses might have been determined by an individual's understanding of the question. One might suggest that the surveys could have been distributed to the same year level(s) at all schools for consistency. Since it was reported that most schools distributed the survey to two classrooms, it seems plausible that surveys could have been given to the same two year levels at all schools. Another potential study weakness was that Geller and colleagues (2002) relied on self-completed questionnaires to determine sun-protective behaviours. Consequently, measurement bias may have been present (self-report bias, social-desirability bias and recall bias), and this may have resulted in under- or over-reporting.

In 2005, Emmons and colleagues invited 37 schools who had previously received SunWise training to participate in an intervention designed to improve school sun-safety policies [127]. The 28 schools that participated were randomised into three groups [127]. Each group received the standard SunWise materials along with educational resources that exemplified sun-safe behaviours and highlighted the value of sunscreen. Schools in the ‘policy’ group received the revised SunWise toolkit which provided detailed information on how to evaluate and improve their school’s sun-protection policy, hints for educators to help incorporate SunWise lessons into the classroom, templates for letters to parents to encourage sun-safety at school, sample sun-safety newsletters and sample school policies [127]. Schools participating in the highest level of the intervention, the ‘policy plus technical assistance’ group, were provided with three technical assistance telephone calls and follow up letters, which documented the key focus points discussed during these calls, in addition to the resources supplied to the other groups [127]. Health educators from each of these schools completed a baseline survey that detailed the school’s current sun-protection policies, sun-safety curriculum and sun-related practices [127]. Some survey questions specifically asked about SunWise (for example, educators were asked if the school curriculum incorporated SunWise materials), while other questions related to features of the school sun-protection policy and the school environment. Most schools did not enforce sun-protective clothing use by students. It was reported that 82% of schools surveyed said that students were permitted to use such clothing when outside however it was not required [127]. Post-intervention surveys were completed four to five months after baseline, to give educators time to consider using the materials provided to incorporate the SunWise criteria into their sun-protection policies. Most schools reported at least one policy change and schools participating in the highest level of the intervention had made the most changes to their policy [127].

Emmons and colleagues (2008) showed that with appropriate support, school communities were more likely to improve their sun-protection policies. Surveys were self-completed therefore it may have been possible that responders over-reported changes to school sun-protection policies. One might suggest that since only 28 schools participated in this study, the researchers could have collected and subsequently independently evaluated each school's policy before and after the intervention. Doing so would have strengthened the results and potentially informed researchers of how school staff members used the SunWise materials to improve school sun-protection policies.

2.8.5 The Sun protection of Florida's children study (America)

The American 'Sun protection of Florida's children' randomised trial, designed to improve student hat-wearing rates at school and home, was completed between August 2006 and June 2008 [129]. This intervention was delivered to fourth grade students at 22 primary schools (intervention schools: 1,115 students. Control schools: 1,376 students) [129]. Each student at intervention schools was provided with two free wide brimmed hats for school and home use [129]. The program included sun-protection education sessions (one 45-minute introductory session and three 60-minute follow up sessions during which hat-use was particularly emphasised), student questionnaires (which included questions about long-sleeve shirt, hat, sunglasses and sunscreen use) and observations of hat-wearing behaviour at school from "inconspicuous vantage points". At baseline, few students at control and intervention schools wore hats (1.7% and 2.0%, respectively) [129]. With data for autumn and spring being even lower at the control schools (0.3% and 1.1% respectively) [129]. Post-intervention, student hat-wearing rates improved at intervention schools (autumn: 29.5% and spring: 40.5%) [129]. At baseline, 13.5% and 24.3% of control and intervention group students respectively, said they wore hats when outdoors at home [129]. These figures remained similar throughout the study despite intervention students being provided with a hat for home use and the value of hats as personal items of sun-protection being emphasised during the education sessions [129].

The main outcome measure of the study presented by Hunter and colleagues (2010) was hat-use at schools. Hunter and colleagues (2010) stated that research assistants who directly observed hat-use at schools 'chose inconspicuous vantage points to ensure that student and teacher behaviours were not influenced by the measurement process'. However, it is not stated if the observations were conducted at unannounced periods. One could suggest that unannounced observations would have provided realistic estimates of typical hat-use by students. If the school communities were aware of the timing of these observations, the likelihood that individual hat-wearing behaviours were influenced should be considered.

Hunter and colleagues (2010) did not describe the school uniform hat and the intervention hat is only described as 'wide-brimmed'. Thus, it is possible that the intervention hat was different to the school hat. Also, it may be possible that the intervention students were deterred from wearing the intervention hat if it was considered, by them and their peers, to be too different from the school hat (which was still being worn by the other students at their school). Hunter and Colleagues (2010) provided two hats free of charge (one for home and one for school) and these hats were laundered during the school break so the same students could use them when they returned to school. By providing students with two hats to keep, the researchers ensured that children had hats to wear and consequently could comply with the behavioural aspects of the intervention.

2.8.6 The skin protection for kids program (America)

The skin protection for kids intervention included the provision of a toolkit to a primary school (at which 75 students were enrolled) which included resources to increase teacher knowledge of sun-safe behaviour and develop a sun-safe policy [130]. School staff (n=10) participated in a training session that was designed to provide them with the knowledge to teach their students about sun protection and encourage them (the teachers) to make physical and social changes to the school environment that supported sun safety [130]. Teachers were then encouraged to use the intervention toolkit to encourage and sustain effective sun safety behaviours [130]. At baseline and post-intervention (post-training session), teacher skin protection knowledge was evaluated, as was the usefulness of the toolkit [130]. Teachers were encouraged to incorporate sun safety education into the classroom and present the school principal with suggestions to improve skin protection at school [130].

At baseline the skin protection knowledge score for teachers was 56% and this score increased to 88% post-intervention [130]. Researchers noted that the teachers were receptive to the training session and willing to use the intervention toolkit to improve skin protection at school [130]. Most teachers reported that they verbally included sun protection education in the classroom and encouraged their students to seek shaded locations when playing outdoors [130]. Most parents surveyed reported that they were unaware of the sun protective measures used at their child's school, and they thought that a skin protection policy would be advantageous at the school [130]. Post-intervention, teachers suggested that their school's uniform be modified to include long shirt sleeves and long pants, and that hats be optional at recess [130].

The skin protection for kids program results indicated that parents and teachers can be receptive to making positive sun protection behavioural changes at schools. There was a high turnover rate of teaching staff at the participating school therefore not all teachers who were surveyed at baseline were available at follow-up. Future evaluations of this intervention could benefit from the inclusion of more schools and consequently more students to increase statistical power. Teacher and parent surveys were self-completed. Consequently, measurement bias may have been present (self-report bias, social-desirability bias and recall bias), and this may have resulted in under- or over-reporting. The use of long sleeved shirts, long pants and hats was not directly observed or reported by school staff during the intervention period therefore it is not known how many students used these sun-protective items at baseline or post-intervention. Future studies could directly observe student behaviour during recess at school to investigate if the suggestions made to school principals by the teachers were implemented.

2.8.7 The SoleSi SoleNo-GISED project (Italy)

From 2001 to 2004 a cluster-randomised trial was undertaken at 113 Italian primary schools [131]. A total of 3,933 students completed the intervention (2,272 students were in the final intervention group and 1,661 students were in the final control group) [131]. The SoleSi SoleNo-GISED educational intervention included the provision of sun-safety educational materials to parents and students, classroom sun-safety lessons and the presentation of a sun-safety video to children during class [131]. The primary outcomes of this intervention were the prevalence of reported sunburns and the difference in naevi counts at baseline and at follow-up [131]. Parents completed surveys that included questions related to their child's sun-protective behaviours when outdoors (specifically hat, sunscreen and long-sleeved shirt use) and their child's history of sunburn at baseline and post-intervention [131]. Researchers counted the number of naevi on the upper limbs of a randomised sample of intervention and control group children at baseline and at follow-up [131].

At follow-up, no significant differences were found in sunburn history or reported sun-protective behaviours between the intervention and control groups [131]. For both the intervention and the control groups, most parents reported that their child wore a hat sometimes when outdoors post-intervention (intervention group: 42.5% and control group: 43.5%) with fewer parents reporting that their child always wore their hat when outdoors (intervention group: 34.4% and control group: 33.6%) [131]. Post-intervention most parents reported that their child always wore sunscreen when outdoors (intervention group: 74.1% and control group: 72.4%) while 10% of intervention parents and 9.2% of control parents reported that their child occasionally/never wore sunscreen when outside [131]. Children in the intervention group were not found to develop fewer naevi than children in the control group. At baseline the mean number of naevi found on intervention and control group children was 5.1 and the mean number of naevi was 6.8 and 6.4 for the intervention and control groups respectfully post-intervention [131].

It could be suggested that the educational materials used during this intervention be investigated to determine if the intervention could have been more successful with alternative materials. Reported sun-protective behaviours were not remarkable at baseline (for example, 38% of parents reported that their child always wore a hat when outdoors at baseline) therefore it is unlikely that the intervention was not successful because sun-protective behaviours were already exemplary at baseline. The use of self-completed parental surveys may be considered a limitation of this study since parents may have under- or over-reported sun-protective behaviours and sunburn history, or misunderstood the question(s) asked via survey. It would have been advantageous if the researchers directly observed the use of hats and long-sleeved shirts at school rather than relied of parental reports of these behaviours only.

2.8.8 Living with the sun (France)

The living with the sun intervention was introduced to 1,365 students, aged 9-12 years, at French primary schools [132]. The intervention was designed to be introduced by school teachers to their pupils over a three-month period, prior to the commencement of school summer holidays [132]. Principle aims of the living with the sun intervention were to education children about the dangers of excessive exposure to the sun and to encourage students to reduce excessive exposure to UVR by modifying their own behaviours when outdoors [132].

To investigate the effectiveness of the living with the sun intervention, students from 70 classrooms were randomly assigned to either the intervention or the control group [132]. Students in classrooms assigned to the control group did not receive the living with the sun intervention materials which were provided to students from intervention classrooms by their teacher during ten workshops [132]. All participants completed self-completed questionnaires pre-intervention, immediately after the intervention, two months after the summer holiday, and one year after the summer holiday [132]. These questionnaires included questions related to skin type, knowledge of the sun, attitudes towards sun-protection and sun behaviours [132].

Immediately post-intervention and one year post-intervention, students from the intervention classrooms were more likely to receive higher sun knowledge scores than students from control classrooms [132]. Post-intervention, students from the intervention group were also more likely to report that they regularly applied sunscreen when outdoors, wore a hat and used shade than students from the control group [132].

The intervention was completed at school however no observations of student sun-protective behaviours at school were made. Instead, questionnaires completed by students at school were used to investigate sun-protection knowledge, attitudes and behaviours of students. One could suggest that direct observation of sun-protective behaviours of intervention and control group participants at school would have strengthened the results of this study since data collected via self-completed questionnaires can be influenced by measurement bias (such as self-report bias, social-desirability bias and recall bias) which may result in under- or over-reporting. It could be suggested that sun-protective behaviour data collected via direct observation at school could have been used in conjunction with self-completed questionnaires to better investigate the sun-protective behaviours of students while they were at school and while they were away from school during holiday periods.

2.8.9 Sunny days, healthy ways (America)

The sunny days, healthy ways intervention was completed by 871 students at 12 American primary schools [133]. The intervention included an interactive multimedia program which could be used by primary school children aged five to 13 [133]. The computer software was designed to enhance user knowledge of sun-safety and effective sun-protective behaviours [133]. Three study groups of schools were described by Buller and colleagues (2008). Students at the first group of schools used the computer software alone, students at the second group of schools participated in teacher-led classroom activities designed to educate children about sun-safety, while students at the third group of schools used the computer software in conjunction with teacher-led presentations [133].

Pre-test and post-test surveys were completed by students and used to assess participant knowledge of sun-safety and sun-protective behaviours [133]. Post-intervention, sun-safety knowledge was reportedly higher for schools in group 3 compared to groups 1 and 2 [133]. Post-intervention, reported sun-protective behaviours were reported to be improved for younger students from group 3 compared to groups 1 and 2 [133]. Reported sun-protective behaviours were similar for older students for the three study groups [133]. It could be suggested that direct observations of sun-protective behaviours of students at schools would have strengthened the results of this study since self-completed surveys can be influenced by measurement bias such as self-report bias, social-desirability bias and recall bias which may result in under- or over-reporting.

2.8.10 The SolSano program (Spain)

The SolSano program was the first health education program for sun-safety at Spanish primary schools [134]. The SolSano education package included an activity guide for teachers, workbooks for students, an information poster and an information pamphlet for families [134]. In 2005, Gilaberte and colleagues (2008) used a non-randomised before and after trial to evaluate the effectiveness of the SolSano program at increasing student knowledge about the sun and effective sun-protective behaviours. The SolSano education materials were presented to 5,845 year one and two students from 215 primary schools in April 2005 then these students completed a ‘draw and write’ activity and a survey to investigate their usual sun-protective behaviours [134]. For example, students drew pictures of themselves and their families at the beach or other outdoor locations and the researchers noted how many forms of sun-protection, such as shade umbrellas, sunscreen, hats and long-sleeved clothing, were used by children and adults (parents) in the drawing [134]. The survey included questions about demographic characteristics, sun-safety knowledge and sun-protective behaviours [134]. A total score of 22 was possible for each participant, comprising of a maximum of ten points for the draw and write activity and 12 points for the survey [134]. Post-intervention (September 2005, after the summer holiday period), participants completed the draw and write activities and survey again [134]. Pre-test and post-test scores were compared.

While almost 6,000 students participated in the pre-intervention draw and write activity and the survey, 1,522 students completed both the pre- and post-intervention surveys [134]. Post-intervention, more participants were likely to report that they used sun-protection when outdoors since total scores increased from approximately 8 (from 22) to approximately 10 (from 22) [134]. Similar to previously described studies [127, 128, 131-133] the potential influence of measurement bias such as self-report bias, social-desirability bias and recall bias should be considered when interpreting these results.

One might suggest that the use of the draw and write activity was a strength of the study completed by Gilaberte and colleagues (2008) since younger students, such as grade one and two students, were potentially better able to communicate their usual sun-protective behaviours through their drawings than by using self-completed surveys alone. It may have been beneficial to complete additional draw and write activities at different time periods (rather than at pre-test and at one point in time post-test alone) to further investigate the usefulness of the SolSano program at improving reported sun-protective behaviours.

Table 2. Summary of the sun-protection programs and interventions presented in Chapter 2.

First author (year), program/ intervention name	Setting: country, # schools, # participants. Study design	Main outcome measures	Comments related to study strengths (S) and weaknesses (W)
Milne (1999-2005), KidSkin intervention.	West Australia, Australia: 33 primary schools, 1,776 year one students. Intervention study (with a control group).	The number of naevi developed on the back of each child.	(S) Longitudinal study (baseline in 1995, final follow up in 2001). (S) Control group was compared to two levels of intervention (moderate and high). (S) Students were filmed to calculate the proportion who wore a hat. (W) Intervention introduced to one year level only. (W) Possibility that schools staff members were aware of the study purpose and then encouraged students to alter their behaviour accordingly. (W) All students were filmed to calculate the proportion of students who wore a hat (although the intervention was delivered to year one only). (W) Reliance on self-completed questionnaires to investigate sun-protective behaviours. (W) Shade was estimated from one aerial image.

Maher (2002), Real Cool School.	New South Wales, Australia: 15 primary schools, 3,700 students. Intervention study (schools acted as their own control [pre vs post]).	School sun-protection policy change over time.	(S) Whole school level approach. (W) Behavioural data (e.g. hat-use) were mentioned but not reported. (W) Small sample size.
Geller (2002), SunWise program.	America: 40 schools, 1,150-1,894 students (at intervention schools). Intervention study (with a control group).	Participant knowledge, attitudes, practices and intended practices pre-test vs post-test.	(S) Pre-tests compared to post-tests. (S) Intervention group compared to control group. (W) The number of control school students was not reported. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) The lack of observational data.
Emmons (2008), SunWise program.	America: 28 schools, 28 health educators. Intervention study (with a control group).	School sun-protection policy change over time.	(S) Schools were provided with resources to develop their sun-protection policies. (W) Small number of schools. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias).

Hunter (2010), Sun protection of Florida's children.	Florida, America: 22 schools, fourth grade students, 1,115 students (intervention), 1,376 students (control). Cluster randomised trial.	Hat-use at school.	(S) Randomised trial. (W) It was not stated if the hat-use observations were made at announced times.
Walker (2012), Skin protection for kids.	America: 1 school, 75 students. Intervention study (schools acted as their own control [pre vs post]).	Skin protection knowledge	(S) Intervention study design. (W) Small number of participants. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) The lack of observational data.
Naldi (2007), SoleSi SoleNo-GISED.	Italy: 122 schools, 2,272 students (intervention), 1,661 students (control). Cluster randomised trial.	Sunburn history. The number of naevi developed on upper limbs.	(S) Randomised trial. (S) Large number of schools and children participated in the intervention. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) The lack of observational data.

Sancho-Garnier (2012), Living with the sun.	France: 70 classrooms, 1,365 students. Randomised control trial.	Knowledge of the sun and reported sun-protective behaviours.	(S) Randomised trial. (S) Large number of children participated in the intervention. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) The lack of observational data.
Buller (2008), Sunny days, healthy ways.	America: 12 schools, 871 students. Intervention study (pre vs post).	Sun-safety knowledge and sun-protective behaviours.	(S) Randomised trial. (S) Pre-test survey data compared to post-test survey data. (W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) Direct observations of sun-protective behaviours were not made.
Gilaberte (2008), SolSano.	Spain: 121 schools, 1,522 students. Intervention study (pre vs post).	Sun-safety knowledge and sun-protective behaviours.	(S) Large number of schools. (S) Pre-test survey data compared to post-test survey data. (S) Draw and write activities were used.

			(W) The use of self-completed surveys (possibility of measurement bias such as recall bias and social-desirability bias). (W) Direct observations of sun-protective behaviours were not made.

Table 2 provides a summary of the sun-protection interventions described in section 2.8.

2.9 Summary

Few studies have independently evaluated sun-protection policies and reported direct observations of the sun-protective behaviours of students and their adult role models at primary schools. Most sun-protection interventions have relied on self-completed questionnaires (completed by school teachers/staff members or by parents) to investigate sun-protective behaviours used by students at school and at home therefore the potential influence of measurement bias such as social-desirability bias and recall bias should be considered when interpreting study findings. A school sun-protection policy should inform the school community of the sun-protective measures used at a school to reduce excessive exposure to sunlight. However not all schools in Australia and abroad have a comprehensive sun-protection policy, or a sun-protection policy at all. Educational interventions designed to improve teacher knowledge of sun safety so that they can better inform their students about sun protection were found to be well received by teachers and school communities, but were not found to consistently improve sun safety behaviours of children (as reported by their parents). Since school communities might be receptive to participating in interventions designed to improve sun safety at school it might be helpful to investigate the adequacy of the usual sun-protection policies at primary schools and the typical sun-protective behaviours used at these schools by directly observing individual behaviours at schools. Once a baseline assessment of sun-protection policies and practices has been made one could work with school communities to determine the best way to improve these policies and practices.

2.10 Introduction to following chapter

The following chapter describes the first study included in this thesis. Study 1 was a cross-sectional study which was completed to investigate the comprehensiveness of north Queensland primary school sun-protection policies. The results of study 1 are presented and discussed in Chapter 3.

2.11 List of references

1. Australian Institute of Health and Welfare, *Cancer in Australia: an overview 2014*. 2014, Australian Institute of Health and Welfare: Canberra.

2. Australian Institute of Health and Welfare, *Health system expenditures on cancer and other neoplasms in Australia, 2000-2001*. 2005, Australian Institute of Health and Welfare: Canberra.
3. Australian Institute of Health and Welfare, *Skin cancer in Australia*. 2016, Australian Institute of Health and Welfare: Canberra, Australia.
4. Thompson, J.F., R.A. Scolyer, and R.F. Kefford, *Cutaneous melanoma.* Lancet, 2005. **365**: p. 687-701.
5. Diepgen, T.L. and V. Mahler, *The epidemiology of skin cancer.* Br J Dermatol, 2002. **146**(Suppl 61): p. 1-6.
6. Madan, V., J.T. Lear, and R.-M. Szeimies, *Non-melanoma skin cancer.* Lancet, 2010. **375**: p. 673-685.
7. Diepgen, T.L. and V. Mahler, *The epidemiology of skin cancer.* Br J Dermatol, 2002. **146**(Suppl. 61): p. 1-6.
8. Buettner, P.G. and B.A. Raasch, *Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 1998. **78**(5): p. 587-593.
9. Buettner, P.G. and B.A. Raasch, *Erratum in: Buettner PG, Raash BA. Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 2001. **93**(2): p. 302-303.
10. Green, A., et al., *Skin cancer in a subtropical Australian population: incidence and lack of association with occupation. The Nambour Study Group.* Am J Epidemiol, 1996. **144**(11): p. 1034-1040.
11. Lomas, A., J. Leonardi-Bee, and F. Bath-Hextall, *A systematic review of worldwide incidence of nonmelanoma skin cancer.* Br J Dermatol, 2012. **166**: p. 1069-1080.
12. Nestor, M.S. and M.B. Zarraga, *The incidence of Nonmelanoma skin cancers and actinic keratoses in South Florida.* J Clin Aesthet Dermatol, 2012. **5**(4): p. 20-24.
13. Rogers, H.W., et al., *Incidence estimate of Nonmelanoma skin cancer (Keratinocyte Carcinomas) in the US population, 2012.* JAMA Dermatology, 2015. **15**(10): p. 1081-1086.
14. Rudolph, C., et al., *Incidence trends of nonmelanoma skin cancer in Germany from 1998 to 2010.* J Dtsch Dermatol Ges, 2015. **13**(8): p. 788-797.

15. Australian Institute of Health and Welfare, *Non-melanoma skin cancer: general practice consultations, hospitalisation and mortality*. 2008, Australian Institute of Health and Welfare: Canberra, Australia.
16. Buettner, P.G. and R. MacLennan, *Geographical variation of incidence of cutaneous melanoma in Queensland.* Aust J Rural Health, 2008. **16**(5): p. 269-277.
17. Australian Institute of Health and Welfare, *Health system expenditure on cancer and other neoplasms in Australia: 2008-09*. 2013, Australian Institue of Health and Welfare: Canberra, Australia.
18. Cancer Australia, *Cancer Australia submission to Inquiry into skin cancer in Australia*. 2014, Australian Government: Australia.
19. Menzies Institute for Medical Research. *Non-melanoma skin cancer in Tasmania*. 09/09/16]; Available from: http://www.menzies.utas.edu.au/research/diseases-and-health-issues/research-projects/non-melanoma-skin-cancer-in-tasmania.
20. Staples, M.P., et al., *Non-melanoma skin cancer in Australia: the 2002 national survey and trends since 1985.* Med J Austr, 2006. **184**: p. 6-10.
21. Fransen, M., et al., *Non-melanoma skin cancer in Australia.* Med J Austr, 2012. **197**: p. 565-568.
22. Fitzpatrick, T.B., *The validity and practicality of sun reactive skin types I through VI.* Arch Dermatol, 1988. **124**: p. 869-871.
23. Clark, W.H., et al., *A study of tumor progression: The precursor lesions of superficial spreading and nodular melanoma.* Hum Pathol, 1984. **15**(12): p. 1147-1165.
24. Green, A.C., R. MacLennan, and V. Siskind, *Common acquired naevi and the risk of malignant melanoma.* Int J Cancer, 1985. **35**(3): p. 297-300.
25. Swerdlow, A.J., et al., *Benign melanocytic naevi as a risk factor for malignant melanoma.* Br Med J, 1986. **292**: p. 1555-1559.
26. Garbe, C., et al., *Risk factors for developing cutaneous melanoma and criteria for identifying persons at risk: multicenter case-control study of the central malignant melanoma registry of the German Dermatological Society.* J Invest Dermatol, 1994. **102**: p. 695-699.

27. English, D.R., E. Milne, and J.A. Simpson, *Sun protection and the development of melanocytic nevi in children.* Cancer Epidemiol Biomarkers Prev, 2005. **14**(12): p. 2873-2876.
28. Hauschild, A., et al., *Melanocytic nevi.* J Dtsch Dermatol Ges, 2011. **9**(9): p. 723-734.
29. Tucker, M.A. and A.M. Goldstein, *Melanoma etiology: where are we?* Oncogene, 2003. **22**: p. 3042-3052.
30. Lock-Andersen, J., K.T. Drzewiecki, and H.C. Wulf, *Eye and hair colour, skin type and constitutive skin pigmentation as risk factors for basal cell carcinoma and cutaneous malignant melanoma: A Danish case-control study* Acta Derm Venereol, 1999. **79**: p. 74-80.
31. Elwood, J.M., et al., *Malignant Melanoma in England: Risks Associated with Naevi, Freckles, Social Class, Hair Colour, and Sunburn* Int J Epidemiol, 1990. **19**(4): p. 801-810.
32. Osterlind, A., et al., *The Danish case-control study of cutaneous malignant melanoma. II. Importance of UV-light exposure.* Int J Cancer, 1988. **42**: p. 319-324.
33. Green, A., et al., *Sunburn and malignant melanoma.* Br J Cancer, 1985. **51**: p. 393-397.
34. Sander-Wiecker, T., et al., *Moderate sun exposure and nevus counts in parents are associated with development of melanocytic nevi in childhood: a risk factor study in 1, 812 kindergarten children.* Cancer, 2003. **97**(3): p. 628-638.
35. Siegel, J.A., K. Korgavkar, and M.A. Weinstock, *Current perspective on actinic keratosis: a review.* Br J Dermatol, 2016. **Early view**.
36. Rossi, R., M. Mori, and T. Lotti, *Actinic keratosis.* Int J Dermatol, 2007. **46**(9): p. 895-904.
37. Werner, R.N., et al., *The natural history of actinic keratosis: a systematic review.* Br J Dermatol, 2013. **169**(3): p. 502-518.
38. Ghissassi, F.E., et al., *A review of human carcinogens - part D: radiation.* Lancet Oncol, 2009. **10**(8): p. 751-752.
39. English, D.R., et al., *Case-control study of sun exposure and squamous cell carcinoma of the skin.* Int J Cancer, 1998. **77**(3): p. 347-353.

40. Iannacone, M.R., et al., *Patterns and timing of sunlight exposure and risk of basal cell and squamous cell carcinomas of the skin - a case-control study.* BMC Cancer, 2012. **12**: p. 417-428.
41. Kricker, A., et al., *Does intermittent sun exposure cause basal cell carcinoma? A case-control study in Western Australia.* Int J Cancer, 1995. **60**: p. 489-494.
42. van Dam, R.M., et al., *Risk factors for basal cell carcinoma of the skin in men: results from the health professionals follow-up study.* Am J Epidemiol, 1998. **150**(5): p. 459-468.
43. Marks, R., G. Rennie, and T.S. Selwood, *Malignant transformation of solar keratoses to squamous cell carcinoma.* Lancet, 1988. **1**(8589): p. 795-797.
44. Youl, P.H., et al., *Body site distribution of skin cancer, pre-malignant and common benign pigmented lesions excised in general practice.* Br J Dermatol, 2011. **165**: p. 35-43.
45. Gilchrest, B.A., et al., *The pathogenesis of melanoma induced by ultraviolet radiation.* N Engl J Med, 1999. **340**(17): p. 1341-1348.
46. Koh, H.K., *Cutaneous melanoma.* N Engl J Med, 1991. **325**(3): p. 171-182.
47. Pfahlberg, A., et al., *Timing of excessive ultraviolet radiation and melanoma: epidemiology does not support the existence of a critical period of high susceptibility to solar ultraviolet radiation-induced melanoma.* Br J Dermatol, 2001. **144**(3): p. 471-475.
48. Cicarma, E., et al., *Latitude gradient for melanoma incidence by anatomic site and gender in Norway 1966-2007.* J Photoch Photobio B, 2010. **101**(2): p. 174-178.
49. Phan, A., et al., *Acral lentiginous melanoma: a clinicoprognostic study of 126 cases.* Br J Dermatol, 2006. **155**(3): p. 561-569.
50. Wiecker, T.S., et al., *Moderate sun exposure and nevus counts in parents are associated.* 2003.
51. Kelly, J.W., et al., *Sunlight: a major factor associated with the development of melanocytic naevi in Australian schoolchildren.* J Am Acad Dermatol, 1994. **30**(1): p. 40-48.
52. Harrison, S.L., *The development of melanocytic naevi (moles) in children born and raised in tropical Australia*, in *School of Public Health, Tropical Medicine and Rehabilitation Sciences*. 1999, James Cook University: Townsville, Queensland.

53. Garbe, C., et al., *Associated factors in the prevalence of more than 50 common melanocytic nevi, atypical melanocytic nevi, and actinic lentigines: Multicenter case-control study of the central malignant melanoma registry of the German Dermatological Society.* Journal of Investigative dermatology 1994. **102**(5): p. 700-705.
54. Sagebiel, R.W., *Melanocytic nevi in histologic association with primary cutaneous melanoma of superficial spreading and nodular types: effect of tumor thickness.* J Invest Dermatol, 1993. **100**: p. 322S-325S.
55. Farber, M.J., E.R. Heilman, and R.J. Friedman, *Dysplastic nevi.* Dermatol Clin, 2012. **30**: p. 389-404.
56. Bauer, J. and C. Garbe, *Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data.* Pigm Cell Res, 2003. **16**(3): p. 297-306.
57. Harrison, S.L., P.G. Buettner, and R. MacLennan, *Body-site distribution of melanocytic nevi in young Australian children.* Arch Dermatol, 1999. **135**(1): p. 47-52.
58. Harrison, S.L., et al., *Sun exposure and melanocytic naevi in young Australian children.* Lancet, 1994. **344**(8936): p. 1529-1532.
59. Elwood, J.M. and J. Jopson, *Melanoma and sun exposure: an overview of published studies.* Int J Cancer, 1997. **73**: p. 198-203.
60. Holman, C.D. and B.K. Armstrong, *Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: an analysis separating histogenetic types.* J Natl Cancer Inst, 1984. **73**(1): p. 75-82.
61. Carli, P., et al., *The density of melanocytic nevi correlates with constitutional variables and history of sunburns: A prevalence study among Italian schoolchildren* Int J Cancer, 2002. **101**: p. 375-379.
62. Fritschi, L., et al., *Naevi in schoolchildren in Scotland and Australia.* Br J Dermatol, 1994. **130**(5): p. 599-603.
63. Harrison, S.L., R.M. MacKie, and R. MacLennan, *Development of melanocytic nevi in the first three years of life.* J Natl Cancer Inst, 2000. **92**(17): p. 1436-1438.
64. Kricker, A., et al., *Pigmentary and cutaneous risk factors for non-melanocytic skin cancer - a case-control study.* Int J Cancer, 1991. **48**(5): p. 650-662.

65. Khalesi, M., et al., *A meta-analysis of pigmentary characteristics, sun sensitivity, freckling and melanocytic nevi and risk of basal cell carcinoma of the skin.* Cancer Epidemiol, 2013. **37**(5): p. 534-543.
66. Argenziano, G., et al., *Twenty nevi on the arms: a simple rule to identify patients younger than 50 years of age at higher risk for melanoma.* Eur J Cancer Prev, 2014. **23**(5): p. 458.
67. Skender-Kalnenas, T.M., D.R. English, and P.J. Heenan, *Benign melanocytic lesions: risk markers or precursors of cutaneous melanoma?* J Am Acad Dermatol, 1995. **33**(6): p. 1000-1007.
68. Watt, A.J., S.V. Kotsis, and K.C. Chung, *Risk of melanoma arising in large congenital melanocytic nevi: a systematic review.* Plast Reconstr Surg, 2004. **113**(7): p. 1968-1974.
69. Cancer Council Victoria. *Slip, slop, slap, seek & slide: Sid Seagull*. SunSmart 2016 10/09/2016]; Available from: http://www.sunsmart.com.au/tools/videos/current-tv-campaigns/slip-slop-slap-seek-slide-sid-seagull.html.
70. Diffey, B., *When should sunscreen be reapplied.* J Am Acad Dermatol, 2001. **45**: p. 882-885.
71. Cancer Council Australia. *SPF 50+ sunscreen*. Preventing cancer 2016 10/09/2016]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/preventing-skin-cancer/spf50sunscreen.html.
72. Cancer Council Victoria. *Slop on sunscreen*. 2016 27/06/2016]; Available from: http://www.sunsmart.com.au/uv-sun-protection/slop-on-sunscreen.
73. Diaz, A., et al., *The children and sunscreen study. A crossover trial investigating children's sunscreen applicatin thickness and the influence of age and dispenser type.* Arch Dermatol, 2012. **148**(5): p. 606-612.
74. Autier, P., et al., *Quantity of sunscreen used by European students.* Br J Dermatol, 2001. **144**(2): p. 288-291.
75. Garbe, C. and P.G. Buettner, *Predictors of the use of sunscreen in dermatological patients in central Europe.* Prev Med, 2000. **31**(2): p. 134-139.
76. Novick, R., et al., *Factors that influence sunscreen application thickness and potential preservation exposure.* Photodermatol Photoimmunol Photomed, 2015. **31**: p. 212-223.

77. Green, A., et al., *Reduced melanoma after regular sunscreen use: randomized trial follow-up.* J Clin Oncol, 2010. **29**(3): p. 257-263.
78. van der Pols, J.C., et al., *Prolonged prevention of squamous cell carcinoma of the skin by regular sunscreen use.* Cancer Epidemiol Biomarkers Prev, 2006. **15**: p. 2546-2548.
79. Autier, P., et al., *Sunscreen use, wearing clothes, and number of nevi in 6- to 7-year-old European children.* J Natl Cancer Inst, 1998. **90**(24): p. 1873-1880.
80. Azizi, E., et al., *Use of sunscreen is linked with elevated naevi counts in Israeli school children and adolescents.* Melanoma Res, 2000. **10**: p. 491-498.
81. Goldenhersh, M.A. and M. Koslowsky, *Increased melanoma after regular sunscreen use?* J Clin Oncol, 2011. **29**: p. e557-558.
82. Lee, T.K., J.K. Rivers, and R.P. Gallagher, *Site-specific protective effect of broad-spectrum sunscreen on nevus development among white schoolchildren in a randomized trial.* J Am Acad Dermatol, 2005. **52**(5): p. 786-792.
83. de Maleissye, M.-F., et al., *Sunscreen use and melanocytic nevi in children: a systematic review.* Pediatr Dermatol, 2013. **30**(1): p. 51-59.
84. Bauer, J., et al., *Effect of sunscreen and clothing on the number of melanocytic nevi in 1,812 German children attending day care.* Am J Epidemiol, 2005. **161**(7): p. 620-627.
85. English, D.R., E. Milne, and J.A. Simpson, *Ultraviolet radiation at places of residence and the development of melanocytic nevi in children (Australia).* Cancer Cause Control, 2006. **17**: p. 103-107.
86. Enta, T., *Melanocytic nevi in sun-protected Canadian Hutterite children.* Arch Dermatol, 1998. **134**: p. 379-381.
87. Harrison, S.L., *Sun exposure and the epidemiology of melanoma and melanocytic nevi (moles)*, in *Rural and Remote Environmental Health*, D.V. Canyon and R. Speare, Editors. 2001, Australasian College of Tropical Medicine: Townsville. p. 110-124.
88. Armstrong, B.K. and A. Kricker, *How much melanoma is caused by sun exposure?* Melanoma Res, 1993. **3**: p. 395-401.
89. Moise, A.F., P.G. Buttner, and S.L. Harrison, *Sun exposure at school.* Photochem Photobiol, 1999. **70**(2): p. 269-274.

90. Australian Government. *School term dates*. 2016 16/09/2016]; Available from: http://www.australia.gov.au/about-australia/special-dates-and-events/school-term-dates.

91. Department of Education and Training. *Hours of operation*. 2016 16/09/2016]; Available from: http://education.qld.gov.au/parents/school-life/hours.html.

92. Cancer Council Australia. *UV alert*. 2016 27 June 2016]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/uv-alert/.

93. Cancer Council New South Wales. *What is Ultraviolet radiation (UV) radiation and the SunSmart UV alert?* 2016 04/09/16]; Available from: http://www.cancercouncil.com.au/23856/cancer-prevention/sun-protection/sunsmart-program-for-primary-schools-and-ohsc/sunsmart-information-and-news/what-is-uv-radiation/.

94. Australian Radiation Protection and Nuclear Safety Agency. *Townsville realtime UV index data*. 2011 May 2009 to June 2015]; http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm]. Available from: http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm.

95. Downs, N., S.L. Harrison, and A. Parisi, *Queensland teacher sun survey: measurements and procedures for recording occupational UV exposures in Townsville and Toowoomba.* Annals of the ACTM, 2015. **17**(2): p. 8.

96. Downs, N.J., A.V. Parisi, and D. Igoe, *Measurements of occupational ultraviolet exposure and the implications of timetabled yard duty for school teachers in Queensland, Australia: Preliminary results.* J Photoch Photobio B, 2014. **131**: p. 84-89.

97. Downs, N.J. and A.V. Parisi, *Ultraviolet exposures in different playground settings: a cohort study of measurements performed in a school population.* Photodermatol Photoimmunol Photomed, 2009. **25**(4): p. 196-201.

98. Dadlani, C. and S.J. Orlow, *Planning for a brighter future: a review of sun protection and barriers to behavioral change in children and adolescents.* Dermatol Online J, 2008. **14**(9): p. 1.

99. International Union for Health Promotion and Education, *Achieving health promoting schools: guidelines to promote health in schools*, D.o.H.a.H. Services, Editor. 2009, International Union for Health Promotion and Education Saint-Denis Cedex - France. p. 1-4.

100. Pratt, H.D. and A.K. Tsitsika, *Fetal, Childhood, and Adolescence Interventions Leading to Adult Disease Prevention.* Prim Care, 2007. **34**(2): p. 203-217.
101. Parrott, R. and A. Duggan, *Using coaches as role models of sun protection for youth: Georgia's "Got youth covered" project.* J Appl Commun Res, 1999. **27**(2): p. 107-119.
102. Winett, R.A., et al., *The effects of the safe-sun program on patrons' and lifeguards' skin cancer risk reduction behaviors at swimming pools.* J Health Psychol, 1997. **2**(1): p. 85-95.
103. James Cook University. *Library one search*. 2017 02/2009 to 05/2017]; Available from: https://www.jcu.edu.au/library.
104. Montague, M., R. Borland, and C. Sinclair, *Slip! Slop! Slap! and SunSmart, 1980-2000: Skin cancer control and 20 years of population-based campaigning.* Health Educ Behav, 2001. **28**: p. 290-305.
105. Sinclair, C., S. Dobbinson, and M. Montague, *Can a skin cancer control programme make a difference? A profile of the SunSmart programme in Victoria.* Radiat Prot Dosim, 2000. **91**(1-3): p. 301-302.
106. Cancer Council Victoria, *SunSmart program 2003-2006*, SunSmart Victoria, Editor. 2002, Cancer Council Victoria: Victoria.
107. SunSmart Victoria. *SunSmart. Our History*. 2012 25/01/2013]; Available from: http://www.sunsmart.com.au/about_us/our_history.
108. Jones, S.B.W., K. Beckmann, and J. Rayner, *Australian primary schools' sun protection policy and practice: evaluating the impact of the National SunSmart Schools Program.* Health Promot J Aust, 2008. **19**(2): p. 86-90.
109. Dobbinson, S.J., et al., *Are Victorian primary schools SunSmart?* Health Promot J Aust, 2000. **10**(1): p. 43-50.
110. The Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, *Being SunSmart - a guide for primary schools*, The Cancer Council South Australia, Editor. 2005, The Cancer Council: Carlton. p. 22.
111. Radvan, D. *Advances towards a SunSmart State: sun protection in schools*. in *Advances towards a SunSmart State - from research to practice*. 2006. Brisbane, Australia: Queensland Health and The Cancer Council Queensland.
112. Aulbert, W., et al., *Certification of sun protection practices in a German child day-care centre improves children's sun protection - the 'SunPass' pilot study.* Br J Dermatol, 2009. **161**(Suppl. 3): p. 5-12.

113. The Cancer Association of South Africa, *Be SunSmart: A guide for schools*, Cancer Assocation of South Africa, Editor. 2010: Bedfordview, South Africa.

114. Cancer Research UK. *Sun protection in schools*. SunSmart 2009 15-01-2013]; Available from: http://sunsmart.org.uk/schools.

115. Glanz, K., et al., *Skin cancer prevention for children, parents, and caregivers: A field test of Hawaii's SunSmart program.* J Am Acad Dermatol, 1998. **38**: p. 413-7.

116. Reeder, A.I., J.A. Jopson, and A. Gray, *Baseline survey of sun protection policies and practices in primary school settings in New Zealand.* Health Educ Res, 2009. **24**(5): p. 778-87.

117. Miller, K.A., et al., *SunSmart: Evaluation of a pilot school-based sun protection intervention in Hispanic early adolescents.* Health Educ Res, 2015. **30**(3): p. 371-379.

118. Milne, E., et al., *Improved sun protection behaviour in children after two years of the Kidskin intervention.* Aust NZ J Public Health, 2000. **24**(5): p. 481-487.

119. Milne, E., et al., *The use of observational methods for monitoring sun-protection activities in schools.* Health Educ Res, 1999. **14**(2): p. 167-175.

120. Milne, E., et al., *Evaluation of an Intervention to Reduce Sun Exposure in Children. Design and Baseline Results.* Am J Epidemiol, 1999. **150**(2): p. 164-73.

121. Milne, E., et al., *The impact of the kidskin sun protection intervention on summer suntan and reported sun exposure: Was it sustained?* Prev Med, 2006. **42**: p. 14-20.

122. Milne, E., et al., *Effect of a School-based Sun-Protection Intervention on the Development of Melanocytic Nevi in Children.* Am J Epidemiol, 2002. **155**: p. 739-745.

123. Milne, E., et al., *Direct measurement of sun protection in primary schools.* Prev Med, 1999. **29**: p. 45-52.

124. Maher, N., B. Hill, and Y. Cass, *'Real Cool School': a strategy to encourage an environmental approach to sun protection.* Health Promot J Aust, 2002. **13**: p. 51-55.

125. Geller, A., et al., *Evaluation of the SunWise School Program.* J Sch Nurs, 2003. **19**(2): p. 93-99.

126. National Environmental Education Foundation. *Sunwise*. 2016 15/01/2016]; Available from: https://www.neefusa.org/sunwise.

127. Emmons, K.M., et al., *The SunWise Policy Intervention for School-Based Sun Protection: A Pilot Study.* J Sch Nurs, 2008. **24**(4): p. 215-21.

128. Geller, A.C., et al., *The Environmental Protection Agency's National SunWise School Program: Sun protection education in US schools (1999-2000).* J Am Acad Dermatol, 2002. **46**: p. 683-689.

129. Hunter, S., et al., *Sun protection at elementary schools: a cluster randomized trial.* J Natl Cancer Inst, 2010. **102**: p. 484-492.

130. Walker, D., *Skin protection for (SPF) kids program.* J Pediatr Nurs, 2012. **27**: p. 233-242.

131. Naldi, L., et al., *Improving sun-protection behavior among children: results of a cluster-randomized trial in Italian elementary schools. The "SoleSi SoleNo-GISED" project.* J Invest Dermatol, 2007. **127**: p. 1871-1877.

132. Sancho-Garnier, H., B. Pereira, and Cesarini, *A cluster randomized trial to evaluate a health education programme "living with sun at school".* Int J Environ Res Public Health, 2012. **9**: p. 2345-2361.

133. Buller, M.K., et al., *Randomized trial evaluating computer-based sun safety education for children in elementary school.* J Cancer Educ, 2008. **23**: p. 74-79.

134. Gilaberte, Y., et al., *Evaluation of a health promotion intervention for skin cancer prevention in Spain: the SolSano program.* Health Promot Int, 2008. **23**(3): p. 209-219.

Chapter 3
Study 1: A cross-sectional study of the comprehensiveness of primary school sun-protection policies

3.1 Introduction

In 1988, the Australian Cancer Council (formerly known as the Anti-Cancer Council of Victoria) developed the SunSmart program to improve the sun-protective behaviours of Australian children at schools [1-4]. Since the SunSmart program was first introduced, it has evolved to include a national voluntary accreditation program known as the SunSmart School (SSS) Program [4, 5]. The SSS Program has been operational in Victorian primary schools since 1994, Queensland primary schools since 1999 and in primary schools in the other Australian states and territories for over a decade [6]. All Australian primary schools, regardless of school ownership (that is, whether they are government funded or non-government [privately] funded (non-government schools are usually independent schools with a religious denomination) can apply to be a SSS. To apply to be SunSmart accredited, a school is required to formulate and submit their school sun-protection policy to their relevant state or territory's Cancer Council for approval [7, 8]. Additionally, SSSs are encouraged to regularly review their sun-protection policies by completing an online checklist and providing their current policy to their state or territory's Cancer Council [8, 9].

In Queensland, government owned primary schools are expected to use the sun safety guidelines available via the Queensland government's Department of Education and Training website to formulate a sun-protection policy [10]. Currently, these guidelines do not mention a review process therefore it is unknown how often, if at all, sun-protection policies are evaluated at these schools.

Prior research that investigated school sun-protection policies at Australian and international schools relied on self-completed questionnaires and/or telephone surveys to collect policy comprehensiveness data [11-14]. That is, school staff were surveyed and asked to provide a response that indicated whether specific sun-protection policy criteria were addressed in their school's sun-protection policy. Accordingly it could be suggested that reporting bias, in the form of exaggerated or under-reported policy criteria, may have been introduced to these studies.

3.2 Development of the research question

To my knowledge, the sun-protection policies of Australian primary schools are not evaluated by an external, impartial body to assess policy comprehensiveness (with reduced reporting bias). To investigate the adequacy of north Queensland primary school sun-protection policies the following research question was formulated:

> *How comprehensive are the sun-protection policies at north Queensland primary schools in the geographical regions of Townsville (latitude 19.3˚S, longitude 146.8˚E), Cairns (latitude 16.87˚S, longitude 145.75˚E) and The Atherton Tablelands (Atherton: latitude 17.26˚S, longitude 145.48˚E)?*

To address this research question the following study was completed:

> *A cross-sectional study of the comprehensiveness of primary school sun-protection policies. Written sun-protection policies of primary schools located at Townsville, Cairns and the Atherton Tableland regions were assessed and the influence of school characteristics such as school ownership (independent or government owned), SunSmart status, the number of students enrolled at the school, and index of community socio-educational advantage (ICSEA) score on policy comprehensiveness were evaluated.*

The results of this study are presented in the following peer-reviewed manuscript.

3.3 Publication arising from study 1

Article as originally published in **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "School sun-protection policies – does being SunSmart make a difference?" Health Education Research 29 (3): 367-377.
Refer to contribution statement for my contribution.

HEALTH EDUCATION RESEARCH

Vol.29 no.3 2014
Pages 367–377
Advance Access published 20 March 2014

School sun-protection policies—does being SunSmart make a difference?

Denise Turner[1]*, Simone L. Harrison[1], Petra Buettner[2] and Madeleine Nowak[1,3]

[1]Skin Cancer Research Group, School of Public Health, Tropical Medicine and Rehabilitation Sciences, Anton Breinl Centre for Health Systems Strengthening, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, Queensland, Australia [2]Tropical Health Solutions Pty Ltd, Idalia and [3]School of Medicine, James Cook University, Townsville, Queensland, Australia

*Correspondence to: D. Turner. E-mail: Denise.Turner@my.jcu.edu.au

Received on August 22, 2013; accepted on February 18, 2014

Abstract

Evaluate the comprehensiveness of primary school sun-protection policies in tropical North Queensland, Australia. Pre-determined criteria were used to assess publicly available sun-protection policies from primary schools in Townsville (latitude 19.3°S; $n = 43$), Cairns (16.9°S; $n = 46$) and the Atherton Tablelands (17.3°S; $n = 23$) during 2009–2012. Total scores determined policy comprehensiveness. The relationship between policy score, SunSmart status and demographic characteristics was explored. At least 96.6% of primary schools sampled had a sun-protection policy. Although policies of Cancer Council accredited 'SunSmart' schools addressed more environmental, curriculum and review-related criteria than those of 'non-SunSmart' schools, the overall median score for both groups was low at 2 from a possible 12 (48.5% of SunSmart schools [SSSs]: interquartile range [IQR = 2.0–9.0] versus 65.9% of non-SSSs: [IQR = 2.0–3.0], $P = 0.008$). Most policies addressed hat wearing, while criteria related to shade provision at outdoor events, regular policy review and using the policy to plan outdoor events were poorly addressed. Although most primary schools in skin cancer-prone North Queensland have written sun-protection policies, the comprehensiveness of these policies could be vastly improved. These schools may require further support and advice to improve the comprehensive of their policies and incentives to continually implement them to achieve and maintain exemplary sun-protection compliance.

Introduction

Skin cancer is Australia's most common and expensive cancer [1, 2]. It is estimated that two-thirds of Australians will acquire a non-melanoma skin cancer during their life with the annual cost of these cancers to the health system being >$260 million [1–3]. Furthermore, the incidence rate of cutaneous melanoma in Australia is 13 times higher than that in other countries [4].

A leading cause of skin cancer is sun exposure [4–6]. Sun protection during the first 10 years of life is extremely important given that time spent outdoors and latitude of residence during this period may be linked to future cutaneous melanoma development [7]. Sun exposure during the childhood years, particularly if it results in sunburn, damages the skin and increases the proliferation of melanocytic nevi [8–11]. Children raised in geographical regions with high ambient ultraviolet radiation (UVR), such as Queensland, Australia, develop more melanocytic nevi than those raised elsewhere [9, 11–13]. An increased number of melanocytic nevi are a phenotypic risk factor for cutaneous melanoma development, increasing the risk ratio of developing this disease up to 20-fold [6, 8–11, 14].

In 1988, 8 years after the internationally recognized 'Slip! Slop! Slap!' population-based campaign began in Australia, the Cancer Council (formerly known as the Anti-Cancer Council of Victoria) developed the SunSmart program to encourage sun-protective behaviors of children and adolescents [15–17]. The 'SunSmart Schools' (SSSs) accreditation program was rolled out in Victorian primary schools in 1994, Queensland schools in 1999 and has since been introduced in other Australian states and settings including early childhood services [18].

Australian primary schools seeking SunSmart accreditation must: formulate and implement a comprehensive sun-protection policy; encourage students and staff to wear wide-brim, bucket or legionnaire-style hats and are expected to work toward scheduling outdoor assembly, class and recreational periods outside peak UVR exposure times to reduce the UVR exposure levels of students and staff [18] (Table I outlines the criteria for SunSmart accreditation). A SSS is encouraged to provide students and staff with personal sun-protection such as sunscreen and to strive to improve shade availability [18]. The SunSmart program is now internationally recognized and some schools in America, England, New Zealand, Scotland and South Africa have adopted the values it promotes [19–24]. As the SSSs program expands globally, it is especially pertinent to ensure that the program is effective at promoting and achieving sun-safe behavior.

Government primary schools in Queensland are required by the Department of Education, Training and Employment to develop and implement sun-safety policies in the school community that incorporate education programs and skin cancer prevention strategies [18, 25]. These policies must stipulate: that an effort is being made to reduce the duration of peak UVR exposure received by students and staff, that students must wear protective clothing such as hats when outdoors, that schools should provide SPF 30+ sunscreen for student use and that adult role modeling of good sun-protective behaviors in the school environment is valued [25]. Consequently, a sun-protection policy should be in place at all Queensland schools regardless of SunSmart status.

This study describes the adequacy of sun-protection policies at primary schools in North and Far North Queensland, Australia, and explores whether the comprehensiveness of these policies varies according to SunSmart status. To our knowledge, this is the first study to independently evaluate primary school sun-protection policies using pre-determined criteria in Australia.

Methods

Location

Townsville (latitude 19.25°S, longitude 146.77°E), Cairns (latitude 16.87°S, longitude 145.75°E) and the Atherton Tablelands (Atherton: latitude 17.26°S, longitude 145.48°E), Queensland, Australia, are associated with a tropical climate, with hot humid summers, dry winters and high levels of UVR year round [26, 27]. Townsville and Cairns are regional cities located on the east coast of North Queensland, adjacent to the 'Great Barrier Reef', while the local government area of the 'Atherton Tablelands' includes numerous elevated dairy farming towns (average 700 m above sea level) in the 'Great Dividing Range' southwest of Cairns.

Ethics

Approval to conduct a study of sun-protection in primary schools in these areas was obtained from James Cook University (approval number H3365) and the Department of Education and Training (Ref. 11/54273), although ethics approval is not formally required for evaluation of publicly available documents such as these which can be obtained from school websites.

Data collection

School lists for primary schools in the local government areas of Townsville, Cairns and the Tablelands were obtained from the Education Queensland school directory [28]. The Education Queensland schools directory also provided further assignment of schools to the education zones (localities) of 'provincial city (urban)', 'rural' or 'remote' [28]. The SunSmart status of each school was verified by the

Table I. *Sun protection criteria used to assess the sun protection policies of 112 primary schools in Townsville, Cairns and the Atherton Tablelands in Queensland, Australia*

Sun-protection policy criteria[a]	Minimum inclusions for specified criterion to be considered 'present'
Behavior: five points	
Behavior 1 (Hats): All staff and students at the school wear a broad brimmed, legionnaire or a bucket style hat (with a deep crown and brim width of at least 6 cm) whenever they are outdoors.	'No hat, no play'; or hat wearing is specifically mentioned and a description of a GSH[b] is provided in uniform guidelines; or there is a stated expectation that students will wear a hat when outside.
Behavior 2 (Clothing): Clothing that covers as much skin as possible is provided as part of the school uniform/dress code: for example, midriff and singlet tops are not appropriate.	Uniform[c] is described as 'SunSmart'; or uniform is specified or shown in photos to include a sleeved dress[d] or polo-shirt/shirt/t-shirt/blouse,[d] shorts/skirt/skort/culotte,[e] socks and enclosed footwear.
Behavior 3 (Shade use): Children are encouraged to use available areas of shade for outdoor activities.	Mentions students are encouraged to use shade (not limited to those students without hats staying in the shade).
Behavior 4 (Role models): Staff are requested and parents are encouraged to act as role models by following sun protection measures.	Wearing of hats and/or sun safe clothing by staff, parents and/or adult role models is mentioned; or mentions parents/carers/guardians are expected to support the SunSmart/sun safety policy.
Behavior 5 (Sunscreen): The use of SPF 30+ broad-spectrum, water-resistant sunscreen is encouraged with time for application allowed.	Mentions that SPF 30+ sunscreen is provided, encouraged, used or applied to students.
Environment: two points	
Environment 1 (Adequate shade): The school has enough shade or is trying to increase the number of trees and shade structures to provide shady areas in the school grounds.	Mentions presence of shade structures; notes that the school is trying to improve shade availability.
Environment 2 (Shade at events): Shade is considered when organizing outdoor activities, such as physical education (PE) and sports carnivals.	Mentions shade is considered when planning outdoor events.
Curriculum: four points	
Curriculum 1 (Rescheduling): Outdoor activities are rescheduled to minimize sun exposure during peak UV times.	Mentions that an effort is made to minimize time spent outdoors given that school hours coincide with peak UVR exposure times.
Curriculum 2 (Promote sun-safety): SunSmart behavior is regularly reinforced and promoted to the whole school community, for example by newsletters or assemblies.	Use of newsletters or assemblies is mentioned as a way of promoting sun safety.
Curriculum 3 (Sun-safety education): Curriculum information and activities about sun protection are included in at least 3-year levels.	Policy states sun safety, sun-protection and/or SunSmart information is included in the curriculum or mentions a commitment to educating students about sun safety.
Curriculum 4 (Policy use): The sun protection policy is used when planning all outdoor events: for example, camps, fairs, excursions and sporting events.	Mention of sun-protection policy being used when planning outdoor events.
Review: one point	
Evaluation (Review regularly): The school is responsible for regularly reviewing its sun protection policy. This will focus on how well the policy works in influencing student and staff behavior, shade provision and curriculum materials. The school will participate in The Cancer Council's regular review process.	Policy states that sun-protection policies are reviewed and/or updated; or there is evidence of previous review, e.g. Policy dated 2008, reviewed 2010, next review 2012.

[a]Taken from the Cancer Council's guide to being Sun Smart [32]. [b]GSH—gold standard hat: includes broad brim, legionnaire and bucket style hats. [c]Regulation day uniforms were assessed rather than winter or formal uniform options (where present). The type of school uniform options described reflects the tropical climate of the sample area. [d]A sleeve that covered the shoulders and finished at least half way to the elbow was required to be described or shown in photographs for a point to be awarded. [e]A pant length that was described as being at least mid-thigh was required to meet the criteria.

Cancer Council, Queensland, while demographic information (e.g. government/non-government school, location and student enrolments) was obtained from Education Queensland [29] and the 'index of community socio-educational advantage' (ICSEA) values were retrieved from the Australian 'My School' website [30]. ICSEA is a scale that represents educational advantage and is calculated using student family background data to represent the levels of educational advantage students bring to their studies [31]. Values range from 500 (schools with students from extremely educationally disadvantaged backgrounds) to 1300 (schools with students from highly educated families) and the average ICSEA value is set at 1000 [31].

Sun-protection policy collection and evaluation

Search functions and links provided on school websites were used to locate sun-protection policies during 2009–2012. Sun-protection policies were found in school handbooks, prospectus and/or policy links on school websites; these were subsequently downloaded. When no information about a sun-protection policy was discovered, the school was contacted to request an enrolment package. The Cancer Council's guide to being SunSmart [18, 32] was used to assess all sun-protection policies. One assessor evaluated all sun-protection policies to ensure continuity of data collection. The assessor also trained another research assistant to evaluate policies in the same way for a related study and a high level of agreement was achieved when the same policies were reviewed by both assessors (concordance coefficient = 0.963, 95% CI 0.877, 0.989). In doing so, numerous policies were read and the 'minimum inclusions' (i.e. key words and phrases) listed in Table I were defined. While the wording in the policies varied, the key words/phrases used by schools were similar, perhaps because an example sun-protection policy is publicly available on the Cancer Council's SunSmart website [18]. Each sun-protection policy criterion was recorded as 'present' or 'absent' in the school policies. Table I outlines the minimum requirements for criteria to be recorded as 'present'. A maximum score of 12 was possible with five being allocated for the behavioral, two for the environmental and four for the curriculum sub-categories while one point was awarded if a review process was mentioned. Similar methods have been documented previously [23, 33, 34].

Statistical analysis

IBM SPSS Statistics version 19 (IBM SPSS, Inc., Chicago, IL, USA) was used for data analysis. As data were not normally distributed, non-parametric Mann–Whitney, Kruskal–Wallis and chi-squared tests were used to assess differences in scores according to school characteristics. An alpha level of 0.05 was used to determine statistical significance.

Results

Sample

Sun-protection policies were obtained for 112 of the 116 (96.6%) primary schools in the sampling area (unavailable to public or did not exist for three schools in the Atherton Tablelands and one in Townsville). Most of the 112 primary schools from the local government areas of Townsville, Cairns and the Atherton Tablelands with written sun-protection policies were government owned (66.1%), situated in urban areas (64.3%), enlisted in the SSS program (60.7%) and had an ICSEA score below 1000. A greater proportion of Cancer Council-endorsed SSS were large schools (>800 students) compared with non-SSSs (NSSS) (17.6% versus 4.5%; $P = 0.039$; Table II).

Most schools (55.4%) addressed 2 criteria of the 12 specified, while only 6 (5.4%) schools addressed all 12. Of the schools with a perfect score, five were SSS. Approximately 5% of all schools obtained a total score of 1 or less (Table III).

The sun-protection policies of SSS were more likely than those of NSSS to mention promoting sun-safety messages within the school community ($P = 0.001$); shade provision at outdoor school events/carnivals ($P = 0.002$); regularly reviewing their policies ($P = 0.006$) and rescheduling outdoor

Table II. *SunSmart and NSSS characteristics of 112 primary schools in Townsville, Cairns and the Tablelands in Queensland, Australia*

Characteristic		All schools ($n = 112$) N (%)	SunSmart ($n = 44$) N (%)	Non-SunSmart ($n = 68$) N (%)	P-value
Ownership	Government	74 (66.1)	25 (36.8)	13 (29.5)	0.433
	Non-government	38 (33.9	43 (63.2)	31 (70.5)	
School size[a]	Small (≤399 students)	55 (49.1)	29 (42.6)	26 (59.1)	0.039
	Medium (400–799 students)	43 (38.4)	27 (39.7)	16 (36.4)	
	Large (≥800 students)	14 (12.5)	12 (17.6)	2 (4.5)	
ICSEA[b] status	≤mean (≤1000)	81 (72.3)	47 (69.1)	34 (77.3)	0.348
	Above mean (≥1001)	31 (27.7)	21 (30.9)	10 (22.7)	
Locality[c]	Urban	72 (64.3)	47 (69.1)	25 (56.8)	0.186
	Rural	36 (32.1)	19 (27.9)	17 (38.6)	
	Remote	4 (3.6)	2 (2.9)	2 (4.5)	
Region	Townsville (latitude 19.25°S, longitude 146.77°E)	43 (38.4)	29 (42.6)	14 (31.8)	0.208
	Cairns (latitude 16.87°S, longitude 145.75°E)	46 (41.1)	27 (39.7)	19 (43.2)	
	The Atherton Tablelands (latitude 17.26°S, longitude 145.48°E)	23 (20.5)	12 (17.6)	11 (25.0)	

[a]Using 2008 enrolment data obtained from Education Queensland [29]. [b]ICSEA—index of community socio-educational advantage. The mean value is set to 1000 [31]. [c]Locality refers to the education zone assigned to a school by Education Queensland [28].

Table III. *Summary of the total sun-protection policy evaluation scores obtained by the 112 primary schools in Townsville, Cairns and the Tablelands in Queensland, Australia: stratified by school SunSmart status and ownership*

		SunSmart school		School ownership	
Sun-protection policy score	Number of schools (%)	Yes ($n = 68$)	No ($n = 44$)	Non-government ($n = 38$)	Government 2($n = 74$)
0	2 (1.8)	1 (1.5)	1 (2.3)	1 (2.6)	1 (1.4)
1	4 (3.6)	2 (2.9)	2 (4.5)		4 (5.4)
2	62 (55.4)	33 (48.5)	29 (65.9)	16 (42.1)	46 (62.2)
3	8 (7.1)	3 (4.4)	5 (11.4)	3 (7.9)	5 (6.8)
4	2 (1.8)	2 (2.9)			2 (2.7)
5	2 (1.8)		2 (4.5)	2 (5.3)	
6	4 (3.6)	2 (2.9)	2 (4.5)	2 (5.3)	2 (2.7)
7	4 (3.6)	4 (5.9)		3 (7.9)	1 (1.4)
8	3 (2.7)	2 (2.9)	1 (2.3)	2 (5.3)	1 (1.4)
9	6 (5.4)	6 (8.8)		4 (10.5)	2 (2.7)
10	4 (3.6)	3 (4.4)	1 (2.3)	1 (2.6)	3 (4.1)
11	5 (4.5)	5 (7.4)		1 (2.6)	4 (5.4)
12	6 (5.4)	5 (7.4)	1 (2.3)	3 (7.9)	3 (4.1)

activities to minimize peak UVR exposure ($P = 0.007$); as well as encouraging students to utilize both shade ($P = 0.005$) and SPF 30+ sunscreen ($P = 0.018$), expecting adults to model good sun-protection behaviors ($P = 0.017$); including sun-protection education in the curriculum ($P = 0.012$) and ensuring the school grounds are adequately shaded ($P = 0.037$) (Table IV). Fewer differences were found between the sun-protection policies of non-government and government run

Table IV. *The proportion of 112 primary schools in Townsville, Cairns and the Tablelands in Queensland, Australia, that achieved the full score for each sun-protection policy criterion: stratified by school characteristics*

		School characteristic								
		SunSmart			Ownership			ICSEA score		
Policy criterion[a]	All schools $n=112$ (%)	Yes $n=68$ (%)	No $n=44$ (%)	*P-value*	Non-government $n=38$ (%)	Government $n=74$ (%)	*P-value*	Below median $n=81$ (%)	Above median $n=31$ (%)	*P-value*
Hats	93.8	95.6	90.9	0.320	97.4	91.9	0.259	95.1	90.3	0.356
Clothing	98.2	98.5	97.7	0.755	97.4	98.7	0.630	100.0	93.5	0.022
Shade use	23.2	32.4	9.1	0.005	31.6	18.9	0.135	22.2	26.2	0.689
Role models	31.3	39.7	18.2	0.017	50.0	21.6	0.002	29.6	25.8	0.552
Sunscreen	28.6	36.8	15.9	0.018	42.1	21.6	0.024	25.9	35.5	0.319
Adequate shade	26.8	33.8	15.9	0.037	29.0	27.9	0.712	25.9	29.0	0.741
Shade at events	15.2	23.5	2.3	0.002	15.8	16.2	0.898	14.8	16.1	0.863
Rescheduling	22.3	30.9	9.1	0.007	29.0	20.6	0.230	21.0	25.8	0.585
Promote sun safety	21.4	32.4	4.5	0.001	29.0	19.1	0.167	21.0	22.6	0.855
Sun-safety education	26.8	35.3	13.6	0.012	39.5	22.1	0.031	25.9	29.0	0.741
Policy use	9.8	13.2	4.5	0.133	15.8	7.4	0.130	8.6	12.9	0.500
Review regularly	19.6	27.9	6.8	0.006	31.6	14.7	0.023	16.0	29.0	0.123

[a]Refer to Table 1 for detailed criteria explanation.

schools. Non-government schools did however place greater emphasis on role modeling of sun-protective behaviors by adults ($P=0.002$), sunscreen use ($P=0.024$), periodic review of policies ($P=0.023$) and inclusion of sun-protection education in the curriculum ($P=0.031$) than government school policies. Inclusion of behavioral, environmental, curriculum-based and review criteria in a school's sun-protection policy did not appear to be influenced by the school's ICSEA score, other than for the sun-protective uniform criterion (Table IV).

SSS tended to address more criteria in the environmental ($P=0.013$), curriculum ($P=0.032$) and review ($P=0.006$) categories than NSSS (Table V). Non-government schools addressed more behavioral ($P=0.049$) and review criteria ($P=0.023$) than government schools (Table V). Total sun-protection policy scores did not vary with school size, geographical location in Northern Queensland (Townsville, Cairns or the Atherton Tablelands) or locality (urban, rural or remote).

The median total score obtained for all schools was 2.0 [inter-quartile range (IQR) = 2.0–6.8] from 12.0 while scores for SSS and NSSS were 2.0 [IQR = 2.0–9.0] and 2.0 [IQR = 2.0–3.0], respectively ($P=0.008$). Non-government schools achieved a higher median total score compared with government schools (3.0 [IQR = 2.0–8.3] versus 2.0 [IQR = 2.0–3.3]; $P=0.020$).

Discussion

A major finding of this study was that only 5.4% of North and Far North Queensland primary schools scored the possible 12/12 for their sun-protection policies, while the median total policy score was 2 from a possible 12. However, even though many were not very comprehensive, almost all of these schools had some form of written sun-protection policy. A comprehensive written sun-protection policy could be the first step toward promoting and improving sun-protective behaviors at schools, especially if school staff, parents and care-givers actively encourage such behavior and become sun-safety role models. However, data supporting the link between sun-protection policies and observations of sun-protective behavior at primary schools are lacking. Research involving independent assessment of policies and direct unannounced observations of behavior to better represent usual sun-protective practices (rather than self-reported data) would be particularly beneficial.

Table V. *Behavior, environment, curriculum and review scores attained by 112 primary schools in Townsville, Cairns and the Atherton Tablelands, North Queensland, Australia: stratified by school SunSmart status, ownership and ICSEA score*

		School characteristic								
		SunSmart school			School ownership			ICSEA score		
Sub-criteria: score attained[a]	All schools $n = 112$ (%)	Yes $n = 68$ (%)	No $n = 44$ (%)	*P*-value	Non-government $n = 38$ (%)	Government $n = 74$ (%)	*P*-value	Below median $n = 81$ (%)	Above median $n = 31$ (%)	*P*-value
Behavior										
0	1.8	1.5	2.3	0.106	2.6	1.4	0.049	0.0	6.5	0.269
1	4.5	2.9	6.8		0.0	6.8		4.9	3.2	
2	58.9	52.9	68.2		44.7	66.2		61.7	51.6	
3	7.1	5.9	9.1		13.2	4.1		7.4	6.5	
4	7.1	7.4	6.8		7.9	6.8		7.4	6.5	
5	20.5	29.4	6.8		31.6	14.9		18.5	25.8	
Environment										
0	72.3	64.7	84.1	0.013	71.1	73.0	0.948	72.8	71.0	0.942
1	13.4	13.2	13.6		13.2	13.5		13.6	12.9	
2	14.3	22.1	2.3		15.8	13.5		13.6	16.1	
Curriculum										
0	70.5	60.3	86.4	0.032	60.5	75.7	0.194	70.4	71.0	0.644
1	4.5	5.9	2.3		2.6	5.4		6.2	0.0	
2	7.1	7.4	6.8		13.2	4.1		7.4	6.5	
3	9.8	14.7	2.3		10.5	9.5		8.6	12.9	
4	8.0	11.8	2.3		13.2	5.4		7.4	9.7	
Review										
0	80.4	72.1	93.2	0.006	68.4	86.5	0.023	84.0	71.0	0.122
1	19.6	27.9	6.8		31.6	13.5		16.0	29.0	

[a]Refer to Table 1 for detailed criteria explanation.

Sun-protection policies of SSS addressed more individual criteria and consequently scored higher total scores than NSSS. SSS and NSSS characteristics were similar therefore it is possible that other factors, such as motivation to develop a sun-protection policy for SunSmart accreditation, influenced the comprehensiveness of such policies. SSS did not consistently address the 12 criteria better than NSSS which could suggest that greater guidance may be required to ensure that all criteria are understood and subsequently addressed. Non-government schools were found to have more comprehensive sun-protection policies than government schools and a school ICSEA value above the mean was not associated with a better sun-protection policy. A relationship between sun-protection policy scores and socio-economic status, school size, school locality or region was not found.

Most schools sampled achieved overall scores that were considerably lower than those awarded to the majority of New Zealand primary schools [23, 33] and only slightly higher than those attained by American primary schools [24]. Overall, SSS sun-protection policies were more comprehensive than those of NSSS, suggesting that schools participating in the SunSmart program demonstrate more interest in policy development and/or have better access to resources to help develop their policies.

Almost all sun-protection policies addressed student hat wearing while outdoors which is commendable. School hats were described as being ‘SunSmart’ or broad brim, bucket or legionnaire style which are considered to be ‘gold standard hats’ since they provide better protection to the face, head and neck regions than cap/visor styles [35, 36]. Most policies stated a ‘no hat, no play’ rule for students and specified students without hats were to play in shaded areas.

SSS sun-protection policies were more likely to encourage all students to use shade when outside; however, this criterion was addressed by less than a quarter of school policies overall. While we found that students might be encouraged to use shade if they did not have a hat, shade use should be encouraged at all times, regardless of hat wearing. Combining multiple methods of personal sun protection as recommended by the Cancer Council's slip (on sun-protective clothing), slop (on SPF30+ sunscreen), slap (on a hat), seek (shade) and slide (on sunglasses) message is the optimal way to reduce sun damage [37].

The importance of adult role modeling of sun-protective behaviors was more likely to be mentioned in SunSmart and non-government schools policies but was poorly addressed overall. The value of adult role models for encouraging and reinforcing sun safe behaviors has been demonstrated [38, 39] thus the importance of this criterion in sun-protection policies should not be understated. Schools may have placed less emphasis on adult role modeling in their policies because they assume that school staff and parents/care-givers act as role models without being asked to do so. However, our research suggests that <20% of adults accompanying students to and from school grounds wear a hat, suggesting it is necessary to address adult role modeling in school policies [40]. Similarly, sunscreen use should be included in sun-protection policies since when it is applied properly and used in conjunction with other personal sun-protection items, such as hats, it can be a valuable form of sun-protection since regular application may reduce skin cancer development [37, 41–43]. While SSS were more likely to mention that sunscreen was provided to students than NSSS, the criterion was addressed poorly overall.

Overall, shade provision was poorly addressed, with few schools considering shade when planning their outdoor events. Policies of SSS were more likely than those of NSSS to mention the availability of adequate shade in the school grounds or to consider shade when planning outdoor events.

Perhaps shade availability was poorly addressed overall because providing built shade structures and portable shade structures at outdoor events can be costly. Principals consider shade to be an important component of sun protection for students; however, the construction of new shade structures can be limited by school budgets and lack of funding [23].

Although principals generally consider shade provision to be important for their students, constructing new fixed shade structures and purchasing portable shade for outdoor events (e.g. athletics carnivals) are costly, and therefore may be limited by school budgets and lack of funding [23]. Alternative forms of shade, such as native trees, can be planted by school students, and offer an affordable alternative to built shade; however, it can take many years for trees to reach maturity and provide considerable shade [44]. Shade utilization should be promoted by schools in conjunction with sun-protective clothing and sunscreen. Furthermore, shade adequacy should be considered when planning outdoor events (e.g. swimming carnivals), since such events may take place during peak UVR exposure periods.

Rescheduling outdoor activities such as physical education classes and designated meal break/play times would be beneficial since they usually coincide with peak UVR exposure periods. Most policies made no mention of attempts to reschedule outdoor activities or using the policy to plan outdoor activities such as school excursions and sports carnivals. Less than one-quarter of school policies mentioned that sun-safety information was regularly included in school newsletters and/or assemblies. Nor did the majority of schools state that sun-safety education was incorporated into the school curriculum. Given that the incidence of cutaneous melanoma in Australia is among the highest in the world [4], sun-safety education in Australian primary schools should be improved to establish good sun-protection habits early in life. Sun-safety education is included in the curriculum of > 60% of primary schools in England, suggesting that there is room for improvement in Australian schools [44]. It was not possible to evaluate the comprehensiveness of the sun-protection education included in the curriculum using publicly available information alone. As it is possible that the quality of such information could vary at the school, state or national level, it is important to ensure that only evidence-based material is included in such curricula.

Unlike previous studies, we did not find that school size (as determined by number of enrolments) influenced the comprehensiveness of sun-protection polices [23, 45]. Nor did we find an association between school location (urban, rural or remote) and adequacy of policies. The educational advantage of students attending schools, as represented by school ICSEA score, was not associated with better sun-protection policies.

Our research is strengthened by the use of independently assessed sun-protection policy evaluation criteria in contrast to the self-reported data commonly used in other studies [23, 33, 44–47]. The use of a single policy assessor could be considered a study limitation; however, we believe that it improved the consistency of data collection. Likewise, publicly available school sun-protection policies may not always include the most recent information, but do reflect the information this is most readily available to parents/care-givers. Furthermore, a causal relationship between SunSmart status and comprehensiveness of sun-protection policies cannot be implied due to the cross-sectional study design used. Future research that explores school staff perspectives toward sun-safety policies and practice would be beneficial.

In conclusion, only 5% of schools received a perfect score and the majority of school policies only scored 2 from a possible 12. While SSS and non-government schools were found to address more criteria than NSSS and government schools there is room for improvement at almost all schools. Although policy is not necessarily indicative of practice, a comprehensive sun-protection policy is an essential part of establishing a good attitude to sun safety in school communities. The importance of sun-protection policies in the school environment should be emphasized. When developing their policies, schools should be directed to the support available such as the resources available from the Cancer Council Australia. Our team is currently funded by Queensland Health to pilot a program that monitors sun-protection compliance in schools; rewards schools that consistently practice sun-safe behaviors and provides incentives to encourage schools to achieve and continue to maintain high levels of sun protection. These data will serve as a valuable baseline from which the impact of future interventions aimed at improving sun-protection policies and practices in schools can be measured.

Acknowledgements

The authors would like to thank research assistants Michelle Sinclair and Hilla Cohen for their assistance with data collection.

Funding

Queensland Health provided funding support for this research. [Project ID 57543].

Conflict of interest statement

None declared.

References

1. Australian Institute of Health and Welfare. *Health System Expenditures on Cancer and Other Neoplasms in Australia,* 2000–01. Canberra: Australian Institute of Health and Welfare, 2005.
2. Australian Institute of Health and Welfare, Cancer Australia. *Non-Melanoma Skin Cancer: General Practice Consultations, Hospitalisation and Mortality*. Canberra: Australian Institute of Health and Welfare, 2008.
3. Australian Institute of Health and Welfare. *Australia's Health 2012*. Canberra: Australian Institute of Health and Welfare, 2012.
4. Australian Institute of Health and Welfare, Australasian Association of Cancer Registries. *Cancer in Australia: An Overview*. Canberra: Australian Institute of Health and Welfare, 2010.
5. Dixon H, Borland R, Hill D. Sun protection and sunburn in primary school children: the influence of age, gender, and colouring. *Prev Med* 1999; **28**: 119–30.
6. Bauer J, Garbe C. Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data. *Pigment Cell Res* 2003; **16**: 297–306.
7. Holman CDJ, Armstrong BK. Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: an analysis separating histogenetic types. *J Natl Cancer Inst* 1984; **73**: 75–82.
8. Harrison SL. Sun exposure and the epidemiology of melanoma and melanocytic nevi (moles). In: Canyon DV, Speare R (eds). *Rural and Remote Environmental Health*.

Townsville: Australasian College of Tropical Medicine, 2001, 110–24.
9. Harrison SL, MacKie RM, MacLennan R. Development of melanocytic nevi in the first three years of life. *J Natl Cancer Inst* 2000; **92**: 1436–8.
10. Harrison SL, MacLennan R, Speare R *et al*. Sun exposure and melanocytic naevi in young Australian children. *Lancet* 1994; **344**: 1529–32.
11. Kelly JW, Rivers JK, MacLennan R *et al*. Sunlight: a major factor associated with the development of melanocytic naevi in Australian school children. *J Am Acad Dermatol* 1994; **30**: 40–8.
12. Fritschi L, McHenry P, Green AC *et al*. Naevi in school children in Scotland and Australia. *Br J Dermatol* 1994; **130**: 599–603.
13. Sander-Wiecker T, Luther H, Buettner PG *et al*. Moderate sun exposure and nevus counts in parents are associated with development of melanocytic nevi in childhood: a risk factor study in 1, 812 kindergarten children. *Cancer* 2003; **97**: 628–38.
14. Skender-Kalnenas TM, English DR, Heenan PJ. Benign melanocytic lesions: risk markers or precursors of cutaneous melanoma? *J Am Acad Dermatol* 1995; **33**: 1000–7.
15. SunSmart Victoria. *SunSmart. Our History*. Victoria: Australia: Cancer Council Victoria, 2012. Available at: http://www.sunsmart.com.au/about_us/our_history. Accessed: 25 January 2013.
16. Cancer Council Victoria. *SunSmart program*, 2003–2006. In: Victoria S (ed). Victoria: Cancer Council Victoria, 2002.
17. Montague M, Borland R, Sinclair C. Slip! Slop! Slap! and SunSmart, 1980–2000: skin cancer control and 20 years of population-based campaigning. *Health Educ Behav* 2001; **28**: 290–305.
18. Cancer Council Queensland. *SunSmart Policy Guidelines*, 2009. Available at: http://www.cancerqld.org.au/icms_docs/54253_SunSmart_policy_guidelines.pdf. Accessed: 10 February 2013.
19. Aulbert W, Parpart C, Schulz-Hornbostel R *et al*. Certification of sun protection practices in a German child day-care centre improves children's sun protection—the 'SunPass' pilot study. *Br J Dermatol* 2009; **161**: 5–12.
20. The Cancer Association of South Africa (CANSA). *Be SunSmart: a guide for schools*. Bedfordview, South Africa: CANSA, 2010.
21. Cancer Research UK. *Sun Protection in Schools. SunSmart*. London: Cancer Research UK, 2009. Available at: http://sunsmart.org.uk/schools. Accessed: 15 January 2013.
22. Glanz K, Chang L, Song V *et al*. Skin cancer prevention for children, parents, and caregivers: a field test of Hawaii's SunSmart program. *J Am Acad Dermatol* 1998; **38**: 413–7.
23. Reeder AI, Jopson JA, Gray A. Primary school sun protection policies and practices 4 years after baseline—a follow up study. *Health Educ Res* 2012; **27**: 844–56.
24. Reynolds KD, Buller DB, French SA *et al*. School sun-protection policies: measure development and assesments in 2 regions of the United States. *J Sch Health* 2012; **82**: 499–507.
25. Department of Education Training and Employment. Developing a sun safety strategy. Department of Education, Training and Employment. Brisbane: Queensland Government, 2012. Available at: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html. Accessed: 10 January 2013.
26. Bureau of Meteorology. *Climate Statistics for Australian Locations*. Commonwealth of Australia, Bureau of Meteorology, 2012. http://www.bom.gov.au/climate/averages/tables/cw_086071.shtml. Accessed: 10 January 2013.
27. Bureau of Meteorology. *Climate of Cairns*. Australian Government: Bureau of Meterology, 2013. http://www.bom.gov.au/qld/cairns/climate.shtml. Accessed: 10 February 2013.
28. Department of Education Training and Employment. *Schools Directory Advanced Search*, 2009. Available at: http://education.qld.gov.au/directory/schools/advanced-search.html. Accessed: 10 February 2013.
29. Department of Education and Training and Employment. *State School Full-Time Enrolment Counts, census 2005–2009*, Queensland Government, 2009. Available at: http://education.qld.gov.au/school/statistics. Accessed: 12 April 2010.
30. Australian Curriculum Assessment and Reporting Authority. *My School*. Sydney, Australia: ACARA, 2010. Available at: http://www.myschool.edu.au. Accessed: 11 January 2013.
31. Australian Curriculum Assessment and Reporting Authority (ACARA). *My School. Guide to Understanding ICSEA*. ACARA. Sydney, Australia: ACARA, 2012.
32. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group. *Being SunSmart—a Guide for Primary Schools*. Australia: The Cancer Council, 2005. Available at: http://www.sunsmart.com.au. Accessed: 10 February 2013.
33. Reeder AI, Jopson JA, Gray A. Baseline survey of sun protection policies and practices in primary school settings in New Zealand. *Health Educ Res* 2009; **24**: 778–87.
34. Ettridge KA, Bowden JA, Rayner JM *et al*. The relationship between sun protection policy and associated practices in a national sample of early childhood services in Australia. *Health Educ Res* 2011; **26**: 53–62.
35. Gies P, Javorniczky J, Roy C *et al*. Measurements of the UVR protection provided by hats used at school. *Photochem Photobiol* 2006; **82**: 750–4.
36. Diffey B, Cheeseman J. Sun protection with hats. *Br J Dermatol* 1992; **127**: 10–2.
37. SunSmart Victoria. *Sun Protection. SunSmart*. Victoria SunSmart: Victoria, 2013. Available at: http://www.sunssmart.com.au/sun_protection. Accessed: 5 February 2013.
38. Parrott R, Duggan A. Using coaches as role models of sun protection for youth: Georgia's "Got youth covered" project. *J Appl Commun Res* 1999; **27**: 107–19.
39. O'Riordan DL, Geller AC, Brooks DR *et al*. Sunburn reduction through parental role modeling and sunscreen vigilance. *J Pediatr* 2003; **142**: 67–72.
40. Turner D, Harrison S, Buettner P *et al*. Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure. *Prev Med* 2014; **60**: 107–14.
41. Linos E, Keiser E, Fu T *et al*. Hat, shade, long sleeves, or sunscreen? Rethinking US sun protection messages based on

their relative effectiveness. *Cancer Causes Control* 2011; **22**: 1067–71.

42. Green A, Williams GM, Logan V *et al*. Reduced melanoma after regular sunscreen use: randomized trial follow-up. *J Clin Oncol* 2010; **29**: 257–63.
43. van der Pols JC, Williams GM, Pandeya N *et al*. Prolonged prevention of squamous cell carcinoma of the skin by regular sunscreen use. *Cancer Epidemiol Biomarkers Prev* 2006; **15**: 2546–8.
44. Horsley L, Charlton A, Wiggett C. Current action for skin cancer risk reduction in English schools: a report on a survey carried out for the Department of Health. *Health Educ Res* 2000; **15**: 249–59.
45. Dono J, Ettridge KA, Sharplin GR *et al*. The relationship between sun protection policies and practices in schools with primary-age students: the role of school demographics, policy comprehensiveness and SunSmart membership. *Health Educ Res* 2013; **28**: 1–12.
46. Dobinson SJ, Peipers AM, Borland R *et al*. Are Victorian primary schools SunSmart? *Health Promot J Austr* 2000; **10**: 43–50.
47. Jones SBW, Beckmann K, Rayner J. Australian primary schools' sun protection policy and practice: evaluating the impact of the National SunSmart Schools Program. *Health Promot J Austr* 2008; **19**: 86–90.

The following errors were noted in the above publication.

Abstract: First sentence – "We aimed to" should have been inserted before "evaluate the comprehensiveness of".

Abstract: Final sentence – "comprehensiveness" should have been written instead of "comprehensive".

Table III: The number "2" should not have been present in heading of the last column. The heading of that column should have been "Government (n=74)", not "Government 2(n=74)"

Discussion: The first sentence of paragraph nine should have been removed because it is present in the previous paragraph. Paragraph nine should have started at "Alternative forms of shade".

3.4 Summary and future directions

Most of the school sun-protection policies assessed were limited to a few lines within a school handbook or prospectus. Most policies referred to the use of hats and clothing (i.e. the school uniform) but few policies referred to the other sun-protection criteria considered to constitute a comprehensive sun-protection policy (such as the expectation that school communities would use the policy when planning outdoor activities). It could be suggested that was because school staff assumed few people read their school's sun-protection policy, school communities did not consider their sun-protection policy to be important, or because school staff had limited time or resources to develop adequate policies. It might be helpful to remind school communities that their sun-protection policy has the potential to inform numerous people, including parents of students, of the sun-protective measures used at their school. Therefore a sun-protection policy might serve as an important means through which schools could communicate their commitment to sun-safety. Neither the sun-safety resources available to schools nor the barriers perceived by school staff to developing comprehensive sun-protection policies were investigated during study 1. It might be advantageous to evaluate the adequacy of sun-safety resources, including SSS resources, and investigate how these resources are used to develop school sun-protection policies. Qualitative study methods may be useful for this purpose. It would be advantageous for skin cancer researchers to work with north Queensland primary school communities to improve their policies and ensure that these improved policies are read by the members of the school community, including parents and staff.

Longitudinal studies that investigate the relationship between sun-protection policies and sun-protective behaviours would serve as a useful means for evaluating the value of school sun-protection policies. Evidence to support that a comprehensive school sun-protection policy translated to good sun-protective behaviours in the school environment is necessary. More school communities might be encouraged to develop comprehensive sun-protection policies if there was evidence to support that good policies were associated with good sun-protective behaviours.

3.5 Introduction to following chapter

The sun-protection policies of most north Queensland primary schools were under-developed. This finding prompted us to consider how students are protected from excessive sun-exposure at north Queensland primary schools. Since the Australian Cancer Council and the Queensland government's Department of Education and Training stipulate that primary school uniforms should be designed to cover a substantial proportion of the body [7, 10], we decided to examine the proportion of the body covered by school uniforms. During study 2, the uniform guidelines at north Queensland primary schools were collected and a standardised method was used to assess the body surface area (BSA) that was covered by each school uniform. The following chapter describes the methodology used to determine the BSA covered by uniforms and discusses the main results of study 2.

3.6 List of references

1. Montague, M., R. Borland, and C. Sinclair, *Slip! Slop! Slap! and SunSmart, 1980-2000: Skin cancer control and 20 years of population-based campaigning.* Health Educ Behav, 2001. **28**: p. 290-305.
2. SunSmart Victoria. *SunSmart. Our History*. 2012 25/01/2013]; Available from: http://www.sunsmart.com.au/about_us/our_history.
3. Cancer Council Victoria, *SunSmart program 2003-2006*, SunSmart Victoria, Editor. 2002, Cancer Council Victoria: Victoria.

4. Cancer Council Queensland. *SunSmart policy guidelines*. 2009 07/07/2009]; Available from: http://www.cancerqld.org.au/icms_docs/54253_SunSmart_policy_guidelines.pdf.
5. Cancer Council Queensland. *Be SunSmart*. 2009 22/04/2013]; Available from: http://www.cancerqld.org.au/page/prevention/skin_cancer/national_sunsmart_schools_and_early_childhood_centres/.
6. Cancer Council Queensland. *SunSmart related links*. 2009 05/10/2009]; Available from: http://www.sunsmart.com.au/about.
7. The Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, *Being SunSmart - a guide for primary schools*, The Cancer Council South Australia, Editor. 2005, The Cancer Council: Carlton. p. 22.
8. Cancer Council Queensland. *SunSmart school review form*. 2016 27/06/2016]; Available from: https://cancerqld.org.au/cancer-prevention/understanding-risk/being-sunsmart/national-sunsmart-program/sunsmart-school-review-form/.
9. SunSmart Victoria. *SunSmart schools and early childhood program: online policy review/membership renewal*. 2016 27/06/2016]; Available from: http://www.sunsmart.com.au/forms/default.asp?ContainerID=online-policy-review.
10. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
11. Dono, J., et al., *The relationship between sun protection policies and practices in schools with primary-age students: the role of school demographics, policy comprehensiveness and SunSmart membership.* Health Educ Res, 2014. **29**: p. 1-12.
12. Reynolds, K.D., et al., *School sun-protection policies: measure development and assesments in 2 regions of the United States.* J Sch Health, 2012. **82**: p. 499-507.
13. Eakin, P., et al., *Sun protection policy in elementary schools in Hawaii.* Prev Chronic Dis 2004. **1**(3): p. A05.

14. Jones, S.B.W., K. Beckmann, and J. Rayner, *Australian primary schools' sun protection policy and practice: evaluating the impact of the National SunSmart Schools Program.* Health Promot J Aust, 2008. **19**(2): p. 86-90.

Chapter 4
Study 2: A cross-sectional study of the proportion of the body covered by regulation uniforms at primary schools within the Townsville, Cairns and the Atherton Tableland regions

4.1 Introduction

For Caucasian populations, there is an established link between excessive ultraviolet radiation (UVR) exposure during the childhood years and naevi development [1-4]. The presence of many naevi, along with fair skin colour (Fitzpatrick skin type I or II [5]) are important melanoma risk factors [6-10]. The role of sun-protective clothing, such as shirts with elbow length sleeves, for reducing the development of new naevi in a population of young Townsville children has been documented [11, 12].

Queensland primary school children attend school for approximately 200 days a year, during peak UVR periods [13]. In Queensland, most primary schools enforce a uniform policy therefore most students wear a uniform to school [14]. The Australian Cancer Council's SunSmart school (SSS) program guidelines suggest a school uniform cover as much skin as possible, including the shoulder and mid-rift regions [15]. Additionally, the Queensland government's Department of Education and Training sun safety guidelines suggest that a school consider sun-protection when designing their uniform [16].

4.2 Australian clothing standard

It has been twenty years since the 'sun protective clothing – evaluation and classification' clothing standard (AS/NZS 4399:1996) was approved on behalf of both the Australian and the New Zealand Council of Standards [17]. The standard was chiefly designed to describe the relative sun-protection capabilities of textiles and clothing [18]. In 1990, the Australian government developed and trademarked the 'Ultraviolet Protection Factor' (UPF) rating scheme that is currently used to label sun-protective clothing in Australia [19, 20]. UPF ratings describe the percent of UVR blocked by a material as follows: UPF 15 or 20 (good protection; 93.3-95.9% UVR blocked), UPF 25, 30 or 35 (very good protection; 96-97.4% UVR blocked); and UPF 40, 45, 50 or 50+ (excellent protection; >97.5% UVR blocked) [20]. Before garments can be assigned a UPF label, a sample of the material must be tested by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to ensure that it complies with the minimum sun-protection requirements [19, 20]. The body surface area (BSA) covered by a garment is not considered when a UPF label is assigned. The current clothing standard is currently being reviewed by ARPANSA and it is expected to incorporate a BSA calculation [21].

4.3 Development of the research question

Despite the potential value of sun-protective clothing for reducing naevi development, studies that investigate the type of school uniforms worn by primary school aged children are absent. To determine the body surface area (BSA) covered by north Queensland primary school uniforms the following research question was developed:

> *What BSA is covered by regulation school uniforms at primary schools in Townsville (latitude 19.3˚S, longitude 146.8˚E), Cairns (latitude 16.87˚S, longitude 145.75˚E) and the Atherton Tablelands (Atherton: latitude 17.26˚S, longitude 145.48˚E)?*

To address this research question the following study was completed:

> *A cross-sectional study of the BSA covered by regulation uniforms at primary schools within the Townsville, Cairns and the Atherton Tableland regions. The maximum BSA which could be covered by school uniforms was determined and then the BSA covered by school uniforms was calculated and compared to this value. Schools were grouped according to school characteristics to investigate any potential influence of these characteristics over the BSA covered by school uniforms.*

The results of this study are presented in the following peer-reviewed manuscript.

4.4 Publication arising from study 2

Article as originally published in **Turner, D.** and Harrison, S. L. (2014). “Sun protection provided by regulation school uniforms in Australian schools: an opportunity to improve personal sun protection during childhood.” Photochemistry and Photobiology 90 (6): 1439-1445.

Refer to contribution statement for my contribution.

Photochemistry and Photobiology, 2014, 90: 1439–1445

Sun protection Provided by Regulation School Uniforms in Australian Schools: An Opportunity to Improve Personal Sun protection During Childhood

Denise Turner and Simone L. Harrison*

Skin Cancer Research Group, School of Public Health, Tropical Medicine and Rehabilitation Sciences, Anton Breinl Centre for Health Systems Strengthening, Australian Institute of Tropical Health and Medicine (AITHM), James Cook University, Townsville, Qld, Australia

Received 10 April 2014, accepted 25 June 2014, DOI: 10.1111/php.12312

ABSTRACT

Childhood sun exposure is linked to excessive pigmented mole development and melanoma risk. Clothing provides a physical barrier, protecting skin from ultraviolet radiation (UVR). Extending sleeves to elbow length and shorts to knee length has been shown to significantly reduce mole acquisition in preschoolers from tropical Queensland. We used publicly available uniform images and guidelines from primary schools in Townsville (latitude 19.25°S, *n* = 43 schools), Cairns (16.87°S, *n* = 46) and the Atherton Tablelands (17.26°S, *n* = 23) in tropical Australia to objectively determine the body surface proportion covered by regulation school uniforms. Uniforms of nongovernment, large (≥800 students), urban, educationally advantaged schools with comprehensive sun protection policies covered more skin than those of government schools (63.2% *vs* 62.0%; *P* < 0.001), smaller schools (63.4% *vs* 62.3%; *P* = 0.009), rural (62.7% *vs* 61.9%; *P* = 0.002) and educationally disadvantaged schools (62.8% *vs* 62.3%; *P* < 0.001) with underdeveloped sun protection policies (62.8% *vs* 62.2%; *P* = 0.002). Overall, SunSmart and non-SunSmart school uniforms covered identical body surface proportions (62.4%, *P* = 0.084). Although wearing regulation school uniforms is mandatory at most Australian primary schools, this opportunity to improve children's sun protection is largely overlooked. Recent evidence suggests that even encouraging minor alterations to school uniforms (*e.g.* slightly longer sleeves/dresses/skirts/shorts) to increase skin coverage may reduce mole acquisition and melanoma risk, especially in high-risk populations.

INTRODUCTION

Exposure to ultraviolet radiation (UVR) is causatively linked to cutaneous melanoma (CM) and epithelial skin cancer development (1–3) and Queensland, Australia has among the highest rates of these cancers in the world (4). UVR exposure during the childhood years is linked to the development of melanocytic nevi (pigmented moles) which are a risk factor for CM development (3,5–7) and children raised in geographical locations with high levels of ambient UVR, such as Queensland, develop more moles than those raised elsewhere (8–13).

Protecting the skin from the harmful effects of UVR during childhood by wearing suitable clothing such as long-sleeved shirts and hats reduces mole development and skin cancer risk (12,14–19). Clothing manufactured using tightly woven polyester blends, darker dyes (*e.g.* black and dark blue), UV-absorbing compounds (*e.g.* titanium dioxide) and durable press treatments (*e.g.* resin applications) that allow fabrics to retain their shape after repeated laundering can block UVR the skin would otherwise be exposed to (20–23). Hats physically cover the scalp; however, the amount of shade provided to the face and neck depends on hat style (*e.g.* broad-brim/visor/bucket), and how it is positioned on the head (24,25). Unlike sunscreen, clothing and hats provide a physical barrier between the skin and UVR. Disadvantages of sunscreen include the potential for uneven coverage and the need for regular reapplication (21).

Children spend a large proportion of their weekdays at school during peak UVR exposure times (26) and virtually all Australian schools expect students to wear regulation school uniforms, providing an ideal opportunity to improve personal sun protection. The SunSmart Schools (SSS) Program was introduced by the Cancer Council in 1988 to further encourage sun-protective behaviors in Australian schools (27–29). Australian SSS students are expected to wear sun-protective school uniforms (midriff and singlet tops are not appropriate) and broad-brim, legionnaire or bucket-style hats with a deep crown and minimum 6 cm brim when outdoors (30). Australian SSS must also formulate and implement a comprehensive sun protection policy and work toward scheduling outdoor activities to avoid peak UVR times and improving shade availability (31). Some schools in America, England, New Zealand, Scotland and South Africa have also recently introduced the SunSmart Program (32–36).

We describe the proportion of the body surface area (BSA) covered by the regulation primary school uniforms worn in the extreme UVR environment of North Queensland (NQ), Australia in relation to school demographics and SunSmart status.

MATERIALS AND METHODS

Publicly available school uniform data were obtained from primary schools in Townsville (latitude 19.25°S, longitude 146.77°E), Cairns (latitude 16.87°S, longitude 145.75°E) and the Atherton Tablelands (Atherton: latitude 17.26°S, longitude 145.48°E), NQ, Australia. Schools were

*Corresponding author e-mail: simone.harrison@jcu.edu.au (Simone Lee Harrison)

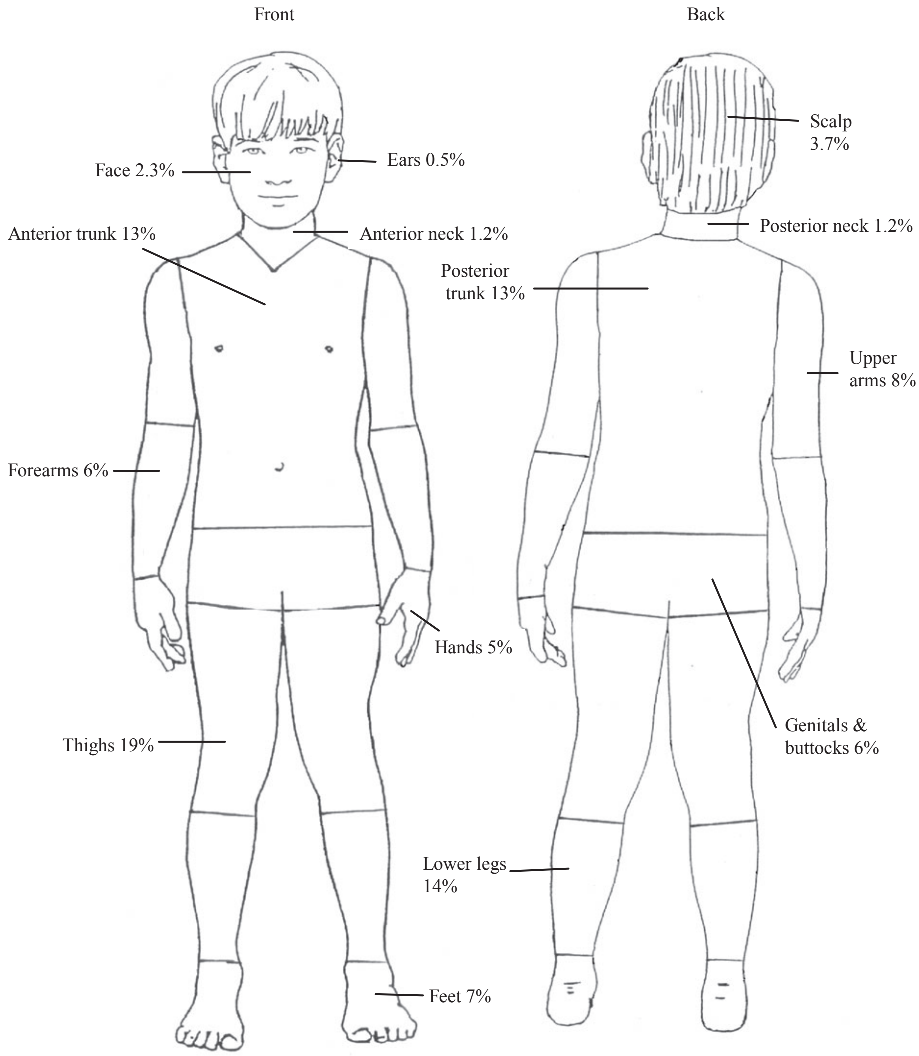


Figure 1. Body maps with predetermined percentages allocated to specific body regions and used to calculate body surface area (BSA) covered by regulation school uniforms. Body maps and predetermined percentages were adapted from publications 44–46.

included if they educated primary school-aged children (first 8 years of formal education; generally 5- to 12-year-olds). NQ has a tropical climate and experiences hot humid Summers, dry Winters and high levels of UVR year-round (37,38).

Regulation school uniform data were collected from school handbooks, prospectuses and/or websites from 2009 to 2013. School lists for the local government areas of Townsville, Cairns and the Atherton Tablelands were obtained from the Queensland Government Department of Education, Training and Employment (DETE) school directory which also assigned schools to the education zones (localities) of "provincial city/urban", "rural" or "remote" (39). The Cancer Council, Queensland verified the SunSmart status of schools while demographic data (*e.g.* school ownership; location; enrollment numbers) were obtained from links provided on the DETE website (40). Demographics unavailable from DETE such as nongovernment school enrollment numbers and the "Index of community socio-educational advantage" (ICSEA) were obtained from the Australian "My School" website (41). ICSEA uses student family background data to determine the level of educational advantage students bring to their studies and the mean value is set at 1000 (42). School sun protection policies were scored previously (median of 2 from a possible 12) using predetermined criteria (43).

The BSA covered by each school uniform was calculated using predetermined percentages allocated to specific body regions (44–46). Where multiple uniform options were provided (*e.g.* "girls may wear navy blue shorts or pleated skirt/skort") we analyzed the first option listed. Total BSA calculations excluded the head since shade provided by school hats varies according to the size and fit of each hat and the angle at which it is positioned on the head (25). Thus, the maximum BSA assessed was 93.4% (Fig. 1) incorporating the upper body (anterior and posterior neck and trunk, upper arms, forearms and hands = 47.4% BSA), midsection (genitals, buttocks and thighs = 25% BSA) and lower body (lower legs and feet = 21% BSA).

Example calculations of covered BSA. Upper body: neck collar (1%) + posterior trunk (13%) + anterior trunk (13% if collar buttoned or 12.6% if unbuttoned/not specified) + upper arms (sleeve covered ¾ of upper arms [6%]; covered arms to >2″ above elbow [5.3%]; covered ½ arm between elbow and shoulder (used for undefined sleeve lengths) [4%]; 1/3 upper arms covered [2.7%]; or cap sleeve [1%]).

Midsection: genitals and buttocks (6%) + thighs (thighs covered to knees [19%]; just above knees [17.7%]; ¾ thighs covered [used for undefined lengths; 14.3%]; or mid-thigh garment [11.4%]).

Lower body: feet (open sandals [4.5%] or whole foot covered [7%]) + lower legs (ankle-high and undefined socks; [4%]; midshin socks [5.6%]; or knee-high socks [12.6%]).

IBM SPSS Statistics version 19 (IBM SPSS, Inc., Chicago, Illinois) was used for data analysis. As numerical data were normally distributed, mean and standard deviation (SD) were used to describe the BSA covered by school uniforms. "Combined" uniform data represent the average BSA of male and female uniforms together. Independent groups *T*-test and ANOVA were used to assess differences in BSA according to school characteristics.

Ethics approval was obtained from James Cook University, although not formally required for evaluation of publicly available documents such as these.

RESULTS

Uniform data were obtained for 98.3% of 116 primary schools in the study area (uniform guidelines for two Atherton Tablelands schools were not found). Most schools were as follows: government owned (65.8%); enlisted in the SSS program (61.4%); had an ICSEA score ≤1000 (75.4%); had <400 students enrolled (50.0%) and a sun protection policy score ≤ 2 (Table 1).

BSA covered in relation to SunSmart status, school ownership and size

BSA covered by "combined" uniforms were statistically similar for SSS and NSSS with regard to total body (both 62.4%; $P = 0.084$), upper body (30.6% *vs* 30.7%; $P = 0.136$) and lower body (11.1% *vs* 10.9%; $P = 0.966$). Midsection coverage (mostly thighs) for the "combined" uniforms was 0.2% higher for NSSS than SSS ($P < 0.001$). Similarly, this coverage for female uniforms was 0.3% higher for NSSS than SSS ($P = 0.004$). "Combined" uniforms worn at nongovernment schools and schools with ≥800 students covered more BSA than those at government schools (63.2% *vs* 62.0%; $P < 0.001$) and smaller schools (63.4% *vs* 62.3%; $P = 0.009$). Female nongovernment school uniforms covered 1% more BSA and male nongovernment school uniforms covered 1.4% more BSA than equivalent government school uniforms ($P < 0.001$, respectively; Table 2). Male uniforms of large schools covered almost 2% more BSA ($P = 0.004$) than uniforms worn by boys attending smaller schools, mostly due to differences in lower body coverage (Table 2).

Table 1. School characteristics of 114 primary schools in Townsville, Cairns and the Atherton Tablelands in Queensland, Australia.

Characteristic		*N* (%)
Ownership	Government	75 (65.8)
	Nongovernment	39 (34.2)
SunSmart school*	No	44 (38.6)
	Yes	70 (61.4)
School size†	Small (1–399 students)	57 (50.0)
	Medium (400–799 students)	43 (37.7)
	Large (≥800 students)	14 (12.3)
ICSEA‡ status	≤mean (0–1000)	86 (75.4)
	>mean (1001+)	28 (24.6)
Locality§	Urban	73 (64.0)
	Rural	37 (32.5)
	Remote	4 (3.5)
Sun protection policy evaluation score¶	≤median (0–2)	68 (60.7)
	>median (3+)	44 (39.3)
Region	Townsville (latitude 19.25°S, longitude 146.77°E)	44 (38.6)
	Cairns (latitude 16.87°S, longitude 145.75°E)	46 (40.4)
	The Atherton Tablelands (latitude 17.26°S, longitude 145.48°E)	24 (21.1)

*SunSmart status as at December 2012; †Using 2008 enrollment data (40); ‡ICSEA – Index of community socio-educational advantage (42); §Locality refers to the education zone assigned to a school (39); ¶School sun protection policies were evaluated using predetermined criteria (43).

BSA covered in relation to school ICSEA score, location and sun protection policy score

"Combined" uniforms of schools with above average ICSEA scores covered 0.5% more total BSA than those from schools with lower ICSEA scores ($P < 0.001$; Table 3). Differences in BSA by ICSEA score were more marked for male (0.8%, $P < 0.001$) than female uniforms (0.2%, $P = 0.007$). On average, the "combined" uniforms of urban schools covered 0.8% more total BSA ($P = 0.002$) and up to 0.5% more of the midsection ($P = 0.021$) than uniforms of rural and remote schools. This difference was also statistically significant for male uniforms at urban *versus* rural/remote schools (1.1%, $P = 0.015$; Table 3). "Combined" uniforms of schools with higher sun protection policy scores covered 0.6% more BSA than those of schools with lower policy scores ($P = 0.002$; Table 3). This difference was more striking for male (0.8%, $P = 0.004$) than for female uniforms (0.4%, $P = 0.127$; Table 3).

Sun protection provided by hats

Broad-brim, bucket, legionnaire and caps provide physical coverage to the scalp. Broad-brim and bucket hats offer higher protection factor (PF) ratings for the cheeks and ears, whereas legionnaire hats offer good protection for the posterior neck (Table 4).

DISCUSSION

To our knowledge, this is the first study to evaluate the proportion of BSA covered by regulation school uniforms. We found that the uniforms of large, urban, nongovernment NQ primary schools, with higher ICSEA and sun protection policy scores (43) tended to cover more BSA than uniforms of smaller, rural/remote, government-operated or socio-educationally disadvantaged schools with less comprehensive sun protection policies. Increased BSA coverage could be associated with larger, urban and independently owned schools because greater financial resources and increased autonomy present the opportunity to redesign school uniforms; human and financial resources provide the capacity to develop and introduce new uniform guidelines; and parents have the resources to purchase these new uniforms over time. The findings from an earlier survey which suggested that Australian SSS uniforms tend to incorporate longer (elbow length) sleeves and pants than NSSS (47) were not supported in this region of northern Australia where the BSA protected by SunSmart and non-SunSmart School (SSS) uniforms was identical. However, no objective assessment of uniforms (*e.g.* BSA covered) was conducted by Jones and co-workers to validate their self-reported uniform data.

While some NQ schools allowed longer clothing to be worn for warmth during winter, our tropical study location meant such garments were not part of the usual uniform. However, some schools in Hawaii, which also has a tropical climate, offer long skirts, trousers and long-sleeved uniform options (36,48). A recent study of NQ outdoor workers found that the core body and mean skin temperatures of subjects performing manual labor was similar whether they wore long cotton drill pants or cotton

Table 2. Mean (SD) body surface area (BSA) (total and body site specific) covered by regulation school uniforms worn year-round by students of 114 primary schools in the Townsville, Cairns and Atherton Tablelands regions of North Queensland, Australia stratified by school SunSmart status, ownership and size.

BSA % (total or body region specific)	All schools (*n* = 114)	SunSmart school SSS (*n* = 70)	NSSS (*n* = 44)	*P* value	School ownership Nongovernment (*n* = 39)	Government (*n* = 75)	*P* value	School size Small** (*n* = 57)	Medium†† (*n* = 43)	Large‡‡ (*n* = 14)	*P* value
*Combined uniform**											
Total BSA†	62.4 (1.8)	62.4 (1.6)	62.4 (2.2)	0.084	63.2 (2.7)	62.0 (1.0)	<0.001	62.3 (1.7)	62.3 (1.1)	63.4 (3.3)	0.009
Upper body‡	30.7 (0.6)	30.6 (0.6)	30.7 (0.7)	0.136	30.9 (1.0)	30.6 (0.3)	<0.001	30.7 (0.4)	30.6 (0.1)	30.9 (1.7)	0.172
Midsection§	20.7 (1.2)	20.6 (1.0)	20.8 (1.4)	0.001	21.2 (1.5)	20.5 (0.9)	<0.001	20.7 (1.3)	20.7 (1.1)	20.8 (1.3)	0.901
Lower body¶	11.0 (1.0)	11.1 (1.0)	10.9 (1.0)	0.966	11.1 (1.8)	11.0 (0.0)	<0.001	10.9 (0.9)	11.0 (0.0)	11.7 (2.3)	<0.001
Female uniform											
Total BSA†	62.3 (1.7)	62.2 (1.2)	62.5 (2.3)	0.008	63.0 (2.4)	62.0 (1.1)	<0.001	62.3 (1.7)	62.2 (1.0)	62.8 (3.0)	0.604
Upper body‡	30.6 (0.6)	30.6 (0.6)	30.8 (0.7)	0.343	30.9 (0.8)	30.5 (0.5)	0.015	30.7 (0.4)	30.6 (0.1)	30.5 (1.7)	0.628
Midsection§	20.8 (1.3)	20.6 (1.0)	20.9 (1.6)	0.004	21.2 (1.6)	20.5 (0.9)	<0.001	20.7 (1.3)	20.6 (1.0)	21.2 (1.6)	0.402
Lower body¶	11.0 (0.6)	11.0 (0.2)	10.9 (1.0)	0.036	10.9 (1.1)	11.0 (0.0)	0.007	10.9 (0.9)	11.0 (0.0)	11.1 (0.4)	0.409
Male uniform											
Total BSA†	62.5 (1.9)	62.6 (1.9)	62.3 (2.0)	0.947	63.4 (2.9)	62.0 (0.8)	<0.001	62.2 (1.6)	62.4 (1.2)	64.1 (3.6)	0.004
Upper body‡	30.7 (0.6)	30.7 (0.6)	30.7 (0.7)	0.543	30.9 (1.1)	30.6 (0.0)	<0.001	30.7 (0.4)	30.6 (0.1)	31.2 (1.6)	0.005
Midsection§	20.7 (1.1)	20.6 (1.0)	20.8 (1.3)	0.095	21.1 (1.5)	20.4 (0.8)	<0.001	20.7 (1.2)	20.8 (1.2)	20.5 (0.7)	0.697
Lower body¶	11.1 (1.3)	11.3 (1.5)	10.9 (1.0)	0.336	11.3 (2.2)	11.0 (0.0)	<0.001	10.9 (0.9)	11.0 (0.0)	12.3 (3.1)	<0.001

SD = standard deviation; SSS = SunSmart school; NSSS = non-SunSmart school; *"combined" uniform refers to the average of male and female uniform data; †total BSA excludes the head thus was set to 93.4% instead of 100% for the purpose of this analysis. ‡upper body incorporates neck, trunk, upper arms, forearms and hands; §midsection incorporates genitals/buttock region and thighs; ¶lower body incorporates lower legs and feet; **small school defined as 1–399 students enrolled; ††medium school has 400–799 students; ‡‡large school has ≥800 students.

shorts under the same conditions (49). Likewise, high ultraviolet protection factor (UPF) T-shirts with elbow-length sleeves and below-knee shorts were well tolerated by NQ children in our randomized controlled trial of sun-protective clothing (16) and significantly reduced the number of moles they acquired at protected body sites (18), inferring reduced melanoma risk. These findings suggest that longer clothing styles could be used to improve sun protection at school, without causing heat stress, even in tropical regions.

Regulation school uniforms worn during the warmer months of the year, particularly in areas which experience extreme levels of UVR, should ideally be made of high UPF fabrics and protect as much skin as possible to reduce future skin cancer risk. Our results suggest that the efficacy of the SSS program could be improved by encouraging schools to use their uniforms to enhance childhood sun protection to reduce mole development and future melanoma risk. Schools (particularly small schools and those in rural/remote areas) could be provided with information about the proportion of BSA covered by their existing uniform and possible simple changes to uniform guidelines that increase BSA covered while ensuring the uniforms remain practical and comfortable for students (*e.g.* skirts/dresses/shorts to be at least knee length; sleeves to cover the arms to the elbows, etc). Information about optimal fabrics would also help schools that are contemplating changing their uniform (30). Our research group is currently conducting a pilot program in NQ primary schools to evaluate the effect that this and related sun protection compliance feedback (*e.g.* hat-wearing rates) has on improving sun protection at school. These data will serve as a valuable baseline from which changes in BSA protected by regulation school uniforms can be monitored over time.

In 1996, Australia was the first country to introduce a standard (AS/NZS 4399:1996) for evaluating sun-protective clothing (50). Evaluation is based on the UPF (*i.e.* a relative ranking of sun-protective capabilities) of the fabric, without taking into account garment design (50). Under the current standard, garments made of UPF 40–50+ fabrics (block ≥97.5% of erythemally effective UVR) are considered to provide "excellent protection", while UPF 15–20 textiles (absorb 93.3–95.8% of erythemally effective UVR) offer "good protection" (51). Given recent evidence that wearing clothing that covers more BSA helps protect children from developing excessive numbers of pigmented moles (16,18), consideration should be given to revising the current standard to include a composite sun-protective rating that considers both the UPF of the fabric and the BSA covered by the garment. Such a classification scheme would be more informative and would make selecting appropriate clothing easier for parents, and designing regulation uniforms easier for schools (and other organizations). Methods employed in the current research could be adapted for use in the revision, and are currently being refined by the authors with this purpose in mind.

Hats described in the NQ primary school uniform guidelines we evaluated included broad-brim, bucket and legionnaire styles. Bucket-style hats with the brim sloped downward, close to the face and ears, provide similar sun protection to broad-brimmed hats but are more popular among school students (25). The way a hat is positioned on the head, how well it fits and the size of the brim determine how much skin on the head and neck is shaded from the sun since hats intercept direct UV light and do not physically cover the face or neck (25,52,53). We included a comparison of the protection provided by caps since our observational research showed that some students wear caps at school even when they are not part of the uniform (54).

Our research is strengthened by the relatively large sample size which enabled us to infer that statistical differences found were a result of actual differences between groups and that lack of statistical difference was a result of group similarities. While some of these differences may seem small, they are important given that small increases in the BSA covered by clothing have been shown to slow the development of the major phenotypic risk marker (pigmented moles) for melanoma (18). Our research is unique because we independently collected and assessed

Table 3. Mean (SD) body surface area (BSA) (total and body site specific) covered by regulation school uniforms worn year-round by students of 114 primary schools in the Townsville, Cairns and Atherton Tablelands regions of North Queensland, Australia stratified by school ICSEA score, geographical location, locality and sun protection policy score.

BSA % (total or body region specific)	ICSEA score			Geographical location*				Locality†				Sun protection policy score‡		
	≤Mean (n = 86)	>Mean (n = 28)	P value	Townsville (n = 44)	Cairns (n = 46)	Tablelands (n = 24)	P value	Urban (n = 73)	Rural (n = 37)	Remote (n = 4)	P value	≤Median (n = 68)	>Median (n = 44)	P value
Combined uniform§														
Total BSA¶	62.3 (1.4)	62.8 (2.7)	<0.001	62.4 (1.8)	62.8 (1.9)	61.8 (1.5)	0.009	62.7 (2.0)	61.9 (1.3)	61.9 (0.0)	0.002	62.2 (1.6)	62.8 (2.1)	0.002
Upper body**	30.7 (0.6)	30.6 (0.7)	0.934	30.8 (0.9)	30.6 (0.5)	30.6 (0.0)	0.245	30.7 (0.7)	30.6 (0.0)	30.6 (0.0)	0.398	30.6 (0.3)	30.8 (0.9)	<0.001
Midsection††	20.6 (1.1)	21.1 (1.5)	<0.001	20.6 (1.2)	20.9 (1.4)	20.4 (0.7)	0.045	20.8 (1.4)	20.4 (0.7)	20.3 (0.0)	0.021	20.7 (1.2)	20.8 (1.2)	0.437
Lower body‡‡	11.0 (0.0)	11.1 (2.1)	<0.001	11.0 (0.2)	11.2 (1.3)	10.7 (1.3)	0.042	11.1 (1.0)	10.8 (1.1)	11.0 (0.0)	0.096	10.9 (0.8)	11.2 (1.3)	0.057
Female uniform														
Total BSA¶	62.3 (1.5)	62.5 (2.3)	0.007	62.3 (1.9)	62.7 (1.6)	61.8 (1.5)	0.116	62.6 (1.9)	61.9 (1.3)	61.9 (0.0)	0.135	62.2 (1.6)	62.6 (1.9)	0.127
Upper body**	30.7 (0.6)	30.5 (0.6)	0.992	30.7 (0.9)	30.6 (0.6)	30.6 (0.0)	0.780	30.7 (0.8)	30.6 (0.0)	30.6 (0.0)	0.902	30.6 (0.4)	30.7 (0.9)	0.004
Midsection††	20.6 (1.1)	21.2 (1.6)	<0.001	20.6 (1.2)	21.1 (1.5)	20.4 (0.7)	0.079	20.9 (1.5)	20.5 (0.8)	20.3 (0.0)	0.189	20.7 (1.2)	20.9 (1.3)	0.792
Lower body‡‡	11.0 (0.0)	10.8 (1.3)	0.001	11.0 (0.2)	11.0 (0.0)	10.7 (1.3)	0.130	11.0 (0.2)	10.8 (1.1)	11.0 (0.0)	0.296	10.9 (0.8)	11.0 (0.2)	0.326
Male uniform														
Total BSA¶	62.3 (1.4)	63.1 (3.0)	<0.001	62.6 (1.8)	62.9 (2.1)	61.8 (1.5)	0.078	62.9 (2.1)	61.8 (1.2)	61.9 (0.0)	0.015	62.2 (1.6)	63.0 (2.4)	0.004
Upper body**	30.7 (0.6)	30.8 (0.8)	0.338	30.8 (1.0)	30.7 (0.4)	30.6 (0.0)	0.248	30.8 (0.8)	30.6 (0.0)	30.6 (0.0)	0.343	30.6 (0.2)	30.9 (1.0)	<0.001
Midsection††	20.6 (1.1)	20.9 (1.3)	0.052	20.7 (1.2)	20.8 (1.2)	20.4 (0.7)	0.431	20.9 (1.3)	20.4 (0.6)	20.3 (0.0)	0.107	20.7 (1.2)	20.7 (1.0)	0.405
Lower body‡‡	11.0 (0.00	11.4 (2.6)	<0.001	11.0 (0.2)	11.4 (1.8)	10.7 (1.3)	0.129	11.3 (1.4)	10.8 (1.1)	11.0 (0.0)	0.255	10.9 (0.8)	11.4 (1.8)	0.009

SD = standard deviation; ICSEA = Index of community socio-educational advantage (42); *Education Queensland school directory listed schools as being in the local government areas of Townsville, Cairns and the Atherton Tablelands (39); †Education Queensland school directory classified schools to the education zones (localities) of "provincial city (urban)", "rural" or "remote" (39); ‡Sun protection policy scores were not publicly available for one school in the Townsville and another in the Atherton Tablelands region, thus only 112 schools were included. School sun protection policies were evaluated using predetermined criteria (43); §"combined" uniform refers to the average of male and female uniform data; ¶total body excludes the head thus the total BSA was set to 93.4% instead of 100% for the purpose of this analysis; **upper body incorporates neck, trunk, upper arms, forearms and hands; ††midsection incorporates genitals/buttock region and thighs; ‡‡lower body incorporates lower legs and feet.

Table 4. Summary of the protection provided to the head by different hat types found at 114 primary schools in the Townsville, Cairns and Atherton Tablelands regions.

	Hat type			
Body area	Broad brim (≥7.5 cm brim)	Bucket (2.5–7.5 cm brim)	Legionnaire	Cap
Protection factor provided				
Scalp	3.7	3.7	3.7	3.7
Ears	0.5	0.5	0.5	–
Posterior neck	–	–	1.2	–
Forehead	16 – ≥20	15–≥20	13–≥20	8.8–≥20
Cheeks	2.3–4.3	2.0–3.0	1.6	1.1–1.5
Nose	3.5–7.0	3.0–6.7	5.0	4.6–5.0
Ears	8.2	8.1	4.6	1.1
Chin	1.0–1.2	1.0–1.0	1.1	1.0–1.1
Neck	2.3–5.0	2.0–2.2	4.3	1.0–1.3

Protection factor data sourced from (24,25,52). Protection factor is dependent on factors such as hat positioning on head, hat size and fit; "–" data not found. Higher numbers denote better protection against ultraviolet radiation.

school uniform data rather than relying on self-reported data. Using publicly available school uniform guidelines may have been a limitation of this research since this might not reflect the most current information. However, we chose this approach since it reflects the information most accessible to parents.

In conclusion, regulation school uniforms/clothing should be a central component of sun protection in the school environment (simplest in countries where school uniforms are mandatory). The BSA covered by SunSmart and non-SunSmart school uniforms was identical at 62.4% from a possible 93.4%, suggesting that uniforms at SunSmart accredited schools do not provide superior sun protection; this provides an opportunity to strengthen the SunSmart program. The BSA covered by uniforms of NQ government schools, smaller schools, rural/remote and socio-educationally disadvantaged schools with underdeveloped sun protection policies tended to be less than that of their peers. These schools may benefit most from constructive feedback outlining potential modifications to uniforms to enhance the level of sun protection they provide to students. Lengthening the hem of shorts/skirts to below the knees and extending sleeves to elbow length can increase BSA covered by approximately 9.1% where redesigning the uniform is impractical (55). Such changes would benefit students, particularly those from intense UVR climates, since sun protection in early life helps prevent excessive mole development and consequent risk of melanoma.

Acknowledgements—The authors wish to thank Kendra Kamlitz (medical student from the University of North Dakota USA) for her assistance in the early stages of data collection and Dr Madeleine Nowak and Dr Petra Buettner for their assistance in reviewing this manuscript. The image in the graphical abstract was supplied courtesy of Queensland Health 2010.

REFERENCES

1. Kricker, A., B. K. Armstrong and D. R. English (1994) Sun exposure and non-melanocytic skin cancer. *Canc. Caus. Cont.* **5**, 367–392.
2. Dixon, H., R. Borland and D. Hill (1999) Sun protection and sunburn in primary school children: The influence of age, gender, and colouring. *Prev. Med.* **28**, 119–130.
3. Bauer, J. and C. Garbe (2003) Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data. *Pigment Cell Res.* **16**, 297–306.
4. Australian Institute of Health and Welfare, Australasian Association of Cancer Registries (2010) *Cancer in Australia: An Overview*. AIHW, Canberra.
5. Green, A. C., R. MacLennan and V. Siskind (1985) Common acquired naevi and the risk of malignant melanoma. *Int. J. Cancer* **35**, 297–300.
6. Skender-Kalnenas, T. M., D. R. English and P. J. Heenan (1995) Benign melanocytic lesions: Risk markers or precursors of cutaneous melanoma? *J. Am. Acad. Dermatol.* **33**, 1000–1007.
7. Sagebiel, R. W. (1993) Melanocytic nevi in histologic association with primary cutaneous melanoma of superficial spreading and nodular types: Effect of tumor thickness. *J. Invest. Dermatol.* **100**, 322S–325S.
8. Kelly, J. W., J. K. Rivers, R. MacLennan, S. L. Harrison, A. E. Lewis and B. J. Tate (1994) Sunlight: A major factor associated with the development of melanocytic naevi in Australian schoolchildren. *J. Am. Acad. Dermatol.* **30**, 40–48.
9. Harrison, S. L., R. M. MacKie and R. MacLennan (2000) Development of melanocytic nevi in the first three years of life. *J. Natl Cancer Inst.* **92**, 1436–1438.
10. Fritschi, L., P. McHenry, A. C. Green, R. M. MacKie, L. Green and V. Siskind (1994) Naevi in schoolchildren in Scotland and Australia. *Br. J. Dermatol.* **130**, 599–603.
11. Sander-Wiecker, T., H. Luther, P. G. Buettner, J. Bauer and C. Garbe (2003) Moderate sun exposure and nevus counts in parents are associated with development of melanocytic nevi in childhood: A risk factor study in 1, 812 kindergarten children. *Cancer* **97**, 628–638.
12. Harrison, S. L., R. MacLennan, R. Speare and I. Wronski (1994) Sun exposure and melanocytic naevi in young Australian children. *Lancet* **344**, 1529–1532.
13. Holman, C. D. and B. K. Armstrong (1984) Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: An analysis separating histogenetic types. *J. Natl Cancer Inst.* **73**, 75–82.
14. Enta, T. (1998) Melanocytic nevi in sun-protected Canadian Hutterite children. *Arch. Dermatol.* **134**, 379–381.
15. Autier, P., J. F. Dore, M. S. Cattaruzza, F. Renard, H. Luther, F. Gentiloni-Silverj, E. Zantedeschi, M. Mezzetti, I. Monjaud, M. Andry, J. F. Osborn and A. R. Grivegnée (1998) Sunscreen use, wearing clothes, and number of nevi in 6- to 7- year-old European children. *J. Natl Cancer Inst.* **90**, 1873–1880.
16. Harrison, S. L., P. G. Buettner and R. MacLennan (2005) The North Queensland "sun-safe clothing" study: Design and baseline results of a randomized trial to determine the effectiveness of sun-protective clothing in preventing melanocytic nevi. *Am. J. Epidemiol.* **161**, 536–545.
17. English, D. R., E. Milne and J. A. Simpson (2005) Sun protection and the development of melanocytic nevi in children. *Cancer Epidemiol. Biomarkers Prev.* **14**, 2873–2876.
18. Harrison, S. L., P. G. Buettner, R. MacLennan, J. Woosnam, J. Hutton and M. Nowak (2010) Sun-safe clothing helps to prevent the development of pigmented moles – Results of a randomised control trial in young Australian children. *Ann. ACTM* **11**, 49–50.
19. Smith, A., S. Harrison, M. Nowak, P. Buettner and R. MacLennan (2013) Changes in the pattern of sun exposure and sun protection in young children from tropical Australia. *J. Am. Acad. Dermatol.* **68**, 74–83.
20. Wong, J. C. F., I. Cowling and A. Parisi (1997) Reducing Human Exposure to Solar Ultraviolet Radiation. Proceedings of the First Internet Conference on Photochemistry and Photobiology Nov 17–Dec 19 1997. Available at: http://www.photobiology.com/v1/contrib.htm. Accessed on 28 June 2013.
21. Gambichler, T., M. Dissel, P. Altmeyer and S. Rotterdam (2010) Evaluation of sun awareness with an emphasis on ultraviolet protection by clothing: A survey of adults in Western Germany. *J. Eur. Acad. Dermatol. Venereol.* **24**, 155–162.
22. Sarkar, A. K. (2007) On the relationship between fabric processing and ultraviolet radiation transmission. *Photodermatol. Photoimmunol. Photomed.* **23**, 191–196.
23. Gies, P. (2007) Photoprotection by clothing. *Photodermatol. Photoimmunol. Photomed.* **23**, 264–274.

24. Downs, N. and A. Parisi (2008) Patterns in the received facial UV exposure of school children measured at a subtropical latitude. *Photochem. Photobiol.* **84**, 90–100.
25. Gies, P., J. Javorniczky, C. Roy and S. Henderson (2006) Measurements of the UVR protection provided by hats used at school. *Photochem. Photobiol.* **82**, 750–754.
26. Moise, A. F., P. G. Buttner and S. L. Harrison (1999) Sun exposure at school. *Photochem. Photobiol.* **70**, 269–274.
27. SunSmart Victoria (2012) *SunSmart. Our History*. Cancer Council Victoria, Victoria.
28. Cancer Council Victoria (2002) *SunSmart Program 2003–2006*. Cancer Council Victoria, Victoria.
29. Montague, M., R. Borland and C. Sinclair (2001) Slip! Slop! Slap! and SunSmart, 1980–2000: Skin cancer control and 20 years of population-based campaigning. *Health Educ. Behav.* **28**, 290–305.
30. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group (2005) *Being SunSmart – A Guide for Primary Schools*. The Cancer Council Australia, Victoria.
31. Cancer Council Queensland. SunSmart Policy Guidelines 2009. Available at: http://www.cancerqld.org.au/icms_docs/54253_Sun Smart_policy_guidelines.pdf. Accessed on 7 July 2009.
32. The Cancer Association of South Africa (CANSA) (2010) Be SunSmart: A Guide for Schools. Bedfordview, South Africa. Available at http://www.ehrn.co.za/sunsmart/download/schools_guide.pdf. Accessed on 20 January 2012.
33. Cancer Research UK (2009) Sun protection in Schools. SunSmart. London. Cancer Research, UK. Cancer Research UK. Available at: http://sunsmart.org.uk/schools. Accessed on 15 January 2013.
34. Reeder, A. I., J. A. Jopson and A. Gray (2012) Primary school sun protection policies and practices 4 years after baseline – A follow up study. *Health Educ. Res.* **27**, 844–856.
35. Reynolds, K. D., D. B. Buller, S. A. French, M. K. Buller and J. L. Ashley (2012) School sun-protection policies: Measure development and assesments in 2 regions of the United States. *J. Sch. Health* **82**, 499–507.
36. Cassel, K. D. and J. A. Burns (2010) Sun safe kids", implementing a low cost, school-based public policy to protect Hawai'i's children from skin cancer risks. *Hawaii Med. J.* **11**, 274–277.
37. Bureau of Meteorology (2011) Climate Statistics for Australian sites. Australian Government. Available at: http://www.bom.gov.au/climate/data. Accessed on 25 March 2014.
38. Bureau of Meteorology (2012) Average solar Ultraviolet (UV) Index. Australian Government. Available at: http://www.bom.gov.au/jsp/ncc/climate_averages/uv-index/index.jsp?period=jul#maps. Accessed on 25 March 2014.
39. Department of Education, Training and Employment (2009). Schools directory. Advanced search. Department of Education Training and Employment, Australia. Available at: http://education.qld.gov.au/directory/schools/advanced-search.html Accessed on 10 February 2013.
40. Department of Education, Training and Employment (2009). State School Full-Time Enrolment Counts, Census 2005–2009. Department of Education Training and Employment, Australia. Available at: http://education.qld.gov.au/schools/statistics/enrolments.html. Accessed on 12 April 2010.
41. Australian Curriculum Assessment and Reporting Authority. My School 2013. Available at: http://www.myschool.edu.au. Accessed on 11 January 2013.
42. Australian Curriculum Assessment and Reporting Authority (2012) My School. Guide to Understanding ICSEA. ACARA, Sydney, Australia. Available at: http://www.acara.edu.au/verve/_resources/About__ICSEA.pdf#search=ICSEA. Accessed on 22 March 2014.
43. Turner, D., S. Harrison, P. Buettner, M. Nowak (2014) School sun-protection policies–does being SunSmart make a difference? *Health Educ. Res.* **29**(3), 367–377. 2014 Mar 20. doi: 10.1093/her/cyu010. [Epub ahead of print].
44. Lund, C. C. and N. C. Browder (1944) Estimation of areas of burns. *Surg. Gynec. Obstet.* **79**, 352–358.
45. Pearl, D. K. and E. L. Scott (1986) The anatomical distribution of skin cancers. *Int. J. Epidemiol.* **15**, 502–506.
46. Harrison, S. L. (1999) The development of melanocytic naevi (moles) in children born and raised in tropical Australia. Ph.D. thesis, James Cook University, Townsville.
47. Jones, S. B. W., K. Beckmann and J. Rayner (2008) Australian primary schools' sun protection policy and practice: Evaluating the impact of the National SunSmart Schools Program. *Health Promot. J. Austr.* **19**, 86–90.
48. Eakin, P., J. Maddock, A. Techur-Pedro, R. Kaliko and C. Derauf (2004) Sun protection policy in elementary schools in Hawaii. *Prev. Chronic Dis.* **1**, A05.
49. Sinclair, W. H. and J. C. Brownsberger (2013) Wearing long pants while working outdoors in the tropics does not yield higher body temperatures. *Aust. NZ J. Public Health* **37**, 70–75.
50. Standards Australia/Standards New Zealand. Sun protective clothing – evaluation and classification (1996) *AS/NZS 4399*. Standards Australia, Sydney.
51. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Australian Clothing Standard (2012). Available at: http://www.arpansa.gov.au/uvrg/rginfo_p17.cfm. Accessed on 29 July 2013.
52. Downs, N. J. and A. V. Parisi (2006) Comparing variations in the UV facial exposure received by school children in South-East Queensland. Proceedings of the Australian Institute of Physics 17th National Congress. December 3-8 2006.
53. Kimlin, M. and A. Parisi (1999) Ultraviolet Protective Capabilities of Hats Under Two Different Atmospheric Conditions. 2nd Internet Photochemistry and Photobiology Conference July 16–Sep 7 1999. Available at: http://www.photobiology.com/photobiology99/ Accessed on 29 July 2013.
54. Turner, D., S. Harrison, P. Buettner and M. Nowak (2014) Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure. *Prev. Med.* **60**, 107–114.
55. Trapp, D., S. Harrison, M. Nowak and P. Buettner (2010) An evaluation of the sun protective practices of Townsville primary school students. *Ann. ACTM* **11**, 50.

4.5 Additional data from study 2

Additional data from study 2 and a description of these data can be found in Appendix 4.

4.6 Summary and future directions

The regulation school uniform assessed for most schools was a combination of polo shirt, mid-thigh length shorts, ankle length socks and enclosed shoes. It may be helpful for school staff to consult with members of their school community, skin cancer specialists and clothing manufacturers to design a durable, comfortable and sun-protective uniform that is made using UPF 50+ materials and covers a substantial proportion of the body. To my knowledge, the literature does not provide a recommendation that clothing which covers a specific BSA be worn by school students to reduce excessive sun-exposure. However such a recommendation, or at least a recommendation that school uniforms include longer sleeve (for example, elbow length) and pant (for example, knee length) lengths, might be advantageous. As mentioned in section 4.2 above, the revised Australian clothing standard AS/NZS 4399:1996 is expected to include a BSA recommendation. It could be suggested that a clothing standard specifically for school uniforms be established and that school communities were encouraged to consider the suitability of their uniforms according to the standard.

If school uniforms were modified to cover more of the body than the uniforms assessed, school children might be less reliant on other forms of sun-protection, such as sunscreen, to protect themselves from excessive UVR. Sunscreen can be a useful form of personal sun-protection however it needs to be applied correctly and regularly reapplied to be effective [22-24]. Since it has been shown that primary school aged children often inadequately apply sunscreen [25], it may be helpful to explain to school communities that multiple methods of sun-protection, including sun-protective clothing, hats, sunscreen, sunglasses and shade, should be used to reduce excessive UVR exposure at school [26].

4.7 Introduction to following chapter

School sun-protection policies should state that students are encouraged to seek and use shade when outdoors [16, 27]. However, we found it was impossible to measure shade availability at north Queensland primary schools using publicly available documents (as policies and uniforms were assessed during studies 1 and 2). Therefore, to determine how much shade is available at schools, one would need to manually calculate shade-availability at each school for the period of time of interest. A thorough shade-audit can be conducted using shade-planning software called WebShade® and data collected on-site at school. At the commencement of study 3, WebShade® had not been used to estimate shade availability at school without using data collected on-site at school. The following chapter describes a new, remote method to measure shade using WebShade® (which did not require entry onto school property) which was developed by us.

4.8 List of references

1. Kricker, A., B.K. Armstrong, and D.R. English, *Sun exposure and non-melanocytic skin cancer.* Cancer Cause Control, 1994. **5**: p. 367-392.
2. Bauer, J. and C. Garbe, *Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data.* Pigm Cell Res, 2003. **16**(3): p. 297-306.
3. Fritschi, L., et al., *Naevi in schoolchildren in Scotland and Australia.* Br J Dermatol, 1994. **130**(5): p. 599-603.
4. Autier, P., et al., *Sunscreen use, wearing clothes, and number of nevi in 6- to 7-year-old European children.* J Natl Cancer Inst, 1998. **90**(24): p. 1873-1880.
5. Fitzpatrick, T.B., *The validity and practicality of sun reactive skin types I through VI.* Arch Dermatol, 1988. **124**: p. 869-871.
6. Clark, W.H., et al., *A study of tumor progression: The precursor lesions of superficial spreading and nodular melanoma.* Hum Pathol, 1984. **15**(12): p. 1147-1165.
7. Green, A.C., R. MacLennan, and V. Siskind, *Common acquired naevi and the risk of malignant melanoma.* Int J Cancer, 1985. **35**(3): p. 297-300.
8. Swerdlow, A.J., et al., *Benign melanocytic naevi as a risk factor for malignant melanoma.* Br Med J, 1986. **292**: p. 1555-1559.
9. Garbe, C., et al., *Risk factors for developing cutaneous melanoma and criteria for identifying persons at risk: multicenter case-control study of the central malignant melanoma registry of the German Dermatological Society.* J Invest Dermatol, 1994. **102**: p. 695-699.

10. English, D.R., E. Milne, and J.A. Simpson, *Sun protection and the development of melanocytic nevi in children.* Cancer Epidemiol Biomarkers Prev, 2005. **14**(12): p. 2873-2876.
11. Harrison, S.L., et al., *Sun-safe clothing helps to prevent the development of pigmented moles - Results of a randomised control trial in young Australian children.* Annals of the ACTM, 2010. **11**(2): p. 49-50.
12. Harrison, S.L., P.G. Buettner, and R. MacLennan, *The North Queensland "sun-safe clothing" study: design and baseline results of a randomized trial to determine the effectiveness of sun-protective clothing in preventing melanocytic nevi.* Am J Epidemiol, 2005. **161**(6): p. 536-545.
13. Moise, A.F., P.G. Buttner, and S.L. Harrison, *Sun exposure at school.* Photochem Photobiol, 1999. **70**(2): p. 269-274.
14. Department of Education and Training. *Student dress code*. 2016 01/07/2016]; Available from: http://ppr.det.qld.gov.au/education/management/Pages/Student-Dress-Code.aspx.
15. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group. *Being SunSmart - a guide for primary schools*. 2005; Available from: http://www.sunsmart.com.au.
16. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
17. Australian Radiation Protection and Nuclear Safety Agency. *Australian clothing standard*. 2012 22/08/2015]; http://www.arpansa.gov.au/services/upf/index.cfm]. Available from: http://www.arpansa.gov.au/uvrg/rginfo_p17.cfm.
18. Joint technical committee TX/21, *Australian/New Zealand Standard. Sun protective clothing - evaluation and classification*. 1996, Standards Australia and Standards New Zealand: Australia and New Zealand.
19. Australian Radiation Protection and Nuclear Safety Agency. *UPF trademark information*. 2015 04/07/2016]; Available from: http://www.arpansa.gov.au/uv/UPFTrademark.cfm.

20. Australian Radiation Protection and Nuclear Safety Agency, *The UPF Certification Trade Mark and labelling of sun protective products*. 2014, Australian Government: Victoria, Australia.
21. Gies, P. and T. Slevin. *Revision of the sun protection clothing standard AS/NZS 4399*. in *3rd International UV and skin cancer prevention conference*. 2015. Melbourne, Australia.
22. Cancer Council Australia. *SPF 50+ sunscreen*. Preventing cancer 2016 10/09/2016]; Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/preventing-skin-cancer/spf50sunscreen.html.
23. Cancer Council Victoria. *Slop on sunscreen*. 2016 27/06/2016]; Available from: http://www.sunsmart.com.au/uv-sun-protection/slop-on-sunscreen.
24. Diffey, B., *When should sunscreen be reapplied.* J Am Acad Dermatol, 2001. **45**: p. 882-885.
25. Diaz, A., et al., *The children and sunscreen study. A crossover trial investigating children's sunscreen applicatin thickness and the influence of age and dispenser type.* Arch Dermatol, 2012. **148**(5): p. 606-612.
26. Cancer Council Victoria. *Slip, slop, slap, seek & slide: Sid Seagull*. SunSmart 2016 10/09/2016]; Available from: http://www.sunsmart.com.au/tools/videos/current-tv-campaigns/slip-slop-slap-seek-slide-sid-seagull.html.
27. The Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, *Being SunSmart - a guide for primary schools*, The Cancer Council South Australia, Editor. 2005, The Cancer Council: Carlton. p. 22.

Chapter 5
Study 3: A methods comparison study of two shade-estimation methodologies

5.1 Introduction

For studies 1 and 2 (Chapters 3 and 4, respectively) publicly available documents were used to assess the comprehensiveness of sun-protection policies and the body surface area covered by school uniforms of north Queensland primary schools. Currently (2016) there are no publicly available documents relating to shade at north Queensland primary schools. The purpose of study 3 was to encourage schools to become more interested in shade and to determine if a less intrusive way of measuring shade at schools could be developed than the established WebShade® (shade planning computer software) shade-audit (SA) method which had been used to measure shade at primary schools and childcare centres in Australia and New Zealand [1-3]. Shade data calculated during study 3 will also be used in future research to describe shade availability at schools. The following sections describe the importance of shade at schools and how shade has been previously measured at schools.

5.1.1 The value of shade in the school environment

Built shade structures, such as covered walkways and shade sails, with large floor areas and ultraviolet radiation (UVR) resistant roof materials, such as steel roof sheeting, can provide shelter for many individuals from excessive direct and indirect UVR [4]. Large trees with dense canopies are also beneficial in the school environment since they may shelter many people from excessive UVR and might improve local environmental conditions, such as soil and air quality [4-6]. Trees that are adjacent to built structures may also reduce indirect UVR entry into the built structures [4]. Throughout the school day, students should have access to quality shade, that is, shade which protects against UVR where and when it is needed [4]. In the school environment, a mixture of built and natural shade sources may be required to ensure quality shade is available for student use [4]. Most Australian primary school operational hours are approximately 9am to 3pm [7] therefore school hours typically include the peak UVR period of the day [8]. When the ultraviolet index (UVI) is 3 or greater, the Australian Cancer Council recommends that individuals slip (on a shirt), slop (on sunscreen), slap (on a hat), seek (shade) and slide (on sunglasses) [9]. Shade should be considered an important component of a school's sun-safety strategy since children can use shaded locations to shelter from excessive UVR during school recess breaks and outdoor classes in conjunction with other forms of sun-protection [4].

5.1.2 Australian primary school shade requirement

Schools that are accredited by the Australian Cancer Council as a SunSmart school (SSS) should ensure that their school environment has enough shade available for students to use during the school day, work towards improving shade availability at their school and encourage students to use shade when outdoors (refer to Chapter 3) [10, 11]. However the SSS application (and/or renewal) process does not require any school to quantify the amount or type (for example, natural shade from tree canopies or built shade from shade sails) of shade available at their property [10, 11]. According to the Queensland government's Department of Education and Training sun safety guidelines, government owned schools are expected to maximise the use of shade for outdoor activities (refer to Chapter 3) [12]. However, these schools are not required to quantify or report their shade availability [12]. Thus, it seems likely that most Australian primary schools are expected to provide shaded locations and encourage students to use shade without being required to report or increase shade availability.

On the other hand, Australian childcare centres are governed by the Queensland Development Code (part 22) which clearly defines shade requirements [13]. This code stipulates that childcare centres must provide at least five square metres of outdoor usable space per child and that at least one square metre of this space must be shaded [13, 14]. Furthermore, at least half of the outdoor shaded area provided at childcare centres should be roofed with a water and UVR resistant material [14]. Conversely, Australian primary schools are not required to abide by mandatory shade provision guidelines that stipulate how much shade should be available at school or per student. Yet, schools are expected to abide by guidelines for requirements such as formal seating (schools must provide 100mm length of seating per student) and litter disposal (schools must provide one bin per 30 students) [15].

5.1.3 Previously reported attempts to quantify shade availability at schools

Early research which investigated shade availability at Australian primary schools, manually calculated the visibly shaded and unshaded areas from school aerial images [16, 17]. Milne and colleagues commissioned the services of a pilot and a photographer to capture aerial photographs of each school between noon and 1pm [16]. Researchers then met with school staff to ascertain the areas available and unavailable for student use on each aerial photograph and marked the areas accordingly [16]. Buildings, trees, under-cover play areas, covered walkways, balconies and school boundaries were identified on these aerial photographs and the proportion of the school area that was shaded was calculated [16]. Milne and colleagues (1999) also used Geographical Information System software to calculate shaded and unshaded surface areas based on the same school images. Compared to the manual calculation of shade using photographs, the software over-estimated shade provision by approximately 20%, however the less laborious nature of this approach prompted Milne and colleagues (1999) to suggest that more studies in this area were warranted.

While other research has commented on shade availability at Australian and international schools, these have relied on self-completed survey responses from school staff or visual estimations of small play areas within a school property to approximate shade availability [18-23]. For example, Reeder and colleagues (2009), Jones and colleagues (2008) and Buller and colleagues (2002) surveyed one staff member from each of 242 New Zealand, 932 Australian and 412 American primary schools respectively to ascertain if enough shade was available at these schools or if an attempt was being made to improve shade availability at school. On-site measurements of shade were not made during these studies. Aulbert and colleagues (2009) visited one German kindergarten and visually estimated the proportion of a play area that was shaded. Similarly, Hunter and colleagues (2010) visually assessed the playgrounds at 22 American primary schools and categorised each playground to be partly, mostly or fully shaded. Overall it seems that previous studies which estimated shade availability at school may have been expensive, laborious and/or possibly affected by responder bias or measurement error. Also, it appears that a ‘gold-standard’ method to reliably measure shade at schools has not been developed.

5.1.4 Current shade estimation method for Australian schools

Australian schools currently interested in quantifying shade are directed to the online shade audit resource provided by the Victorian Cancer Council [24]. This resource includes a series of questions related to site usage (for example, who uses it, when is it used, duration of use, clothing worn by users), existing built shade (for example, presence of built structures and the condition of their materials), existing natural shade (for example, tree type, age and foliage density), shaded infrastructure (for example, whether seats and benches are shaded by aforementioned sources or whether infrastructure could be moved to a location currently shaded) and barriers to use (for example, accessibility and aesthetics of location) [25]. The New South Wales (Australia) Cancer Institute offers “evidence to practice grants” which require schools and organisations to complete the online shade-audit before applying for shade-related funding, reinforcing the value of shade assessments [26]. However, a thorough shade assessment should account for school boundaries, student out-of-bounds areas and the dimensions of all built structures and trees on-site (that is, on a school property), and not rely on visual estimations alone to estimate shade availability [3]. The heights of built structures and trees are especially important since a shade calculation for any time of interest is reliant on the position of the sun in conjunction with the heights of all built structures and trees present [4, 27].

5.1.5 WebShade® shade planning software

WebShade® is a shade planning software that was developed by Australian architects and is endorsed by the Australian Cancer Council [3, 4]. At the commencement of study 3, we believed that the WebShade® shade-audit method was the best method available to measure shade at schools. However, no formal validation studies were found. WebShade® had been used to measure shade at New Zealand schools and school staff members had reported that the shade-related data produced using WebShade® were useful when planning outdoor activities at school [2]. Similar reports of the usefulness of shade-related data calculated with other shade-planning computer programs were not found.

Images, such as Google Earth photos, architectural plans and freehand drawings, of school sites, parks, residential areas etc. can be uploaded into WebShade® and then the dimensions of built structures and trees on-site can be 'digitised' onto a school image with the program's 'drawing tools' so that the dimensions can be used to calculate shaded areas that result from these built structures and trees. Digitisation is the process of converting information on an image into a format that can be processed by computer software [28]. WebShade® drawing tools include 'free form' (allows the user to click on the visible edges of a built structure, school boundary etc. so that straight lines are drawn that represent the size and shape of the built structure, boundary etc.), 'rectangle' (allows the user to draw a rectangle with specific dimensions on the image that represents the size and shape of a built structure), 'shade structure' (allows the user to click on the outer points of a shade structure, such as a shade sail, to represent the size and shape of the structure) and tree (allows the user to insert a circle shape that represents the size of a tree canopy). The drawing tools can be used to distinguish between built structures that have walls and a roof (for example, a closed in building) and built structures that have a roof but no walls (for example, an under-croft area, a shade sail or covered walkway). Tree type can be specified as deciduous or evergreen and tree foliage density (for example, light or heavy) can be assigned. A school image on which built structures and trees have been digitised with the WebShade® drawing tools can be found below (Figure 1).

Figure 1: WebShade® screenshot of a school image where the outlines of trees and built structures have been drawn.

Figure 1 illustrates how a Google Earth aerial image of a school can be ‘drawn’ on with WebShade® drawing tools so that built structures and trees are digitised. Trees are represented by green circles on this school image. Dark blue shapes represent shade structures such as shade sails or covered walkways (structures that have a roof but no walls) while light blue shapes represent buildings with a roof and walls. Student out-of-bounds areas are marked by red. The school boundary is marked by a black line.

The ‘shade projection’ capabilities of WebShade® can provide a visual representation of shaded areas (represented by dark grey coloured areas on an image) and unshaded areas for any time of the day and for any date of interest (refer to Figure 2 below). For example, a school could use WebShade® to produce a customised shade report which details shade availability as a proportion of the school’s total area and identifies locations within the school boundary that are associated with high levels of sun-exposure throughout the day for any date. The dimensions and potential locations of proposed shade structures can also be represented on a school image for inclusion in subsequent shade projections so that the user can visualise the effect, in terms of shade provision, that these future structures will have at locations of interest. Schools can purchase a WebShade® software license and conduct their own shade audit or employ a WebShade® consultant to visit their school, collect the required data and subsequently produce a shade report.

Figure 2: WebShade® screenshot of a shade projection.

Figure 2 illustrates how WebShade® presents a dark grey colour to illustrate the location of shade at a time of interest.

5.2 Development of the research question and study design

A thorough WebShade® shade-audit (SA) can produce shade-related data which could be used to help schools better plan their outdoor activities according to where the best shade is available at any given time [1, 2]. However, WebShade® is not free to use (that is, one must purchase a license to use the software) and many measurements of school built structures and trees are required to conduct a thorough WebShade® SA therefore SAs might be laborious and expensive. To determine if shade availability at schools can be estimated with WebShade®, but without visiting a school to collect on-site measurements, the following research question was formulated:

> *Can a method to remotely measure shade availability at schools be developed?*

To address this research question, the following study was completed:

> *A methods comparison study of two shade-estimation methodologies. A remote, off-site, approach to shade-estimation was developed and tested at a sample of north Queensland primary schools. Data obtained this way (i.e. off-site, remote-estimation method) were compared to those obtained using the WebShade® shade-audit method (i.e. on-site) method at the same schools.*

5.3 Methods

5.3.1 Ethics statement

The study was approved by James Cook University (approvals H3365 and H5279), Education Queensland (ref 11/54273) and the Catholic Diocese of Townsville (2011-06). Ethics approval documents can be found in Appendix 1.

5.3.2 Study population

The Queensland Government's Department of Education and Training school directory was used to obtain the names of primary schools in Townsville, Cairns and The Atherton Tablelands regions (as described in chapter 3). A total of 116 primary schools were identified for these geographical regions (Townsville n=44, Cairns n=46 and the Atherton

Tablelands region n=26). Not every school was invited to participate in this study because there were insufficient project funds and time available to collect the data from all 116 schools. Prior to contacting schools to invite them to participate in this study, research staff acknowledged that at least one research assistant would be required to attend each school to collect the necessary on-site data for the shade-audit method. It was also assumed that multiple days per school might be required for data collection purposes. A convenience sample of 29 primary schools were invited by telephone or email to participate in this study (7 from the Atherton Tablelands region, 16 from Townsville and 6 from Cairns). These schools were chosen because they were close to our research offices, or because their principal had previously expressed interest in participating in research conducted by our group. Of these schools, 27 (response rate: 93.10%) agreed to participate (two Cairns primary schools did not participate). An information letter and a consent form were sent to these schools (Appendix 1).

5.3.2.1 School descriptive information

The Cancer Council Queensland verified the SunSmart status of schools via email while school ownership, geographical location, ‘Index of community socio-educational advantage’ (ICSEA) score and student enrolment number were obtained from links provided on the Department of Education and Training website and the Australian ‘MySchool’ website [29-31]. ICSEA uses student family background data to determine the level of educational advantage that students bring to their studies and the mean value is set at 1000 for Australian schools [32]. An ICSEA score of 500 would represent a school with extremely educationally disadvantaged students while a value of 1300 would represent a school with very educationally advantaged students [32]. School sun-protection policies were scored previously using pre-determined criteria as described in Chapter 3 [33].

5.3.3 Potential effect-modifiers considered during study 3

To compare the agreement of the remote shade-estimation (RS) method data with the shade-audit (SA) method data, schools were grouped according to potential effect-modifiers which we considered would influence the adequacy of the RS method. These potential effect-modifiers were the proportion of built structures which were single-storey, the proportion of classroom buildings that were single-storey, the total usable land area, and the proportion of the school area that was green-space. The following sections describe how schools were grouped according to these potential effect-modifiers.

5.3.3.1 The proportion of built structures which were single-storey

We considered the accuracy of the RS method to estimate built shade (and consequently combined shade) at schools may have been influenced by the proportion of single-storey built structures (for example classroom buildings, shade sails, covered walkways etc.) present at schools. We anticipated built structure heights might be important for shade-related measurements because taller built structures cast a larger shadow than shorter built structures and multi-storey buildings might have under-croft areas and/or balconies that cannot be identified using the RS method. The data collected on-site (SA method) were used to determine the number of built structures at each school that were single-storey and multi-storey respectively. The proportion of built structures which were single-storey was then calculated for each school. Instead of grouping schools according to the mean proportion of these structures, they were grouped according to an arbitrary cut-off value of 89% to identify schools with mostly single-storey built structures. We considered that future studies investigating shade availability at schools might benefit from the cut-off value of 89%, rather than the mean proportion calculated for our sample, since it would allow investigators to view school images and easily determine if most (approximately 9 out of 10) built structures were single-storey.

5.3.3.2 The proportion of classroom buildings which were single-storey

We considered the validity of the RS method at estimating built shade may have been better at schools where most of the buildings were single-storey since these schools would have fewer under-croft and/or balcony areas that would be missed using the RS method. The SA data were used to determine the number of classroom buildings (or buildings that were accessible to students) that were single-storey and multi-storey respectively. Classroom buildings and administration buildings (collectively referred to as ‘classroom buildings’ from this point forward) were included in the calculation because the purpose of this grouping was to identify schools that had numerous buildings that may have had under-croft areas and/or balconies. Toilet blocks, shade sails, storage sheds and covered walkways were excluded from the calculation since these built structures were unlikely to have under-croft areas and/or balconies. Instead of grouping schools according to this mean value, an arbitrary cut-off value of 89% was used to identify schools at which most classroom buildings were single-storey. The cut-off value of 89% was chosen to allow future investigators to view school images and easily determine if most (approximately 9 out of 10) buildings were single-storey.

5.3.3.3 The total usable land area

The aim of grouping the schools according to land size area was to ascertain if the size of a school's usable area potentially influenced the validity of the RS method. The SA data collected on-site at schools were used to calculate the total usable area within each school boundary. Schools were grouped according to whether their usable land area was above or below the median land size area for our school sample.

5.3.3.4 The proportion of the school area that was green-space

We considered the agreement between the natural shade (and consequently combined shade) data calculated using the RS and the SA methods may have been better at schools with large amounts of green-space since these schools potentially had more trees than schools with less green-space. Google Earth aerial images of each school were used to visually estimate if up to 74% of a school property was comprised of sporting fields, landscaped areas, gardens etc. (green-space) or if at least 75% of the property was green-space. The aim of the 74% cut-off was to identify schools with large areas of green-space.

5.3.4 Shade-audit (SA) methodology

An aerial image of each school was obtained from Google Earth [34]. These images showed bird's eye views of the entire school properties. The Google Earth compass feature was used to identify the north direction on each image since WebShade® required the location of north to predict the position of shade. After obtaining permission from schools, the research assistant entered school property to measure school boundaries, built structure dimensions (height, width and depth) and features (for example, construction material and condition), tree dimensions (canopy diameter and tree height) and special features (for example, foliage density), and student out-of-bounds areas.

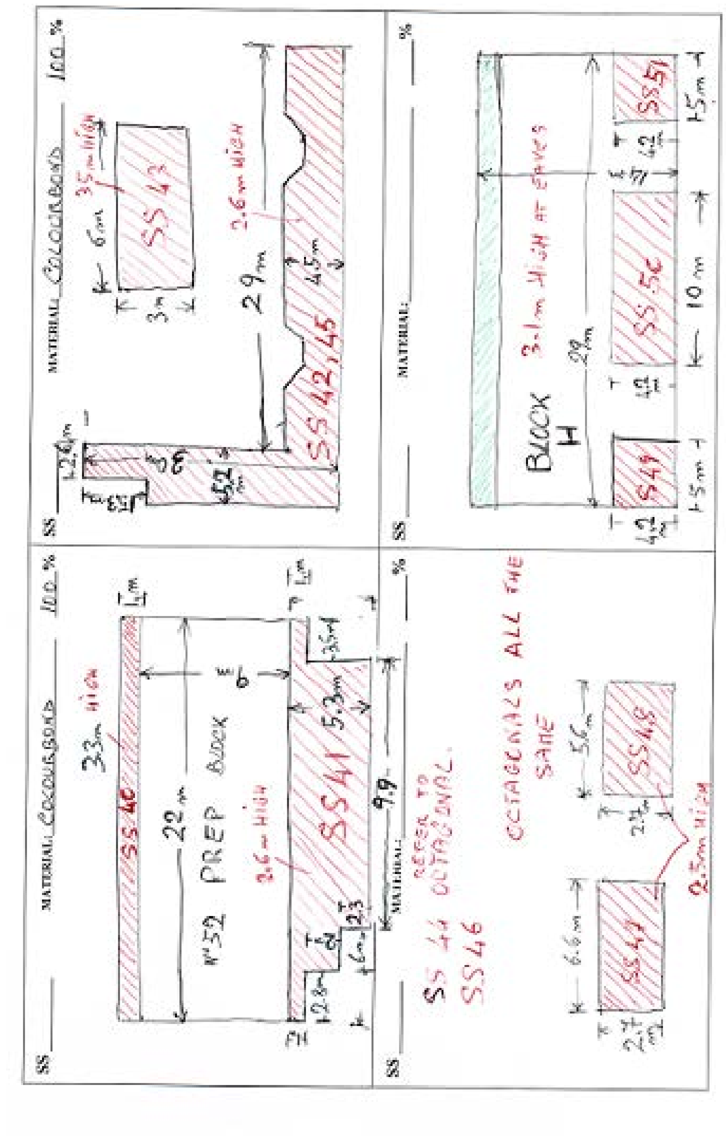
5.3.4.1 School boundary and unusable areas

Each school boundary was measured with a surveyor's wheel (T.T.L model JC316). The boundaries of out-of-bounds areas were measured with either an 8m retractable tape measure or a surveyor's wheel. Measurements were recorded on the WebShade® data sheets (refer to Appendix 5.1).

5.3.4.2 Built shade sources

Each built structure present on a school property was re-drawn onto the WebShade® data sheets to illustrate the dimensions of built structure features not visible on aerial photographs, such as under-croft areas and covered balconies (refer to Figure 3 below for an example of how these structures were drawn onto the fieldwork data sheets). A surveyor's wheel and retractable tape measure were used to measure the length and width of each built structure while a 60m laser measuring device (Makita model LD060P) was used to measure the height of each structure. The width and length of built structures were measured as the distance between roof eaves or shade sail edges while building heights were recorded as the lowest point of a roof eave or support structure (such as the supporting pole for a shade sail).

Figure 3: Example of the way built structures were re-drawn so that features could be identified for subsequent data entry into WebShade®



As illustrated in Figure 3, each built structure was drawn to show features that could not be seen on aerial school images. For example, 'No. 52 Prep block' was a building with two covered areas (balconies). Therefore when this building was digitised using WebShade®, it was drawn as a built structure (with a roof and walls) that was flanked by two other built structures (that each had a roof but no walls). The balconies on this built structure could not be identified on an aerial image.

5.3.4.3 Natural shade sources

Only trees estimated to be over 1.5m high were measured on-site. Tree diameters were measured with a surveyor's wheel or a retractable tape measure. The heights of small trees (estimated to be 1.5m to 5m high) were measured with a retractable tape measure or by using the measured height of a nearby tree or built structure as a reference value. The heights of large trees (approximately 5m or taller) were measured using the ruler technique described in the 'Private Native Forestry Code of Practice Guideline No. 4' [35]. Briefly, this method used two people and a ruler to estimate tree height. Person one stood at the base of a tree while person two stood away from the trunk (at a distance they estimated to be the height of the tree. That is, if person two estimated the tree to be 10m high, they stood 10m away from the tree). Then, person two held up a 40cm ruler vertically in front of themselves, closed one eye, and aligned the 'zero' value on the ruler with the base of the tree. Person two noted the number on the ruler at which person one's head height aligned with. Then, the height of the tree was estimated to be a multiple of person one's actual height. For example, if person one was 1.5m tall and their head height lined up with the number 4 on the ruler, and the top of the tree lined up with the number 16 on the ruler, then the tree height would be estimated as 4 (because 16 divided by 4 = 4) multiplied by 1.5m. Tree species and foliage density were also recorded on the fieldwork sheets as instructed in the fieldwork guide (refer to Appendix 5.1).

5.3.4.4 WebShade® shade-related data calculations

The research assistant and the WebShade consultant used the WebShade® drawing tools to digitise each school image in each WebShade® SA school file. Shade data for 11am and 1:30pm for the 1st of December, 1st of March, 1st of June and the 1st of September were calculated. The times of 11am and 1:30pm were chosen because the recess breaks of the schools that participated in this study were held during the half hour either side of these times. The dates were chosen because they were the calendar start dates of each season. Shade was calculated as natural shade (shade resulting from trees), built shade (shade resulting from built structures such as buildings, shade sails, covered walkways etc.), and combined shade (shade resulting from a combination of both natural and built sources).

5.3.5 The development of the remote shade-estimation (RS) method

The RS remote was designed to use WebShade® in conjunction with pre-defined height values in place of height values obtained on-site at schools. These height values were provided by the WebShade® consultant, following from his years of experience in the field, and they were assigned to each built structure and tree present on a school image. Our intention was to develop a series of pre-defined height values, using on-site heights as a reference, which could be used to test our RS method and potentially other RS methods. On-site heights from our school population were used along with other heights, which were available to the WebShade® consultant from previous shade-audits, to calculate average height values for built structures, trees etc. Therefore the series of pre-defined height values we used were not specific for this study. That is, the average heights provided were anticipated to be typical of single-storey structures, shade sails, small trees etc. in general, and not just of these structures/trees at schools which participated in study 3. The pre-defined height values used were 3m per built structure storey, 2.7m for shade structures (for example, shade sails), 6m for trees with canopy diameters of 1-6m, 12m for trees with canopy diameters greater than 6m, and 10m for palm trees. So that we could compare RS and SA shade-related data, the same, unmarked, Google Earth bird's eye view images of school property used for the SA method were used for the RS method. That is, one aerial photograph was obtained from Google Earth for each school. Each image was uploaded into two separate WebShade® files (one file was for SA data and the other was for RS data).

5.3.6 Remote shade-estimation (RS) method

5.3.6.1 School boundary and unusable areas

The boundary of each school was marked with the WebShade® 'free form' drawing tool as the visible boundary between school property and the surrounding area. For example, a school boundary may have been identified by the location of a fence or change in landscape between what appeared to be school property, such as sports fields and classrooms, and surrounding properties such as houses, commercial property and parklands. The 'free form' drawing tool was used to draw the outline of areas assumed to be student ‘out-of-bounds’ areas. These areas were identified as car parks, tennis courts and swimming pools since it was assumed that students would be prohibited from using these areas during school recess periods.

5.3.6.2 Built shade sources

The ‘street view’ function of Google Earth was used to view school properties from ground-level to determine the number of storeys of a built structure. An attempt was made to view every built structure at each school. However, ‘street view’ function did not allow entry onto private property thus it was not always possible to view buildings clearly. Where it was not possible to view a built structure, the default height value of 3m (one storey) was assigned. The WebShade® ‘free form’ and rectangle/square drawing tools were used to trace over the outlines of all visible built structures that comprised of walls and a roof. The ‘shade structure’ drawing tool was used to draw shade sails and covered walkways since these were structures with a roof but no walls. As explained in 5.3.5, a height value of 2.7m was assigned to each shade sail while a height value of 3m was assigned to each covered walkway.

5.3.6.3 Natural shade sources

The WebShade® ‘measure’ tool was used to measure the diameter of each visible tree on school images. This ‘measure’ tool worked similarly to the Google Earth ruler. The measure tool was used to click on the two outer most points of each visible tree canopy so that the distance between these two points could be measured and rounded to the nearest whole number. As explained in 5.3.5, height values of 6m, 12m and 10m were assigned for trees that had canopy diameters of 1-6m, canopy diameters of greater than 6m, and tell-tale palm frond outline/shadows respectively. The diameter cut-off values and associated height values were provided by the WebShade® consultant from his experience in the field. A default foliage density of ‘heavy’ was assigned to each tree since foliage density could not be determined from aerial photographs.

5.3.6.4 WebShade® shade-related data calculations

The WebShade® program was used to calculate the amount of shade available at each school for 11am and 1:30pm for the 1st of December, 1st of March, 1st of June and the 1st of September. Shade was calculated as natural shade, built shade and combined shade.

5.3.7 Statistical methods

School descriptive information was described using mean and standard deviation (SD) or median and interquartile range (IQR: 25th quartile, 75th quartile) for data which followed a normal and non-normal distribution, respectively. For categorical variables, such as SunSmart status, the number and percentage of schools in each group was presented.

5.3.7.1 Statistical comparison of the RS data against the SA data

Statistically, this study was about concordance of the new RS method compared against the SA method. RS and SA values were graphically displayed using scatterplots. Each scatterplot included a line of equality and a linear regression line of RS against SA data for visual reference. In the respective figures of these scatterplots, these lines are represented by black (line of equality) and red (regression line) colour. On each scatterplot, X-axis values corresponded to the SA shade proportion (%) values, and Y-axis values corresponded to the RS shade proportion (%) values. Pearson's correlation coefficient (r) with 95% confidence intervals (CIs) were calculated to assess the strength of the association between RS and SA data values.

Lin's concordance correlation coefficient (CCC) together with the two-sided 95% CIs were calculated using the online resources provided by Garry Anderson of the University of Melbourne [36, 37]. The CCC provides an indication of the strength of the agreement between the RS and the SA methods. It has been tentatively suggested that one could use the following ranges for CCC when an assessment of the strength of agreement for continuous variables is made: >0.99 almost perfect; >0.95-0.99 substantial; 0.90-0.95 moderate; and <0.90 poor [38]. Lin's CCCs were compared between groups for statistical difference by checking whether their 95% confidence intervals overlapped or not.

In addition, Bland-Altman plots were created to assess agreement of the RS and SA values further [39, 40]. The difference between the RS and SA data were plotted against the average values as Bland-Altman plots. Reference lines which correspond to the regression line of differences in values against the averages, the mean of differences value, lower and upper agreement limits (mean difference +/- 2 multiplied by the SD) and the zero difference line were added to visually assess the agreement between the RS and SA methods. In the Figures of the Bland-Altman plots, these reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line). In each Bland-Altman plot, X-axis values corresponded to the mean of differences values and the Y-axis corresponded to the difference between the SA and RS data values. Further, Pearson's correlation coefficient (r) and 95% CI were calculated to assess the strength of the association between differences and averages. If the data calculated using the RS method were similar to those calculated using the SA method, one would expect the differences of the values to be approximately distributed at random around the zero line, the agreement limits to be within a small range, and r to be close to zero and not statistically significant.

Microsoft Excel 2010 was used for the creation of the plots. IBM SPSS statistics version 22 was used for the calculation of the required statistics described above. An alpha level of 0.05 was used to determine statistical significance.

5.4 Results

To assess the agreement between the RS method and the SA method, shade values were compared at a sample of north Queensland primary schools. This section includes a description of the schools that participated in study 3 and includes a description of the agreement between shade-related data calculated using the RS and the SA method. The SA method was used at 27 schools. Five schools were excluded from the RS method because the boundaries between primary school and secondary school usable yard spaces for two schools and the location of school boundaries for an additional three schools could not been identified. Therefore the RS and the SA methods were compared including 22 of the 27 schools (81.48% of the 27 schools).

5.4.1 Study population

The following table (Table 1) describes the 22 schools that participated in this study according to the characteristics described in section 5.3.2.1.

Table 1. School descriptive information for the 22 schools included in study 3.

Characteristic		Number of schools (%)
Ownership	Public	19 (86.36%)
	Private	3 (13.63%)
Student enrolment number	≤ 399	12 (54.55%)
	400-799	7 (31.82%)
	≥ 800	3 (13.64%)
Locality	Urban	15 (68.18%)
	Rural	7 (31.82%)
Location	Townsville	11 (50.00%)
	Cairns	5 (22.72%)
	The Atherton Tablelands	6 (27.27)
SunSmart school	Yes	16 (72.73%)
	No	6 (27.27%)
ICSEA group	≤ 1000	17 (77.27%)
	≥ 1001	5 (22.72%)
Sun-protection policy score	0-2	14 (63.64%)
	3-12	8 (36.36%)

Most (86.36%) of the schools that participated in this study were government owned schools and most of the schools were located in Townsville (50.0%) (Table 1). The mean ICSEA score for the group of schools that participated in this study was 959.00 (SD: 67.22). The median student enrolment number for participating schools was 256.0 [IQR: 100.5, 401.8]. The median sun-protection policy score for the schools that participated in this study was 2 [IQR: 2, 8.25].

The following table (Table 2) describes the proportion of schools that were assigned to each of the potential effect-modifiers described in section 5.3.3.

Table 2. Distribution of the 22 schools that participated in study 3 according to the potential effect-modifiers anticipated to influence the performance of our remote shade-estimation method.

Characteristic		Number of schools (%)
Proportion of built structures that were single-storey	≤ 89%	12 (54.55%)
	≥ 90%	10 (45.45%)
Proportion of classroom buildings that were single-storey	≤ 89%	11 (50.00%)
	≥ 90%	11 (50.00%)
Usable land area within school boundary	≤ median	11 (50.00%)
	> median	11 (50.00%)
Proportion of school area that was green-space	≤ 74%	15 (68.18%)
	≥ 75%	7 (31.82%)

Most (68.18%) of the 22 participating schools had green-space areas which comprised of up to 74% of their usable school land area. When schools were grouped according to the proportion of classroom buildings which were single-storey, half of the schools were assigned to each group (Table 2). The mean proportion of single-story built structures at participating schools was found to be 86.52% (SD: 13.01%). The mean proportion of single-storey classroom buildings at participating schools was 80.51% (SD: 20.28%). The median land size was calculated to be 28,965.5m^2 [IQR: 20,906.00m^2, 40,468m^2].

5.4.2 Shade-related data for 11am, 1st December

The following table (Table 3) presents shade-related data for 11am on the 1st of December (that is, the first time period for which shade was measured) at the 22 schools for which the RS and SA methods were used. A summary of results for the other time periods will follow the 11am, 1st of December data.

Table 3. The percent of usable school grounds shaded by 'combined' (i.e. natural + built shade) shade, 'natural' shade and 'built' shade at 11am for the 1st of December: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			Natural shade (%)			Built shade (%)		
School ID	SA	RS	Difference (SA-RS)	SA	RS	Difference (SA-RS)	SA	RS	Difference (SA-RS)
A	8.85	9.80	-0.95	3.78	7.60	-3.82	5.51	2.80	2.71
B	18.34	15.70	2.64	12.87	14.90	-2.03	5.76	1.80	3.96
C	22.94	20.40	2.54	14.65	18.40	-3.75	9.38	2.60	6.78
D	41.89	34.60	7.29	33.69	29.20	4.49	8.43	6.30	2.13
E	44.94	36.60	8.34	32.15	35.60	-3.45	12.77	2.20	10.57
F	14.39	18.10	-3.71	6.25	17.40	-11.15	8.29	1.20	7.09
G	31.29	25.50	5.79	23.27	23.20	0.07	9.17	2.20	6.97
H	13.30	6.80	6.50	5.76	3.60	2.16	7.54	3.30	4.24
I	20.24	23.60	-3.36	15.78	22.10	-6.32	5.37	2.20	3.17
J	25.19	27.70	-2.51	20.84	27.40	-6.56	5.60	1.80	3.80
K	33.42	18.80	14.62	24.98	18.10	6.88	8.44	0.90	7.54
L	14.08	15.20	-1.12	4.01	10.70	-6.69	10.07	6.20	3.87
M	37.44	31.80	5.64	30.86	26.00	4.86	8.55	7.20	1.35
N	29.38	18.90	10.48	23.42	17.10	6.32	6.15	2.60	3.55
O	34.43	26.60	7.83	24.40	23.40	1.00	11.56	4.60	6.96
P	17.20	20.70	-3.50	15.24	15.80	-0.56	2.90	5.30	-2.40
Q	30.09	17.50	12.59	28.61	4.40	24.21	1.56	13.30	-11.74
R	28.51	26.50	2.01	24.93	25.20	-0.27	4.40	1.80	2.60
S	41.32	22.80	18.52	25.22	16.30	8.92	18.50	7.20	11.30
T	24.44	7.60	16.84	13.57	1.80	11.77	10.90	5.90	5.00
U	21.75	21.80	-0.05	16.49	16.40	0.09	5.66	6.40	-0.74

V	28.07	23.40	4.67	25.30	22.30	3.00	3.42	1.40	2.02
Mean (SD)	26.43 (9.99)	21.38 (7.82)	5.05 (6.63)	19.37 (9.13)	18.04 (8.64)	1.33 (7.59)	7.72 (3.75)	4.05 (2.95)	3.67 (4.74)

For 11am, 1st of December, the differences between SA and RS combined shade data ranged from -3.71% to 18.52%. For natural shade, the differences between SA and RS data ranged from -11.15% to 24.21%. For built shade, the differences between SA and RS data ranged from -11.74% to 11.30% (Table 3).

The following sections presents a selection of the scatter plots and Bland-Altman plots which were used in conjunction with Lin's CCC values to investigate the agreement between the RS and the SA methods. The figures presented below were created using shade-related data calculated for 11am for the 1st of December. Figures are presented for 'all schools' together and figures for schools stratified according to the potential effect-modifiers listed in Table 2 can be found in Appendix 5.2.

5.4.2.1 All schools considered together as one group

Combined shade

Figure 4. Scatter plot of WebShade® shade-audit (SA) data and remote shade-estimation (RS) data: All schools (n=22) – combined shade at 11am for 1st of December. Line of equality (black line) and regression line (red line) presented for visual reference.

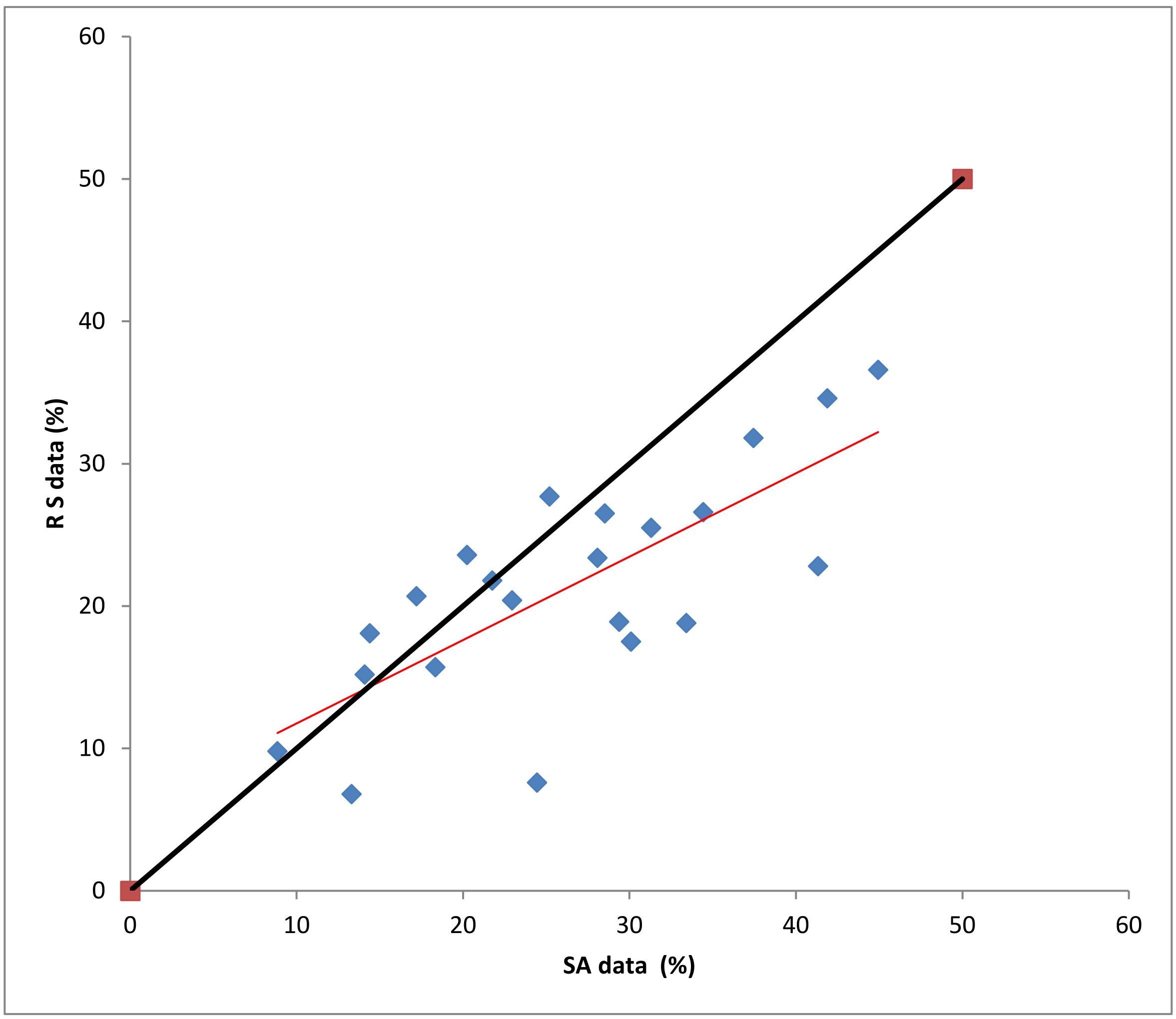


Figure 4 shows that the RS combined shade-related data were smaller than the SA combined-shade related data for most of the schools. For the RS data and the SA data high positive correlation was found (Pearson's r = 0.75, p<0.001).

Figure 5. Bland-Altman plot: Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data): All schools (n=22) – combined shade at 11am, for 1st December. Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

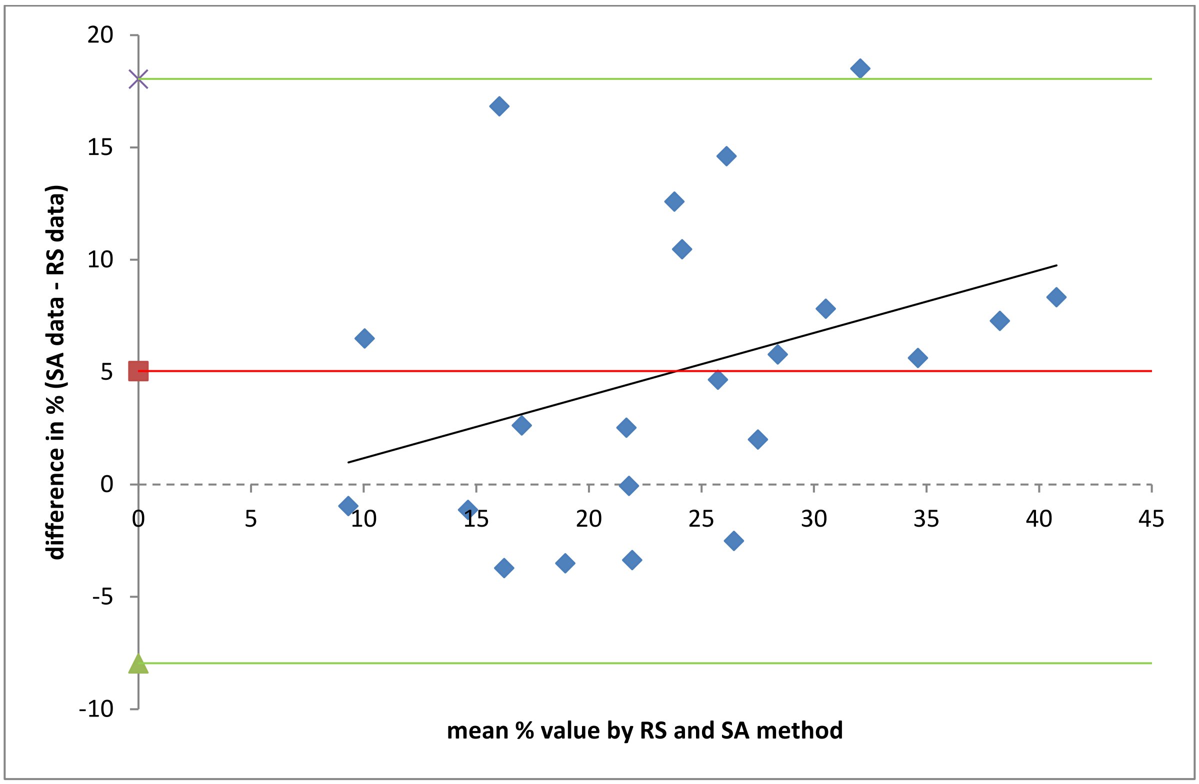


Figure 5 shows that the average difference between the RS and SA combined shade-related data was 5.05% (lower limit:-8.21%; upper limit: 18.32%). Most of the differences values were not distributed around the zero line. For the mean values and the difference values, a non-significant positive correlation was found (Pearson's r = 0.350, p = 0.110).

The CCC assessing the agreement between RS and SA for combined shade was 0.623 (95% CI: 0.353, 0.799).

Natural shade

Figure 6. Scatter plot of WebShade® shade-audit (SA) data and remote shade-estimation (RS) data: All schools – natural shade at 11am for 1st of December. Line of equality (black line) and regression line (red line) presented for visual reference.

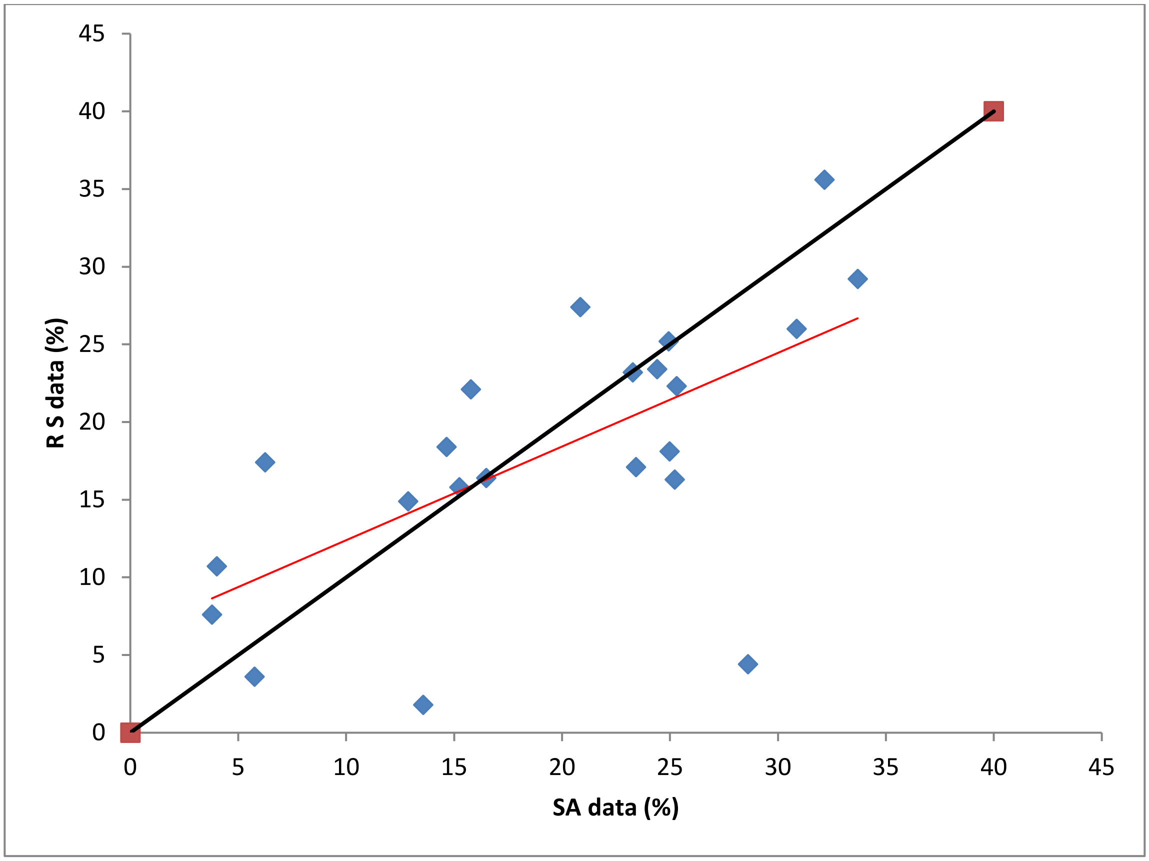


Figure 6 shows that the RS natural shade-related data were smaller than the SA natural shade-related data for most schools. For RS data and SA data a positive correlation was found (Pearson's $r = 0.637$, $p = 0.001$).

Figure 7. Bland-Altman plot: Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data): All schools (n=22) – natural shade at 11am, for 1st December. Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

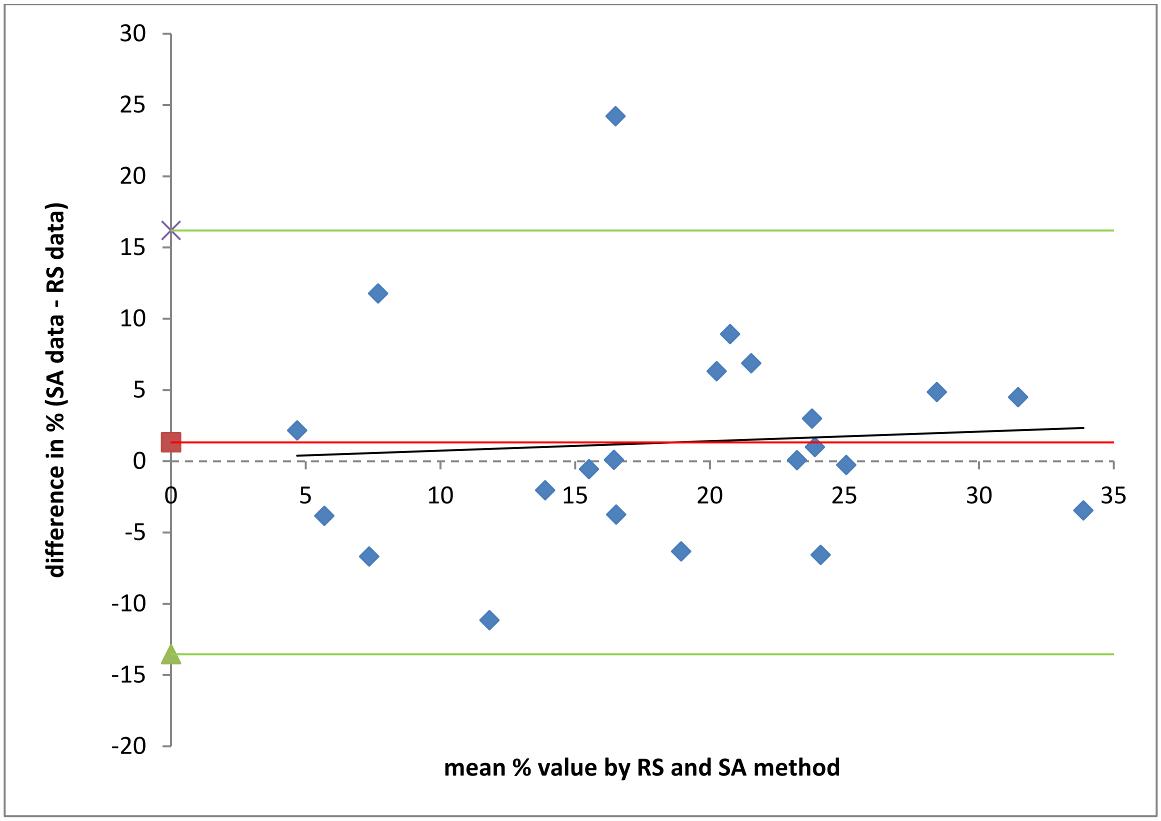


Figure 7 shows that the average difference between natural shade-related data calculated using the RS and the SA methods was 1.33% (lower limit: -13.85%, upper limit: 16.50%). For the mean values and the difference values, Pearson's r value was close to zero and the p value was non-significant (Pearson's r = 0.071, p=0.755).

The CCC assessing the agreement between RS and SA for natural shade was 0.628 (95% CI: 0.297, 0.825).

Built shade

Figure 8. Scatter plot of WebShade® shade-audit (SA) data and remote shade-estimation (RS) data: All schools – built shade at 11am for 1st of December. Line of equality (black line) and regression line (red line) presented for visual reference.

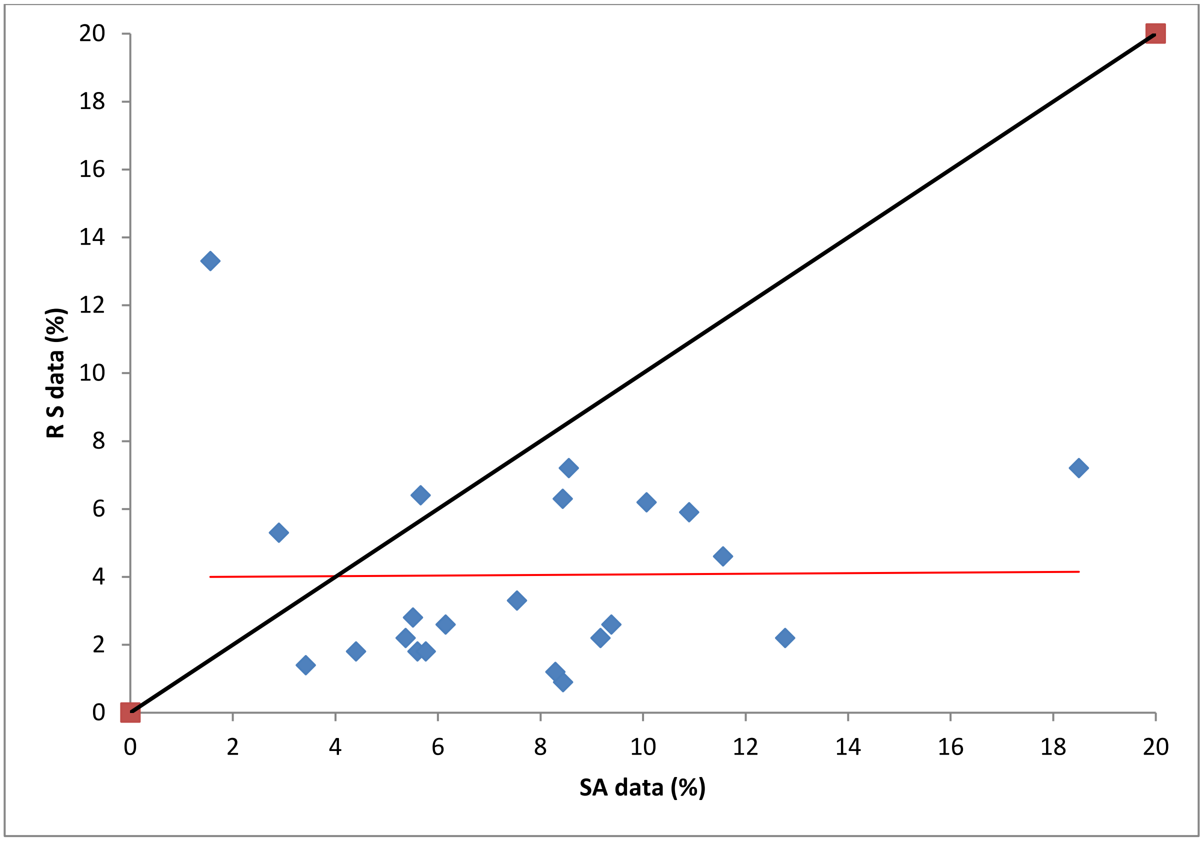


Figure 8 shows that the built shade-related data calculated using the RS method were smaller than the same data calculated using the SA method for almost all of the schools. For the RS data and the SA data negligible correlation was found (Pearson's $r = 0.011$, $p=0.960$).

Figure 9. Bland-Altman plot: Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data): All schools (n=22) – built shade at 11am, for 1st December. Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

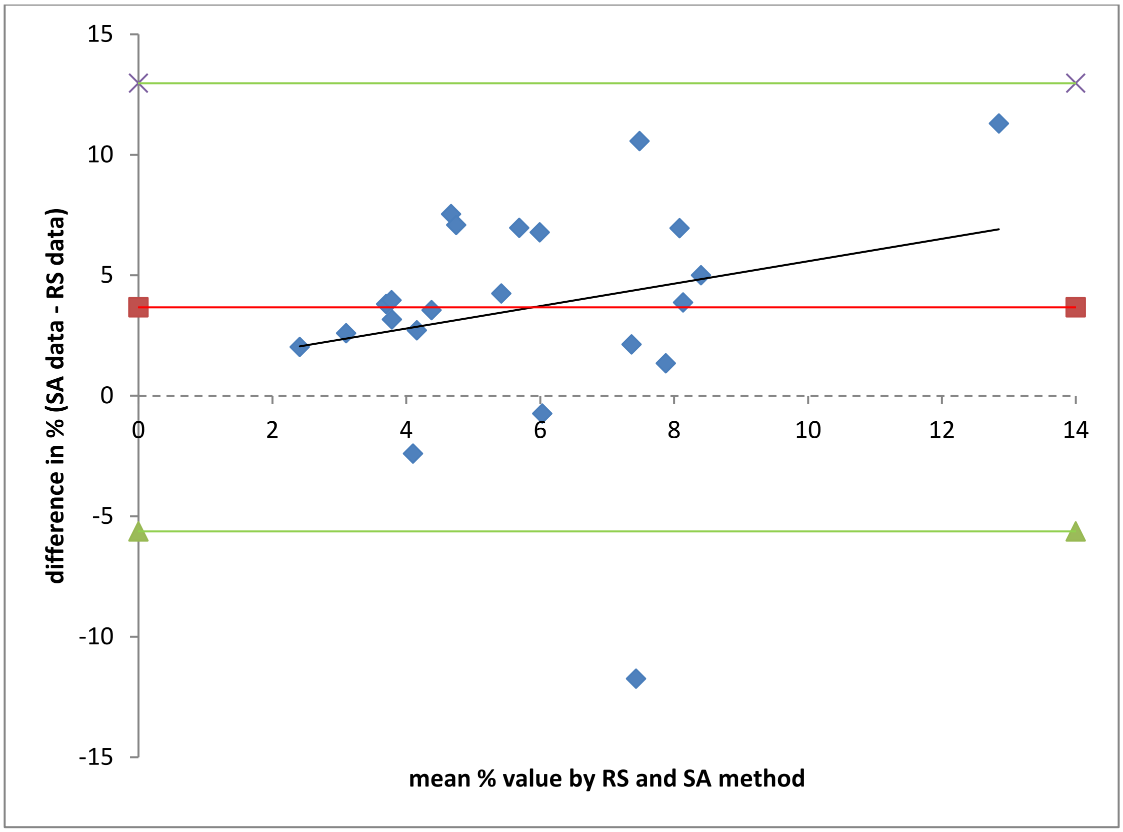


Figure 9 shows that the average difference between the built shade data calculated using the RS and the SA methods was 3.67% (lower limit: -5.82%, upper limit: 13.16%). For the mean values and the difference values a non-significant correlation was found (Pearson's r= 0.235, p=0.292).

The CCC assessing the agreement between RS and SA for built shade was 0.007 (95% CI: -0.250, 0.263).

Summary of 11am, 1st December shade data for 'all schools' (n=22)

Table 4: All schools (n=22). 11am for the 1st of December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	5.05	1.33	3.67
lower limit	-8.21	-13.85	-5.82
upper limit	18.32	16.50	13.16
r (Bland-Altman plot)	0.350	0.071	0.235
lower 95% CI	-0.069	-0.372	-0.432
upper 95% CI	0.626	0.506	1.362
p value	0.110	0.755	0.292
CCC	0.623	0.628	0.007
lower 95% CI	0.353	0.297	-0.250
upper 95% CI	0.799	0.825	0.263
r (scatter plot)	0.749	0.637	0.011
lower 95% CI	0.562	0.293	-0.578
upper 95% CI	1.352	1.052	0.607
p value	<0.001	0.001	0.960

Table 4 provides the results presented by Figures 4 to 9 in a tabulated form. Combined shade and natural shade-related SA and RS data were found to be positively correlated (Pearson's r = 0.749 and 0.637 respectively, p values <0.001 and 0.001 respectively). For combined and built shade, the values were not scattered around the zero difference lines on the respective Bland-Altman plots. For natural shade data, there was some scattering of values around the zero difference line on the respective Bland-Altman plot, and Pearson's r value was close to zero (r = 0.071) and the p value was not significant (p=0.755). For all shade-related data, poor agreement between the RS and SA methods were found (CCC < 0.90). The CCC value was very low for built shade-related data (CCC = 0.007).

5.4.2.2 Schools grouped according to 'the proportion of built structures that were single-storey'

The scatterplots and Bland-Altman plots that were used to assess the comparison of the RS method against the SA method for this school group can be found in Appendix 5.2. A tabulated data summary is presented below.

Schools at which ≤ 89% of built structures were single-storey (n = 12)

Summary of 11am, 1st December shade data for 'schools at which ≤ 89% of built structures were single-storey' (n = 12)

Table 5. Schools at which ≤ 89% of built structures were single-storey (n = 12). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	5.91	1.95	4.13
lower limit	-7.60	-8.18	-4.28
upper limit	19.41	12.07	12.54
r (Bland-Altman plot)	0.197	0.429	0.617
lower 95% CI	-0.450	-0.753	0.090
upper 95% CI	0.809	0.147	1.697
p value	0.539	0.164	0.033
CCC	0.588	0.765	0.181
lower 95% CI	0.136	0.392	-0.114
upper 95% CI	0.837	0.922	0.447
r (scatter plot)	0.664	0.808	0.384
lower 95% CI	0.159	0.298	-0.520
upper 95% CI	1.383	0.928	2.025
p value	0.019	0.001	0.217

Table 5 provides the results presented by Figures 1 to 6 in Appendix 5.2 in a tabulated form**.** Combined shade and natural shade-related SA and RS data were found to be positively correlated (Pearson's r = 0.664 and 0.808 respectively, p values = 0.019 and 0.001, respectively). For all shade-related data, poor agreement between the RS and SA methods were found (CCC < 0.90). The lowest CCC value was found for built shade data

(CCC = 0.181). Data values on the combined shade, natural shade and built shade Bland-Altman plots respectively were not scattered close to the zero differences line.

Schools at which ≥ 90% of built structures were single-storey (n = 10)

Summary of 11am, 1st December shade data for 'schools at which ≥ 90% of built structures were single-storey' (n = 10)

Table 6. Schools at which ≥ 90% of built structures were single-storey (n = 10). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	4.02	0.58	4.12
lower limit	-9.36	-19.60	-1.27
upper limit	17.40	20.76	9.50
r (Bland-Altman plot)	0.549	0.348	0.624
lower 95% CI	-0.148	-0.686	-4.278
upper 95% CI	1.387	1.834	1.048
p value	0.100	0.324	0.054
CCC	0.434	0.190	-0.346
lower 95% CI	-0.040	-0.426	-0.699
upper 95% CI	0.746	0.686	0.141
r (scatter plot)	0.587	0.203	0.579
lower 95% CI	-0.122	-0.850	-0.840
upper 95% CI	2.077	1.430	0.058
p value	0.075	0.574	0.079

Table 6 provides the results presented by Figures 7 to 12 in Appendix 5.2 in a tabulated form. RS and SA combined, natural and built shade data were non-significantly correlated (Pearson's r = 0.587, 0.203 and 0.691, respectively; p values = 0.075, 0.574 and 0.079, respectively). Poor agreement between the RS and SA methods was found for combined shade (CCC = 0.434), and very poor agreement was found for natural shade (CCC = 0.190) and built shade (CCC = -0.346). Data values on Bland-Altman plots for combined, natural and built shade respectively were not scattered close to the zero differences line.

Summary of schools grouped according to the proportion of built structures that were single-storey (Tables 5 and 6)

There was poor agreement between SA and RS data for both school groups since values on each Bland-Altman plot were not scattered around the zero difference line, Pearson's r value (for mean values and difference values) were not close to zero, and all CCC values were below 0.90 (Tables 5 and 6). CCC values were higher for schools with up to 89% single-storey structures than for schools with at least 90% single-storey structures. For example, the CCC value for natural shade-related data was 0.765 for schools with up to 89% single-storey built structures and it was 0.190 for schools with more than 90% single-storey built structures. The CCC value for built shade-related data was low for schools with up to 89% single-storey structures (CCC = 0.181) and negative for schools with at least 90% single-storey structures (CCC = -0.346). Therefore, the proportion of single-storey built structures at a school might have been an effect-modifier for natural and built shade data since the CCC values for natural shade and built shade data indicated that agreement between data were better for schools with up to 89% single-storey built structures. However the 95% CIs for these CCCs over-lapped therefore differences were not statistically significant.

5.4.2.3 Schools grouped according to 'the proportion of classroom buildings that were single-storey'

The scatterplots and Bland-Altman plots that were used to assess the comparison of the RS method against the SA method for this school group can be found in Appendix 5.2.

Schools at which ≤ 89% of classroom buildings were single-storey (n = 11)

Summary of 11am, 1st December shade data for 'schools at which ≤ 89% of classroom buildings were single-storey' (n = 11)

Table 7. Schools at which ≤ 89% of classroom buildings were single-storey (n = 11). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	6.39	2.51	3.98
lower limit	-8.38	-16.71	-8.68
upper limit	21.17	21.74	16.65
r (Bland-Altman plot)	0.201	0.306	0.280
lower 95% CI	-0.562	-1.372	-0.948
upper 95% CI	0.982	0.552	2.140
p value	0.553	0.361	0.405
CCC	0.422	0.363	-0.043
lower 95% CI	-0.035	-0.213	-0.440
upper 95% CI	0.733	0.752	0.367
r (scatter plot)	0.579	0.396	0.067
lower 95% CI	-0.042	-0.221	-1.091
upper 95% CI	1.410	0.814	0.913
p value	0.062	0.228	0.846

Table 7 provides the results presented by Figures 13 to 18 in Appendix 5.2 in a tabulated form. RS and SA combined, natural and built shade data were not significantly correlated (p values = 0.062, 0.228 and 0.846, respectively). There was poor agreement between the RS and SA methods for combined shade and natural shade data since CCC values were

0.422 and 0.363, respectively. For built shade data, the CCC value was negative (CCC = -0.043).

Schools at which ≥ 90% of classroom buildings were single-storey (n = 11)

Summary of 11am, 1st December shade data for 'schools at which ≥ 90% of classroom buildings were single-storey' (n = 11)

Table 8. Schools at which ≥ 90% of classroom buildings were single-storey (n = 11). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	3.71	0.14	3.35
lower limit	-7.93	-9.93	-1.93
upper limit	15.35	10.21	8.64
r (Bland-Altman plot)	0.435	0.571	0.010
lower 95% CI	-0.155	-0.027	-1.178
upper 95% CI	0.710	0.688	1.209
p value	0.181	0.066	0.978
CCC	0.754	0.846	0.097
lower 95% CI	0.400	0.607	-0.181
upper 95% CI	0.912	0.944	0.361
r (scatter plot)	0.843	0.888	0.230
lower 95% CI	0.565	0.742	-0.509
upper 95% CI	1.615	1.691	0.973
p value	0.001	<0.001	0.496

Table 8 provides the results presented by Figures 19 to 24 in Appendix 5.2 in a tabulated form. Combined and natural shade were positively correlated (Pearson's r = 0.843 and

0.888 respectively, p values = 0.001 and <0.001 respectively). Agreement between the RS and SA methods were poor for combined shade, natural shade and built shade since CCC values were less than 0.90 respectively (CCC for built shade = 0.097). On Bland-Altman plots for combined shade, natural shade and built shade, values were not scattered close to the zero differences line. However, for built shade, Pearson's r value for mean values and difference values was close to zero (r = 0.010) and the p value was not significant (p = 0.978).

Summary of schools grouped according to the proportion of classroom buildings that were single-storey (Tables 7 and 8)

For all shade-related data, there was poor scattering of values around the zero difference lines on the respective Bland-Altman plots and there was poor agreement between the RS and SA data (CCC < 0.90). The proportion of single-storey classroom buildings present at a school might have positively influenced agreement between shade-related data since CCC values were higher for schools with at least 90% single-storey classroom buildings (CCC = 0.754, 0.846 and 0.097 for combined shade, natural shade and built shade, respectively) (Table 8) than for schools with up to 89% single-storey classrooms (CCC = 0.422, 0.363 and -0.043 for combined shade, natural shade and built shade, respectively) (Table 7), although these differences were not statistically significant. While Pearson's r value for the mean and difference values of built shade data at schools with mostly single-storey classroom buildings was close to zero (r = 0.010) and the p value was not significant (p = 0.978), the CCC value was very low (CCC = 0.097) and there was almost no scattering of values close to the zero difference line in Figure 25 (Appendix 5.2).

5.4.2.4 Schools grouped according to 'the size of their total usable area'

The scatterplots and Bland-Altman plots that were used to assess the comparison of the RS method against the SA method for this school group can be found in Appendix 5.2.

Schools at which the usable land area was less than the median value for all schools (n = 11)

Summary of 11am, 1st December shade data for 'schools at at which the usable land area was less than the median value for all schools' (n = 11)

Table 9. Schools at which the usable land area was ≤ the median land area (n = 11). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	6.32	0.98	5.24
lower limit	-9.63	-12.21	-1.88
upper limit	22.28	14.16	12.38
r (Bland-Altman plot)	0.227	0.221	0.591
lower 95% CI	-0.558	-0.832	-0.021
upper 95% CI	1.057	0.448	1.493
p value	0.502	0.514	0.055
CCC	0.406	0.676	0.190
lower 95% CI	-0.063	0.187	-0.058
upper 95% CI	0.728	0.897	0.416
r (scatter plot)	0.546	0.691	0.521
lower 95% CI	-0.104	0.124	-0.222
upper 95% CI	1.430	1.050	2.102
p value	0.082	0.019	0.101

Table 9 provides the results presented by Figures 25 to 30 in Appendix 5.2 in a tabulated form. Natural shade data calculated using the RS and SA methods were positively correlated (Pearson's $r = 0.691$, $p = 0.019$). There was poor agreement between the RS and SA methods for combined shade, natural shade and built shade respectively ($CCC < 0.90$, respectively). On Bland-Altman plots for combined shade and natural shade respectively, some data values were scattered close to the zero differences line, while the majority of data values on the Bland-Altman plot for built shade were not close to the zero differences line.

Schools at which the usable land area was more than the median value for all schools (n = 11)

Summary of 11am, 1st December shade data for 'schools at which the usable land area was more than the median value for all schools' (n = 11)

Table 10. Schools at which the usable land area was > the median land area (n = 11). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	3.78	1.67	2.10
lower limit	-6.27	-15.89	-8.70
upper limit	13.82	19.24	12.89
r (Bland-Altman plot)	0.494	0.277	0.146
lower 95% CI	-0.087	-0.455	-2.517
upper 95% CI	0.615	1.016	1.695
p value	0.123	0.410	0.669
CCC	0.800	0.581	-0.271
lower 95% CI	0.050	0.045	-0.678
upper 95% CI	0.928	0.858	0.263
r (scatter plot)	0.894	0.606	0.335
lower 95% CI	0.716	0.008	-0.910
upper 95% CI	1.584	1.513	0.327
p value	<0.001	0.048	0.314

Table 10 provides the results presented by Figures 31 to 36 in Appendix 5.2 in a tabulated form. RS and SA combined shade and natural shade data were positively correlated (Pearson's r = 0.894 and 0.606 respectively, p values <0.001 and 0.048 respectively). Poor agreement was found between the two methods (CCC < 0.90 for combined shade, natural shade and built shade data, respectively). Approximately half of the values on the Bland-Altman plot of natural shade data were scattered around the zero differences line while few values on the respective combined shade and built shade Bland-Altman plots were scattered close to the zero difference lines.

Summary of schools grouped according to the size of usable land area (Tables 9 and 10)

The size of a school's usable land area might have influenced the agreement between combined shade data since the CCC value for combined shade was 0.406 (Table 9) for schools with small (up to median size) land areas and the CCC value was 0.800 (Table 10) for schools with large (more than median size) land areas. Conversely, large land areas might have negatively influenced agreement between natural shade data since the CCC value for natural shade data was 0.581 for schools with large land areas and 0.676 for schools with small land areas. Similarly, the CCC values for built shade data were lowest for schools with large land areas (CCC = -0.271) compared to small land areas (CCC = 0.190). However, none of these differences were statistically significant.

5.4.2.5 Schools grouped according to their amount of green-space

The scatterplots and Bland-Altman plots that were used to assess the comparison of the RS method against the SA method for this school group can be found in Appendix 5.2.

Schools at which the green-space amounted to approximately ≤ 74% (n = 15)

Summary of 11am, 1st December shade data for 'schools at which the green-space amounted to approximately ≤ 74%' (n = 15)

Table 11. Schools at which the green-space amounted to approximately ≤ 74% (n = 15). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	5.22	1.45	3.68
lower limit	-8.55	-15.94	-7.12
upper limit	18.99	18.83	14.48
r (Bland-Altman plot)	0.418	0.089	0.232
lower 95% CI	-0.094	-0.503	-0.750
upper 95% CI	0.713	0.679	1.742
p value	0.121	0.753	0.405
CCC	0.661	0.599	-0.043
lower 95% CI	0.336	0.155	-0.371
upper 95% CI	0.845	0.842	0.293
r (scatter plot)	0.788	0.608	0.069
lower 95% CI	0.555	0.142	-0.844
upper 95% CI	1.529	1.163	0.670
p value	<0.001	0.016	0.808

Table 11 provides the results presented by Figures 37 to 42 in Appendix 5.2 in a tabulated form. Combined and natural shade data calculated using the RS and SA methods were positively correlated (Pearson's $r = 0.788$ and 0.608 respectively, p values <0.001 and 0.016 respectively). There was poor agreement between the RS and SA data (CCC < 0.90

for combined, natural and built shade data, respectively). Few data values on each respective combined shade and built shade Bland-Altman plot were scattered close to the zero differences lines, while approximately half of the values on the natural shade Bland-Altman plot were scattered close to the zero difference line.

Schools at which the green-space amounted to approximately ≥ 75% (n = 7)

Summary of 11am, 1st December shade data for 'schools at which the green-space amounted to approximately ≥ 75%' (n = 7)

Table 12. Schools at which the green-space amounted to approximately ≥ 75% (n = 7). 11am, 1st December: The mean of differences values (i.e. mean value of all the difference (SA minus RS data) values) and the associated lower and upper limits for these mean values, Pearson's correlation coefficient (r) and associated 95% confidence intervals (CIs) for the strength of the correlation between mean values (i.e. average value of SA and RS data) and difference values (i.e. difference of SA data minus RS data) (on Bland-Altman plots), Lin's concordance correlation coefficient values (CCC) and associated CIs, Pearson's correlation coefficient and associated 95% CIs for the strength of the correlation between RS and SA values.

	Combined shade	**Natural shade**	**Built shade**
mean of differences	4.69	1.07	3.65
lower limit	-8.45	-8.94	-2.92
upper limit	17.83	11.08	10.21
r (Bland-Altman plot)	0.109	0.032	0.504
lower 95% CI	-1.156	-0.874	-1.373
upper 95% CI	1.399	0.827	4.206
p value	0.817	0.946	0.249
CCC	0.409	0.749	-0.112
lower 95% CI	-0.253	0.105	-0.378
upper 95% CI	0.807	0.951	0.171
r (scatter plot)	0.526	0.759	0.372
lower 95% CI	-0.495	0.011	-2.417
upper 95% CI	1.650	1.477	1.166
p value	0.225	0.048	0.411

Table 12 provides the results presented by Figures 43 to 48 in Appendix 5.2 in a tabulated form. Natural shade data calculated using the RS and SA methods were positively correlated (Pearson's $r = 0.759$, $p = 0.048$). There was poor agreement between combined shade, natural shade and built shade data (CCC < 0.90, respectively). Most of the data values on the combined shade and built shade Bland-Altman plots respectively were scattered away from the zero differences line. Most of the data values on the natural shade Bland-Altman plot were scattered within ± 5% of the zero difference line.

Summary of schools grouped according to the proportion of green-space (Tables 11 and 12)

The CCC values for combined shade and built shade data were lower at schools with large amounts of green-space (Table 12) than less green-space area (Table 11). For instance, at schools with large amounts (at least 75%) of green-space, the CCC value for combined shade was 0.409 while the CCC value was 0.661 for schools with less green-space (up to 74%). For schools with large amounts of green-space, the CCC value for built shade data was -0.112 while the CCC value was -0.043 for schools with smaller amounts of green-space. Natural shade calculations might have been positively influenced by the amount of green-space at school since the CCC value for natural shade data was 0.749 for schools with large amounts of green-space and it was 0.599 for schools with less green-space. None of these differences were statistically significant.

5.4.3 Additional shade-related data calculated for 11am and 1:30pm

The following section summarises the mean of the difference values (and associated lower and upper limits) and CCC values for all shade-related data. Shade-related data for each school calculated using the RS and the SA methods can be found in Appendix 5.3.

Table 13: Shade availability (combined, natural and built shade) at 11am on the 1st of December, June, March and September respectively: The mean of the difference values (i.e. the average value of all the difference (shade-audit (SA) values minus remote shade-estimation (RS) values) and the associated lower and upper limits for these mean values; and Lin's concordance correlation coefficient values (CCC) and associated 95% confidence intervals (CIs).

	1st December, 11am			**1st June, 11am**			**1 March, 11am**			**1 September, 11am**		
All schools, one group	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**
mean	5.05	1.33	3.67	2.78	-0.16	2.57	4.47	1.10	3.34	3.57	0.46	2.98
lower limit	-8.21	-13.85	-5.82	-9.74	-16.15	-7.24	-8.32	-13.76	-5.95	-9.52	-15.02	-6.59
upper limit	18.32	16.50	13.16	15.30	15.51	12.38	17.26	15.95	12.62	16.67	15.93	12.56
CCC	0.62	0.63	0.01	0.72	0.66	0.12	0.65	0.64	0.04	0.68	0.66	0.05
lower two-sided 95% CI	0.35	0.30	-0.25	0.47	0.34	-0.23	0.38	0.31	-0.24	0.42	0.33	-0.26
upper two-sided 95% CI	0.80	0.82	0.26	0.87	0.84	0.43	0.81	0.83	0.32	0.84	0.84	0.34
Schools grouped according the proportion of their built structures that were single-storey												
<=89% single-storey												
mean	5.91	1.95	4.13	3.04	0.43	2.68	5.15	1.75	3.66	4.00	0.98	3.22
lower limit	-7.60	-8.18	-4.28	-9.90	-11.25	-5.50	-7.95	-8.28	-4.76	-9.76	-10.18	-5.27
upper limit	19.41	12.07	12.54	16.00	12.10	10.86	18.25	11.78	12.06	17.75	12.14	11.70
CCC	0.59	0.76	0.18	0.64	0.77	0.35	0.53	0.76	0.22	0.59	0.76	0.24
lower two-sided 95% CI	0.14	0.39	-0.11	0.20	0.39	-0.09	0.10	0.43	-0.12	0.14	0.39	-0.15
upper two-sided 95% CI	0.84	0.92	0.45	0.87	0.92	0.67	0.80	0.91	0.52	0.84	0.92	0.56
90+% single-storey												

mean	4.02	0.58	3.12	2.46	-0.87	2.44	3.65	0.31	2.95	3.06	-0.18	2.71
lower limit	-9.36	-19.60	-7.89	-10.19	-21.50	-9.50	-9.84	-19.89	-8.08	-9.86	-20.26	-8.49
upper limit	17.40	20.76	14.11	15.12	19.77	14.38	17.15	20.52	13.98	15.98	19.90	13.91
CCC	0.43	0.19	-0.35	0.47	0.22	-0.27	0.42	0.19	-0.32	0.45	0.21	-0.32
lower two-sided 95% CI	-0.04	-0.43	-0.70	-0.09	-0.43	-0.68	-0.07	-0.43	-0.69	-0.08	-0.43	-0.70
upper two-sided 95% CI	0.75	0.69	0.14	0.81	0.71	0.28	0.75	0.69	0.17	0.78	0.71	0.20
Schools grouped according to the proportion of their usable area that was green-space												
<=74% green-space												
mean	5.22	1.45	3.68	3.12	0.40	2.31	4.56	1.22	3.26	3.89	0.91	2.84
lower limit	-8.55	-15.94	-7.12	-8.48	-17.43	-8.91	-8.71	-16.09	-7.53	-8.67	-16.42	-8.12
upper limit	18.99	18.83	14.48	14.72	18.22	13.53	17.83	18.53	14.06	16.44	18.24	13.80
CCC	0.66	0.60	-0.04	0.78	0.65	-0.01	0.69	0.62	-0.03	0.74	0.64	-0.06
lower two-sided 95% CI	0.34	0.15	-0.37	0.51	0.23	-0.43	0.38	0.18	-0.38	0.44	0.21	-0.43
upper two-sided 95% CI	0.84	0.84	0.29	0.91	0.87	0.41	0.86	0.85	0.34	0.89	0.86	0.33
75+% green-space												
mean	4.69	1.07	3.65	2.05	-1.36	3.13	4.27	0.84	3.50	2.90	-0.52	3.29
lower limit	-8.45	-8.94	-2.92	-13.14	-13.34	-3.29	-9.33	-9.34	-2.98	-12.25	-11.97	-3.04
upper limit	17.83	11.08	10.21	17.25	10.64	9.54	17.87	11.08	9.98	18.05	10.93	9.62
CCC	0.41	0.75	-0.11	0.40	0.70	0.00	0.38	0.74	-0.09	0.37	0.71	-0.05
lower two-sided 95% CI	-0.25	0.10	-0.38	-0.39	0.00	-0.38	-0.30	0.09	-0.38	-0.38	0.02	-0.37
upper two-sided 95% CI	0.81	0.95	0.17	0.85	0.94	0.37	0.81	0.95	0.21	0.83	0.94	0.28
Schools grouped according to the size of their usable land area												

<= median land area												
mean	6.32	0.98	5.24	4.32	0.35	4.17	5.72	0.94	4.85	4.99	0.68	4.53
lower limit	-9.63	-12.21	-1.88	-9.23	-13.01	-3.24	-9.86	-12.32	-2.52	-9.60	-12.26	-3.08
upper limit	22.28	14.16	12.38	17.88	13.72	11.57	21.30	14.20	12.22	19.59	13.61	12.15
CCC	0.41	0.68	0.19	0.57	0.75	0.31	0.42	0.69	0.23	0.51	0.74	0.22
lower two-sided 95% CI	-0.06	0.19	-0.06	0.07	0.33	-0.07	-0.06	0.21	-0.08	0.01	0.30	-0.10
upper two-sided 95% CI	0.73	0.90	0.42	0.84	0.92	0.61	0.74	0.90	0.49	0.80	0.92	0.50
> median land area												
mean	3.78	1.67	2.10	1.24	-0.68	0.97	3.22	1.25	1.82	2.15	0.23	1.43
lower limit	-6.27	-15.89	-8.70	-9.92	-19.54	-10.20	-6.84	-16.25	-8.85	-9.23	-18.08	-9.22
upper limit	13.82	19.24	12.89	12.39	18.19	12.15	13.28	18.76	12.49	13.53	18.54	12.09
CCC	0.80	0.58	-0.27	0.83	0.57	-0.41	0.82	0.59	-0.26	0.81	0.58	-0.20
lower two-sided 95% CI	0.05	0.04	-0.68	0.53	0.01	-0.65	0.52	0.05	-0.68	0.49	0.03	-0.66
upper two-sided 95% CI	0.93	0.86	0.26	0.95	0.86	0.45	0.94	0.86	0.30	0.94	0.86	0.37
Schools grouped according to the proportion of their classroom buildings that were single-storey												
<= 89% single-storey classrooms												
mean	6.39	2.51	3.98	4.25	1.85	2.64	5.76	2.46	3.51	5.13	2.26	3.13
lower limit	-8.38	-16.71	-8.68	-8.19	-18.01	-10.34	-8.53	-16.77	-9.12	-8.35	-17.05	-9.63
upper limit	21.17	21.74	16.65	16.69	21.72	15.61	20.05	21.68	16.17	18.60	21.57	15.90
CCC	0.42	0.36	-0.04	0.56	0.44	0.01	0.44	0.38	-0.02	0.50	0.41	-0.04
lower two-sided 95% CI	-0.04	-0.21	-0.44	0.07	-0.14	-0.49	-0.02	-0.20	-0.45	0.02	-0.16	-0.49
upper two-sided 95% CI	0.73	0.75	0.37	0.83	0.79	0.50	0.75	0.76	0.42	0.79	0.78	0.43

90+% single-storey classrooms												
mean	3.71	0.14	3.35	1.31	-2.18	2.50	3.18	-0.26	3.16	2.02	-1.35	2.84
lower limit	-7.93	-9.93	-1.93	-11.16	-12.49	-3.31	-8.60	-10.11	-2.14	-10.53	-11.41	-2.60
upper limit	15.35	10.21	8.64	13.78	8.13	8.32	14.93	9.58	8.46	14.32	8.71	8.27
CCC	0.75	0.85	0.10	0.79	0.83	0.29	0.76	0.85	0.14	0.77	0.84	0.20
lower two-sided 95% CI	0.40	0.61	-0.18	0.41	0.53	-0.15	0.39	0.60	-0.17	0.39	0.57	-0.17
upper two-sided 95% CI	0.91	0.94	0.36	0.94	0.95	0.64	0.92	0.95	0.43	0.93	0.95	0.52

Table 13 shows that for 11am on the 1st of December, June, March and September respectively, Lin's CCC values were lowest for built shade data (for example, at schools with large land areas, the CCC value was -0.27). The highest CCC value was found for natural shade data for schools with at least 90% single-storey classrooms (CCC = 0.85 for the 1st of December and September respectively). There was poor agreement between data calculated using the RS and the SA methods (CCC < 0.90). CCC values for natural shade data were higher at schools with at least 75% green-space (not significantly) however CCC values for combined and built shade were lower at this group of schools than for schools with up to 74% green-space (not significantly). The mean of the difference values were usually lowest for natural shade data, however, the range of lower and upper limits for these mean values were broad. For example, at schools with larger than median land size areas, for 1st September the mean of the difference value for natural shade was 0.23% and the lower and upper limits were -18.08% and 18.54% respectively.

Table 14: Shade availability (combined, natural and built shade) at 1:30pm on the 1st of December, June, March and September respectively: The mean of the difference values (i.e. the average value of all the difference (shade-audit (SA) values minus remote shade-estimation (RS) values) and the associated lower and upper limits for these mean values; and Lin's concordance correlation coefficient values (CCC) and associated 95% confidence intervals (CIs).

	1st December, 1:30pm			**1st June, 1:30pm**			**1st March, 1:30pm**			**1st September, 1:30pm**		
All schools, one group	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**	**Combined**	**Natural**	**Built**
mean	4.50	0.87	3.56	2.06	-0.83	2.36	4.52	0.97	3.52	3.12	0.00	2.90
lower limit	-7.50	-14.26	-5.91	-9.25	-16.37	-7.44	-7.71	-14.00	-5.86	-8.76	-15.07	-6.39
upper limit	16.50	16.00	13.02	13.38	14.72	12.15	16.75	15.93	12.91	15.00	15.07	12.18
CCC	0.68	0.65	0.02	0.78	0.69	0.18	0.68	0.66	0.01	0.74	0.69	0.10
lower two-sided 95% CI	0.43	0.33	-0.25	0.56	0.39	-0.19	0.43	0.35	-0.25	0.50	0.38	-0.22
upper two-sided 95% CI	0.83	0.84	0.28	0.90	0.86	0.50	0.84	0.84	0.27	0.87	0.86	0.40
Schools grouped according the proportion of their built structures that were single-storey												
<=89% single-storey												
mean	4.91	0.99	3.94	2.00	-0.55	2.28	4.91	1.16	3.93	3.12	0.08	3.05
lower limit	-6.69	-8.87	-4.45	-8.54	-11.48	-6.06	-6.98	-8.47	-4.40	-8.43	-10.19	-5.03
upper limit	16.51	10.84	12.32	12.53	10.38	10.61	16.80	10.80	12.26	14.67	10.34	11.13
CCC	0.60	0.79	0.19	0.75	0.81	0.44	0.60	0.80	0.18	0.69	0.82	0.32
lower two-sided 95% CI	0.18	0.48	-0.13	0.39	0.49	-0.05	0.18	0.50	0.12	0.29	0.50	-0.09
upper two-sided 95% CI	0.84	0.92	0.47	0.91	0.94	0.76	0.84	0.93	0.45	0.88	0.94	0.64
90+% single-storey												

mean	4.01	0.72	3.10	2.14	-1.16	2.45	4.06	0.74	3.04	3.12	-0.09	2.72
lower limit	-9.01	-19.64	-7.92	-10.62	-21.58	-9.33	-9.15	-19.47	-7.87	-9.76	-20.12	-8.29
upper limit	17.03	21.08	14.12	14.89	19.26	14.23	17.27	20.93	13.94	16.00	19.94	13.72
CCC	0.46	0.24	-0.31	0.49	0.24	-0.35	0.45	0.25	-0.33	0.47	0.26	-0.35
lower two-sided 95% CI	-0.01	-0.38	-0.67	-0.06	-0.39	-0.74	-0.01	-0.37	-0.69	-0.03	-0.38	-0.72
upper two-sided 95% CI	0.76	0.71	0.17	0.81	0.72	0.21	0.75	0.72	0.16	0.78	0.73	0.17
Schools grouped according to the proportion of their usable area that was green-space												
<=74% green-space												
mean	4.53	0.84	3.54	2.15	-0.50	1.90	4.57	0.98	3.52	3.26	0.25	2.66
lower limit	-7.66	-16.32	-7.28	-7.90	-17.79	-9.09	-7.73	-15.92	-7.18	-7.62	-16.54	-7.84
upper limit	16.72	18.01	14.36	12.19	17.00	12.89	16.87	17.88	14.22	14.14	17.04	13.17
CCC	0.72	0.63	-0.05	0.84	0.68	0.08	0.73	0.65	-0.06	0.80	0.67	0.02
lower two-sided 95% CI	0.43	0.20	-0.38	0.63	0.28	-0.38	0.43	0.23	-0.39	0.55	0.27	-0.38
upper two-sided 95% CI	0.88	0.86	0.30	0.94	0.88	0.51	0.88	0.86	0.29	0.92	0.88	0.41
75+% green-space												
mean	4.44	0.91	3.59	1.88	-1.53	3.33	4.42	0.94	3.54	2.82	-0.54	3.40
lower limit	-8.11	-9.71	-2.77	-12.70	-13.56	-3.57	-8.63	-9.85	-2.90	-11.90	-12.17	-3.12
upper limit	16.98	11.54	9.95	16.45	10.49	10.22	17.47	11.74	9.98	17.54	11.10	9.93
CCC	0.45	0.74	-0.08	0.48	0.72	0.01	0.43	0.73	-0.09	0.44	0.73	-0.04
lower two-sided 95% CI	-0.22	0.08	-0.35	-0.31	0.05	-0.37	-0.24	0.06	-0.37	-0.32	0.05	-0.37
upper two-sided 95% CI	0.83	0.95	0.20	0.88	0.94	0.38	0.83	0.95	0.19	0.85	0.95	0.28
Schools grouped according to the size of their usable land area												

<= median land area												
mean	5.43	0.23	5.16	2.94	-0.88	3.81	5.55	0.48	5.17	4.09	-0.21	4.40
lower limit	-8.68	-12.17	-2.06	-9.09	-13.56	-4.53	-8.88	-11.71	-2.00	-8.68	-12.09	-3.03
upper limit	19.53	12.63	12.38	14.98	11.80	12.14	19.97	12.66	12.33	16.85	11.66	11.82
CCC	0.52	0.75	0.19	0.69	0.80	0.34	0.52	0.77	0.17	0.63	0.80	0.27
lower two-sided 95% CI	0.04	0.34	-0.07	0.24	0.43	-0.11	0.05	0.37	-0.07	0.16	0.44	-0.09
upper two-sided 95% CI	0.80	0.92	0.43	0.89	0.94	0.67	0.81	0.93	0.40	0.87	0.94	0.56
> median land area												
mean	3.58	1.50	1.95	1.18	-0.77	0.90	3.50	1.46	1.87	2.15	0.22	1.40
lower limit	-6.21	-16.47	-8.70	-9.65	-19.39	-9.74	-6.33	-16.41	-8.61	-9.03	-18.10	-8.90
upper limit	13.38	19.47	12.60	12.00	17.85	11.55	13.33	19.33	12.36	13.32	18.53	11.69
CCC	0.81	0.56	-0.25	0.84	0.57	-0.09	0.81	0.56	-0.22	0.82	0.57	-0.15
lower two-sided 95% CI	0.51	0.01	-0.67	0.54	0.01	-0.62	0.52	0.01	-0.66	0.50	0.01	-0.63
upper two-sided 95% CI	0.93	0.85	0.29	0.95	0.86	0.49	0.93	0.85	0.32	0.94	0.86	0.42
Schools grouped according to the proportion of their classroom buildings that were single-storey												
<= 89% single-storey classrooms												
mean	5.42	1.55	3.79	3.14	0.69	2.20	5.53	1.79	3.83	4.24	1.22	2.98
lower limit	-7.87	-17.90	-8.86	-7.66	-18.95	-10.57	-8.01	-17.48	-8.66	-7.62	-17.93	-9.25
upper limit	18.72	21.00	16.44	13.94	20.33	14.96	19.06	21.06	16.31	16.09	20.36	15.22
CCC	0.50	0.39	-0.05	0.65	0.50	0.14	0.51	0.41	-0.05	0.59	0.47	0.05
lower two-sided 95% CI	0.03	-0.19	-0.46	0.18	-0.07	-0.42	0.03	-0.17	-0.45	0.11	-0.11	-0.43
upper two-sided 95% CI	0.79	0.77	0.38	0.88	0.83	0.62	0.79	0.78	0.36	0.84	0.81	0.51

90+% single-storey classrooms												
mean	3.58	0.18	3.32	0.98	-2.35	2.52	3.52	0.15	3.22	2.00	-1.22	2.81
lower limit	-7.29	-9.71	-1.94	-10.93	-12.42	-3.67	-7.53	-9.47	-2.10	-10.02	-11.08	-2.78
upper limit	14.45	10.08	8.59	12.90	7.73	8.70	14.56	9.76	8.55	14.02	8.65	8.40
CCC	0.78	0.86	0.14	0.81	0.83	0.16	0.78	0.86	0.13	0.79	0.85	0.14
lower two-sided 95% CI	0.44	0.63	-0.16	0.47	0.55	-0.25	0.44	0.64	-0.18	0.44	0.61	-0.21
upper two-sided 95% CI	0.92	0.95	0.41	0.94	0.95	0.53	0.92	0.95	0.41	0.93	0.95	0.47

Table 14 shows that for 1:30pm on the 1st of December, June, March and September respectively, there was poor agreement between the RS and the SA methods (all CCCs < 0.90). CCC values were lowest for built shade data than for natural and combined shade data (for example, at schools with more than 90% single-storey classroom buildings, 1st of September data, the CCC value was -0.35). For schools with mostly single-storey classrooms the CCC values were high for natural shade (CCC = 0.86, 1st December and September, respectively) and combined shade (CCC = 0.81, 1st June). Agreement between combined shade data might have been better (not significantly) for schools with large land areas although agreement between natural and built shade-related data were not better at these schools. The mean of the difference values were lowest for natural shade data however the associated lower and upper limits for these mean values were broad. For example, for all schools considered together, for 1st September the mean of the difference value for natural shade was 0.00% and the lower and upper limits were ±15.07 respectively.

The mean of the difference values (i.e. the average value of all the difference (shade-audit data minus shade-estimation data) values) and the associated lower and upper limits for these mean values, and Lin's concordance correlation coefficient values (CCC) and associated 95% confidence intervals (CIs) seemed to be repeatable across the dates and times considered (Tables 13 and 14). Therefore additional results for all times and dates are not provided.

5.5 Discussion

5.5.1 Summary of study 3

The purpose of study 3 was to encourage schools to become more interested in shade and to determine if an off-site method to measure shade could be developed that was less intrusive than an on-site method. We developed and tested a remote shade-estimation (RS) method and compared shade-related data calculated using our RS method with those calculated using the shade-audit (SA) method. WebShade® was used to measure shade at schools because it appeared to be the best method available. For the purpose of this study, we assumed that the SA method estimated shade availability better since on-site measurements of school boundaries, built structures and trees were conducted. Conversely, when the RS method was used, school boundaries were visually estimated on school images and a series of pre-defined height values for built structures and trees were used in place of actual heights.

For most shade-related data, especially built shade-related data, the RS values were lower than the SA values. Poor agreement was found between the RS and the SA shade-related data for 11am and 1:30pm, for all four dates (CCCs < 0.90). The highest CCC values were found for natural shade data at schools with mostly single-storey classroom buildings (CCC values ranged from 0.83 to 0.86). The lowest CCC value was found for built shade at schools with large land areas (CCC = -0.41). Built shade CCC values were generally the lowest of all CCC values. However, the differences between CCC values when potential effect-modifiers were considered were not significant.

Building features such as under-croft areas and balconies could not be included using the RS method because they were not visible on school aerial images. Better agreement was expected between RS and SA built shade data for schools at which most of the classroom buildings were single-storey since there would be fewer under-croft areas and balconies at these schools. Built shade CCC values were slightly higher for schools with at least 90% single-storey classroom buildings (compared to those with fewer single-storey classroom buildings). Built shade CCC values were lower for schools where at least 90% of their built structures were single-storey (compared to schools at which up to 89% of built structures were single-storey). The highest CCC value for built shade was 0.35 (at schools with up to 89% single-storey built structures) and built shade CCC values were often negative (indicating very poor agreement between methods). Perhaps the default height values used for built structures were not similar to the actual height values measured on-site at schools and this resulted in all built shade data values calculated using the RS method being lower than those calculated using the SA method. In particular, the height value assigned to some shade structures during the RS method might have lower than the true height of some structures since structures such as shade sails are usually customised to suit. Therefore the height of shade sails could be much higher or lower than the average height of 2.7m. For example, at some schools, the heights of shade sails were at least 3.5m. For schools that had numerous shade sails and shade structures (such as small roofed structures over sand-pits and seating areas) which were taller than 2.7m, overall built shade-related data would be lower than those data calculated using the SA method.

The natural shade CCC values were higher (not significantly) for schools with at least 90% single-storey classrooms and at schools with up to 89% single-storey built structures. Older schools in our sample had a greater number of established large trees than new schools. Additionally, older schools usually had more multi-storey built structures than newer schools (presumably because it is more expensive to build new multi-storey than single-storey structures). Many classrooms/indoor usable areas can be included in one multi-storey structure, and this structure could take up less ground area (m^2) than one single-storey structure with the same total floor area (m^2). For example, if a single-storey and a multi-storey classroom building, each with a total floor area of $600m^2$ were considered, the total ground space required for the single-storey building would be $600m^2$ while the ground space required for the multi-storey building might be $300m^2$ (if $300m^2$ are available for each of the 2 storeys) or $200m^2$ (if $200m^2$ are available for each of the 3 storeys). Consequently, schools with many multi-storey buildings might also have many large trees since fewer trees may be cleared to make room for a multi-storey building than a large single-storey building. Large trees were usually visible on aerial images, therefore were likely accounted for using the RS method. Thus, the agreement between natural shade data might have been better at schools with many multi-storey structures because these schools also had many large trees. This speculation might explain why natural shade CCC values were higher at schools with mostly multi-storey built structures (for example, CCC = 0.76, 11am 1st December). However this speculation does not explain why natural shade CCC values were higher at schools with mostly single-storey classroom buildings (for example, CCC = 0.86, 1:30pm 1st December).

Combined shade CCC values were higher for schools with large land areas (CCC value = 0.80 for 11am 1st December) than for schools with smaller land areas (CCC value = 0.41 for 11am, 1st December), although differences were not statistically significant. Large land areas might have attenuated the effect of RS method data entry errors, especially errors related to the location of school boundaries. Shade-related data calculations used the size of each school's land area as the denominator to determine shade availability. Therefore the amount of shade calculated using both methods might be lower for schools with large land areas since the total land area determined the proportion of shade. For example, if the total built area was calculated to be 200m^2 and the school total area was 2,000m^2, built shade would be calculated as 200m^2 / 2,000 m^2 = 0.1 (10%). However if the total area was 20,000 m^2, built shade would be calculated as 200m^2 / 20,000 m^2 = 0.01 (1%).

Of all shade-related data, we considered that natural shade data CCC values would be most influenced by the proportion of a school's usable area that was green-space. The CCC values for natural shade were higher for schools with more (CCC = 0.75), rather than less (CCC = 0.60), green-space. Conversely, combined shade CCC values were higher for schools with less (CCC = 0.66), rather than more (CCC = 0.41), green-space. Built shade CCC values were low at both groups of schools. For schools with vast amounts of green-space, natural shade data CCC values might have been higher, although not significantly, because more trees were located at schools with large play ovals and sporting fields. Previous studies had not investigated the possible impact of the potential effect-modifiers considered. Consequently the findings of this study could not be compared to previous results.

Others had reported that shade quantification at schools was a laborious process although the time they spent measuring shaded and unshaded areas on school photographs was never reported [16]. For each SA (study 3), on-site data collection took at least two days, with additional days being required at larger schools with numerous buildings and trees. For both the RS and the SA methods, data entry into WebShade® for each school required multiple hours (at least 3 hours per school for each method). We used the RS and SA methods to calculate shade availability for multiple periods of time using one aerial image per school which had been uploaded to two separate WebShade® files. These shade-related calculations would not have been possible using the methods described by others since they manually calculated visible shaded areas from photographs taken at one point in time [16, 17], used self-completed questionnaires to report shade provision at school [18, 19, 21], or visually estimated shade availability on-site [20]. Although the RS and the SA methods provided more shade-related data than previously reported methods [16-19, 21] both the RS and the SA methods were found to be laborious and expensive since we needed to purchase a license to use WebShade®, employ a WebShade® consultant to enter some SA data and employ a research assistant to collect on-site data for the SA method.

5.5.2 Use of shade-related data generated during study 3

Shade-related values calculated using the RS method were usually smaller than the values calculated using the SA method. Assuming that the SA method is the better method to estimate shade availability than the RS method because it used on-site data to calculate shaded area, the shade reports generated using the RS values are unlikely to provide participating schools with accurate measurements of shade. Instead, the findings of study 3, particularly the potential errors discussed below, might be most helpful to others developing alternative and improved RS methods.

5.5.3 Potential errors introduced by the RS method

The accuracy of the RS method might depend on the person who conducts it, their ability to use WebShade® and how they interpret a school image (for example, where they perceive a school boundary to be). The reproducibility of improved RS methods should be tested and the validity of an improved RS method should be tested against a gold-standard method when it becomes available. The series of pre-defined height values used for the RS method might be considered a source of error. While numerous on-site data were used to calculate these height values, it is possible that they were not representative of the actual height values for every built structure and tree on-site at the schools which participated in this study. While it might be helpful for a RS method to use more height values (for example, different height values for the centre of a building and building edges to represent a peaked roof, or different height values for an under-cover shade shed which is an enclosed building which is typically ground level but has higher eaves than a single-storey building) it would be difficult to determine which height values to assign to which structure using a remote method. The following section describes the potential errors introduced to the RS method that may have influenced the shade data calculations.

5.5.3.1 Natural shade calculations

The RS method relied upon visual estimation of school boundaries and student out-of-bounds areas. It is possible that entire sport fields/ovals were excluded from analysis if they were separated from the 'obvious' school grounds by a road, car park or landscaping features and therefore considered to be separate from the school property. Once the RS method was completed, SA school files were viewed to examine the detail entered into them (in terms of how each school image was digitised to show built structures with under-croft areas and where school boundaries were identified etc.). At this time, it became clear that sport fields from four schools had been overlooked using the RS method since they were seemingly separate from the rest of the school. For instance, at one school, the school sport field was across the road from the school therefore it was excluded from school property using the RS method. These types of errors likely appeared in the associated scatter plots as outliers. For instance, for the group of schools with ≤ 74% green-space there were four obvious outliers on the associated scatter plots. To investigate the influence of these outliers on Lin's values, they were removed from the equation and it was found that Lin's CCC value improved from 0.66 to 0.84. While a CCC value of 0.84 is not indicative of perfect agreement, it is closer to the tentative cut-off value of 0.90 [38], and this example demonstrates how several outliers might influence the CCC. However, the removal of these outliers from the CCC calculation reduced the sample size which consequently reduced statistical power, and it is not recommended to reduce outliers to improve agreement [40].

Natural shade estimations may be influenced by tree type since the quantity and quality of shade provided by a tree with dense foliage is likely to be greater than that provided by a tree with few leaves. The SA method included a visual analysis of every tree, therefore tree species and foliage density were recorded for each tree present at a school. Conversely, tree species or foliage density could not be identified using the RS method therefore the default tree type of 'evergreen' and default tree foliage density of 'heavy' was used for all trees. The default tree type of evergreen might be appropriate for north Queensland locations since fewer deciduous tree species are likely to be found here compared to other regions in Australia, and elsewhere [41]. However, not all evergreen trees have heavy foliage [42]. For example, the eucalyptus tree is an Australian evergreen with a sparse canopy [42] and many of these trees were found at schools in our sample. Since not all trees at the schools in this study were evergreen trees with dense foliage, the RS method was expected to over-estimate natural shade data. However natural shade values were often lower using the RS method than the SA method. Some trees may have been overlooked during the RS method or the canopy diameter might have been incorrectly measured using the WebShade® 'measure' tool (during the RS method).

5.5.3.2 Built shade calculations

The outlines of built structures visible on school aerial images were traced using WebShade® drawing tools to subsequently measure built shade. Since potentially large sources of built shade such as balconies and under-croft areas could not be identified using the RS method, the exclusion of these areas likely reduced the potential RS area estimated. Also, since the 'street view' function of Google Earth could not be used to view every building on a school image, most school buildings were assigned the default height value of 3m (that is, they were assumed to be single-storey buildings). For a school with many multi-storey buildings that were assigned a default single-storey height value, the larger shadows cast by tall buildings would be missed using the RS method.

5.5.3.3 WebShade® data entry

At times, particularly for schools in remote areas, the available Google Earth school images were dark and this made it difficult to use the RS method. Consequently, school boundaries, built structures and trees might have been inadequately digitised because their outlines were unclear.

These potential errors were also likely to have occurred for school images that were captured through thick cloud cover. Human error may have been introduced when school images were digitised using WebShade®. For example, incorrect built structure heights, tree heights etc. might have been entered into WebShade®.

5.5.4 Potential errors introduced by the SA method

5.5.4.1 Data collection

The dimensions of each built structure, tree and school boundary were physically measured on-site at participating schools with measurement devices. Therefore human error may have been introduced to each measurement. In particular, tree heights were a likely source of error since it was impossible to measure their actual height with the laser measuring device or retractable measuring tape.

5.5.4.2 WebShade® data entry

The WebShade® consultant completed most of the WebShade® SA school files. Human error may have been introduced when on-site measurements of buildings, trees etc. were entered into WebShade®, despite his experience with using the WebShade® program.

5.5.5 Study strength and limitations

To strengthen the results of this methods comparison study, I was blinded to the SA data collection process. Since I did not attend schools for the SA method, I had no knowledge of school boundary locations, built structures (and their associated features such as under-croft areas) and trees which were at schools when I conducted the RS method. While this approach was helpful to compare agreement between data calculated using the RS method against the SA method, a blind approach to shade-estimation would likely reduce the accuracy of shade-related data. If the user of an improved RS method knew the location of school boundaries, the true heights of each built structure, the size of under-croft areas etc., the resulting shade-related data might be more meaningful to schools.

The results of study 3 were potentially limited by the small sample size (n = 22) of schools for which RS method data and SA method data were compared. The number of schools assigned to school groups listed above in Table 2 (the potential effect-modifiers) ranged between 7 and 15. Future comparisons of shade-estimation methods would benefit from a larger sample size, especially if schools are divided into groups for analysis.

5.5.6 Future directions

Both the RS method and the SA method used WebShade® to calculate shade availability for specified times and dates. The times of 11am and 1:30pm were chosen because the recess breaks of most participating schools were held during the half hour either side of these times and we anticipated schools would be interested in shade-related data for these times. The four dates were chosen because shade availability can depend on the season. Studies which describe shade availability at schools for different seasons might benefit from using dates which correspond with the astronomical start of seasons because the commencement dates differ [43]. Our results were similar regardless of the time and date for which shade was measured. Perhaps this was because shade was calculated for times within 90 minutes of solar noon. At noon, the sun is directly overhead for all seasons and shade is usually directly under a tree or structure [4]. Others might consider using an improved RS method to measure shade at different times of the day (for example, 9am and 3pm as students arrive at and depart from school, respectively).

Prior to study 3 we knew that the WebShade® program was designed to be used in conjunction with data collected on-site and that it was not intended for use as a RS method. However, we believed it was worthwhile to conduct a study that explored the potential of an off-site WebShade® method because schools, and others, might benefit from a less laborious method of shade quantification. We also believed that a RS method to measure shade might be more feasible than previous shade-estimation methods documented whereby shaded and unshaded areas were measured on school aerial images [16, 17]. The following discussion provides some suggestions for future RS methodologies because both the RS and SA methods were found to be laborious and expensive.

5.5.6.1 Collaborate with schools

It may be possible to improve the natural shade estimates calculated with an improved RS method if schools were consulted prior to a RS to determine the location of their boundary and to ensure that all relevant sporting fields and school green-areas were included in the RS. Natural shade estimations might also improve if schools were provided with the Google Earth image of their school and asked to confirm the presence of the trees visible on the image. For instance, after a severe weather event such as Cyclone Yasi which was the largest and most powerful cyclone to affect north Queensland in known history [44], the presence of trees may not have been accurately represented on the Google Earth images used for the RS method. Therefore, it may be possible to improve the natural shade data calculated with an improved RS method if schools could view their school aerial photograph and comment if most of the trees visible are present at their school and/or mark which trees (especially large trees that likely amount to sizeable quantities of shade) were no longer present. Similarly, if schools were provided with their aerial image and asked to identify which buildings were single-storey and multi-storey, and which buildings had under-croft areas and/or balconies, an improved RS method may better estimate built shade availability.

5.5.6.2 Shade-estimation software

The RS method required us to purchase a software license to use the WebShade® program (cost equated to several thousands of dollars for a license). While WebShade® has worthy shade projection capabilities [1, 45], the costs associated with purchasing the software, collecting data, and evaluating data at many schools warrants consideration. If one expects to use a RS method to measure school shade availability for many schools at numerous locations, a user-friendly and cost-effective method is required. A shade-estimation method that is not reliant on the purchase of a software license is likely to appeal to schools and to stake holders interested in developing a school sun-protection program that includes shade assessments. Future RS methods may benefit from further collaboration with established and experienced shade-planning software developers (such as WebShade® or similar companies) to develop a method that could be made available to interested parties at an affordable cost.

5.5.6.3 School images

Google Earth school images were used for both the SA and the RS methods. These images were captured prior to the commencement of study 3 (for example, 2009). Future studies that measure and report shade availability at schools should use current aerial images. Local councils might provide access to recent aerial images. For example, aerial images of Townsville can be purchased from the local council at a cost that is determined by the size and quality of the image (prices start from $13.00 for an A4 size aerial image, and customised services are available at additional cost) [46]. Alternative sources of aerial images, and the associated cost of these images, should be considered by those interested in developing an improved RS method.

5.5.7 The potential value of a remote shade-estimation method

Schools and similar organisations could benefit from a RS method that estimates shade availability for any location, for any given time and date, without requiring entry onto school property to collect measurements of built structures and trees etc. If school governing bodies introduced shade regulations in the future, an improved RS method might be helpful to monitor school compliance with the new regulations. Additionally, an improved RS method might be useful for organisations (such as the Cancer Council) and researchers etc. interested in quantifying and comparing shade availability at schools, day care centres, public areas, or similar.

Students should have access to natural and built shade throughout the school day and be encouraged to use shade when they are outdoors [4]. Currently (2016) a freely available, user-friendly method to accurately measure shade at schools is not available. Instead, the Australian Cancer Council recommends that school staff interested in estimating shade availability visually assess shaded and un-shaded areas at their school [25]. WebShade® is a useful software for calculating shade-related data [1, 45] however it is not freely available and a thorough SA can be laborious. If an improved RS method was developed which allowed the user to measure shade for any location, time and date of interest, meaningful shade-related data could be calculated. School staff could use a RS method to calculate shade availability per student at school, or for a specific section of the school's usable area. For instance, schools could use a RS method to calculate shade availability per student during physical education classes held at 10am on the first Monday of each month. Physical education teachers could use the shade-related data generated using the RS method to identify outdoor areas which are suitably shaded for the time and dates of interest and then ensure that outdoor activities take place in these shaded areas.

In north Queensland, primary school children are at school during the peak ultraviolet period of the day [47, 48]. Therefore it is especially important that these children are encouraged to use multiple methods of sun-protection, including shade, in the school environment [4, 25]. If school staff could use a RS method to identify where quality shade was available at school, they might better plan their outdoor activities to incorporate shaded areas and direct students to use shaded areas during these activities. If school staff were easily able to measure shade they might become interested in calculating how much shade was available per student. As a result, school staff might find that their school would benefit from the construction of new shade structures. If school staff knew where quality shade was available at school throughout the school day and year, and consistently encouraged students to use shade, children might be better protected from over-exposure to solar ultraviolet radiation at school.

5.5.8 Conclusion

In summary, the SA method might produce useful shade-related data for schools since on-site data are used to measure shade. However the costs associated with purchasing WebShade® and the time required to collect data may discourage schools from conducting SAs. The RS method produced shade-related data which were lower than those calculated using the SA method and agreement between the two methods was found to be poor.

Future RS methods may require collaboration with schools and shade planning software developers to ensure that an improved method is designed which is accurate and cost-effective, yet still allows shade to be measured for any time of interest. If school staff were able to use an improved RS method to calculate shaded areas for any date and time of interest, they could better plan their outdoor activities so that students were better protected from excessive sun exposure. If researchers were able to use an improved RS method, they could compare shade availability at numerous schools. If a shade requirement was introduced to Australian primary schools, a RS method could be used to quantify shade at schools and identify which schools would benefit from additional shade.

5.6 Introduction to the following chapter

Studies 1 and 2 considered primary school sun-protection policies and uniform guidelines respectively while study 3 compared two shade estimation methods. An assessment of sun-protective behaviours in the school environment has not been presented in this thesis thus far. The following chapter describes study 4, which was conducted to evaluate the proportions of Townsville primary school students, and their adult role-models, who wear hats at school.

5.7 List of references

1. Greenwood, J. *Analysis of shade audits of 50 child care centres*. in *3rd International conference on UV and skin cancer prevention*. 2015. Melbourne, Australia.
2. Watts, C. and R. Meikle, *New Zealand shade audit study summary*. 2008, Quigley and Watts Public Health Specialists: Wellington, New Zealand.
3. Greenwood, J. *WebShade*. 2013 24/04/2013]; Available from: http://webshade.com.au.
4. Cancer Council New South Wales, *The shade handbook*. 2008, Cancer Council New South Wales: New South Wales, Australia.
5. Mackay, C., *Environmental shade for protection from UVR: a design & teaching resource*, in *The 26th conference on passive and low energy architecture*. 2009: Quebec City.
6. Moreno, A., et al., *An environmental assessment of school tree shade canopy and implications for sun safety policies: the Los Angeles unified school district.* ISPRS Int. J. Geo-Inf, 2015. **42**(2): p. 607-625.
7. Department of Education and Training. *Hours of operation*. 2016 16/09/2016]; Available from: http://education.qld.gov.au/parents/school-life/hours.html.
8. Bureau of Meteorology. *About UV and sun protection times*. 2016 6/11/2016]; Available from: http://www.bom.gov.au/uv/.
9. Cancer Council Victoria. *Slip, slop, slap, seek & slide: Sid Seagull*. SunSmart 2016 10/09/2016]; Available from: http://www.sunsmart.com.au/tools/videos/current-tv-campaigns/slip-slop-slap-seek-slide-sid-seagull.html.

10. Cancer Council Queensland. *Be SunSmart*. 2009 22/04/2013]; Available from: http://www.cancerqld.org.au/page/prevention/skin_cancer/national_sunsmart_schools_and_early_childhood_centres/.

11. Cancer Council Queensland. *SunSmart school review form*. 2016 27/06/2016]; Available from: https://cancerqld.org.au/cancer-prevention/understanding-risk/being-sunsmart/national-sunsmart-program/sunsmart-school-review-form/.

12. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.

13. Cancer Council Queensland. *Early childhood settings: SunSmart policy guidelines*. 2008 10/08/2016]; Available from: http://www.activehealthy.com.au/files/pdf/Early%20Childhood/54255_Early_Childhood_Settings_SunSmart_Policy_Guidelines_.pdf.

14. Department of Housing and Public Works. *Queensland Development Code*. 2012 01/06/2016]; Version 6:[Available from: http://www.hpw.qld.gov.au/SiteCollectionDocuments/MP5.4ChildCareCentres18July2012.pdf.

15. Infrastructure Division and Department of Education and Early Childhood Development, *Building quality standards handbook*, Department of Education and Early Childhood Development, Editor. 2011, State Government, Victoria: Victoria.

16. Milne, E., et al., *Direct measurement of sun protection in primary schools.* Prev Med, 1999. **29**: p. 45-52.

17. Schofield, M.J., et al., *Solar protection issues for schools: policy, practice and recommendations.* Aust J Public Health, 1991. **15**: p. 135-141.

18. Reeder, A.I., J.A. Jopson, and A. Gray, *Baseline survey of sun protection policies and practices in primary school settings in New Zealand.* Health Educ Res, 2009. **24**(5): p. 778-87.

19. Jones, S.B.W., K. Beckmann, and J. Rayner, *Australian primary schools' sun protection policy and practice: evaluating the impact of the National SunSmart Schools Program.* Health Promot J Aust, 2008. **19**(2): p. 86-90.

20. Aulbert, W., et al., *Certification of sun protection practices in a German child day-care centre improves children's sun protection - the 'SunPass' pilot study.* Br J Dermatol, 2009. **161**(Suppl. 3): p. 5-12.

21. Buller, D.B., et al., *Sun protection policies and environmental features in US elementary schools.* Arch Dermatol, 2002. **138**: p. 771-774.

22. Eakin, P., et al., *Sun protection policy in elementary schools in Hawaii.* Prev Chronic Dis 2004. **1**(3): p. A05.

23. Hunter, S., et al., *Assessment of elementary school students' sun protection behaviors.* Pediatr Dermatol, 2010. **27**(2): p. 182-188.

24. Cancer Council Victoria. *What is a shade audit?* 2015 11/11/2015]; Available from: http://www.sunsmart.com.au/shade-audit/default.aspx?ContentID=what-is-a-shade-audit.

25. Cancer Council Victoria. *Shade audit*. 2015 12/11/2015]; Available from: http://www.sunsmart.com.au/downloads/communities/early-childhood-primary-school/resources/vels/shade-audit.pdf.

26. The Cancer Institute. *Evidence to practice grants. Application guidelines.* 2015 12/11/2015]; Available from: https://www.cancerinstitute.org.au/media/386080/Evidence-to-Practice-Grants-Guidelines-2015.pdf.

27. Gies, P. and C. Mackay, *Measurements of the solar UVR protection provided by shade structures in New Zealand primary schools.* Photochem Photobiol, 2004. **80**: p. 334-9.

28. TechTarget. *Digitization*. 2016 29/09/2016]; Available from: http://whatis.techtarget.com/definition/digitization.

29. Department of Education and Training. *Far north Queensland region*. 2016 10/09/2016]; Available from: http://education.qld.gov.au/schools/maps/pdfs/farnorthqld.pdf.

30. Department of Education and Training and Employment. *State school full-time enrolment counts, census 2005-2009*. 2009 12/04/2010]; Available from: http://education.qld.gov.au/schools/statistics.

31. Australian Curriculum Assessment and Reporting Authority. *My School*. 2013 2009-2013]; http://www.myschool.edu.au/]. Available from: http://www.myschool.edu.au/.

32. Australian Curriculum Assessment and Reporting Authority, *My School. Guide to understanding ICSEA*, Australian Curriculum Assessment and Reporting Authority, Editor. 2012, ACARA Sydney, Australia.
33. Turner, D., et al., *School sun-protection policies – does being SunSmart make a difference?* Health Educ Res, 2014. **29**(3): p. 367-77.
34. Google. *Google Earth*. 2016 August 2011 to September 2016]; Available from: https://www.google.com.au/earth/.
35. Department of Environment & Climate Change. *Private native forestry code of practice guideline No. 4. Techniques for measuring stand height.* 2007 22/06/16]; Available from: http://www.epa.nsw.gov.au/resources/pnf/standheight07392.pdf.
36. Anderson, G. *Lin's Concordance*. 2012 August 20 - September 4, 2016]; Available from: http://services.niwa.co.nz/services/statistical/concordance.
37. Lin, L.I.-K., *A concordance correlation coefficient to evaluate reproducibility.* Biometrics, 1989. **45**: p. 255-268.
38. McBride, G.B., *A proposal for strength-of-agreement criteria for Lin's Concordance Correlation Coefficient*. 2005, Ministry of Health, National Institute of Water & Atmospheric Research Ltd: New Zealand.
39. Bland, J.M. and D.G. Altman, *Statistical methods for assessing agreement between two methods of clinical measurement.* Lancet, 1986. **8**(1): p. 307-310.
40. Bland, J.M. and D.G. Altman, *Measuring agreement in method comparison studies.* Stat Methods Med Res, 1999. **8**: p. 135-160.
41. Salleh, A. *Why don't we have more native deciduous trees in Australia?* 2016 25/10/2016]; Available from: http://www.abc.net.au/news/2016-03-07/deciduous-trees-in-australia/7200608?pfmredir=sm.
42. Patrick, J. *Fact sheet: Small gum trees*. 2011 04/10/2016]; Available from: http://www.abc.net.au/gardening/stories/s3190406.htm.
43. National Centers for Environmental Information. *Meteorological versus astronomical summer - what's the difference?* 2013 28/10/2016]; Available from: https://www.ncdc.noaa.gov/news/meteorological-versus-astronomical-summer%E2%80%94what%E2%80%99s-difference.

44. Colgan, P., O. Vaughan, and H. Davidson, *Cyclone Yasi: how it unfolded*, in *The Australian*. 2011, News Corp Australia: Sydney, Australia.
45. Greenwood, J. *Shade reality check - why aren't the decision-makers listening?* in *3rd International conference on UV and skin cancer prevention*. 2015. Melbourne, Australia.
46. Townsville City Council. *Mosaic mapping service*. 2016 26/10/2016]; Available from: https://www.townsville.qld.gov.au/building-planning-and-projects/mapping-services/mosaic-mapping-service.
47. Cancer Council New South Wales. *What is Ultraviolet radiation (UV) radiation and the SunSmart UV alert?* 2016 04/09/16]; Available from: http://www.cancercouncil.com.au/23856/cancer-prevention/sun-protection/sunsmart-program-for-primary-schools-and-ohsc/sunsmart-information-and-news/what-is-uv-radiation/.
48. Australian Radiation Protection and Nuclear Safety Agency. *Townsville realtime UV index data*. 2011 May 2009 to June 2015]; http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm]. Available from: http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm.

Chapter 6
Study 4: An observational study of the proportions of students and adult-role models who wore their hat at Townsville primary schools

6.1 Introduction

The use of a hat, especially a gold-standard hat (GSH) such as a broad-brimmed, bucket or legionnaire style hat, is considered a practical and effective form of personal sun-protection since a hat can shield the skin of the head and the neck from overhead ultraviolet radiation (UVR) [1-3]. In Australia, government owned primary schools are expected to comply with sun-safety guidelines that stipulate students wear hats when outdoors [4]. Similarly, Australian Cancer Council SunSmart school (SSS) guidelines specify that all school staff and students wear a broad brimmed, legionnaire or a bucket style hat (with a deep crown and brim width of at least 6 cm) whenever they are outdoors [5, 6].

To my knowledge, the earliest report of the proportion of Australian primary school students who wore a hat while outdoors at school presented data collected in 1989 during a lunch-break at New South Wales primary and secondary schools [7]. Schofield and colleagues (1991) reported the median proportion of primary school students who wore their hat (style not defined) during the lunch-break was 13%. The median proportion of secondary school students who wore their hat (style not described) during the lunch-break was reported by Schofield and colleagues (1991) to be 0%. In the 1990s, Milne and colleagues developed and introduced the ‘KidSkin’ sun-protection intervention to a sample of West Australian primary schools [8, 9]. Milne and colleagues (1999) filmed play areas during recess/recreation periods and then reviewed the footage to calculate the proportion of school students and staff that wore a hat. They found that approximately 90% of students wore a hat during recess periods, however only 1.5% to 24.5% of these students wore a GSH style [8]. One in three teachers observed by Milne and colleagues failed to wear a hat while 48% wore a broad brimmed hat and 16% wore a cap style hat [8]. Although Milne and colleagues reported that school staff were not specifically told that the proportions of school student and staff members wearing hats would be calculated from the video footage, school staff were aware that the KidSkin project aimed to improve the use of GSHs by students [8-10]. Therefore, it is possible that the adult and student hat-wearing proportions reported by Milne and colleagues (1999) over-estimated typical hat-use by these individuals. Other Australian and international reports that estimated hat-use at primary schools relied on questionnaires which were completed by school staff, parents and/or students, rather than direct observation of hat-use at schools [11-17]. Additionally hat-use by students at school commencement time (as individuals arrived at school for the commencement of the school day and entered school property) and at school dismissal time (as individuals left school property at the end of the school day) had not been documented when study 4 was developed.

6.2 Adult role-models

The sun-protective behaviours of young children may be positively influenced by the sun-protective behaviours of older peers and adults with them [18-20]. The sun-safety guidelines provided by the Queensland government's Department of Education and Training and the Australian Cancer Council's SSS program, recommend all adults at a school (for example, staff members, parents and care-givers), wear hats when they are outdoors [5, 6, 21]. Thus, for most Queensland schools, there is an expectation that adults will role-model hat-use while they are at school.

6.3 Development of the research question

Most Townsville primary schools have a written sun-protection policy [22]. These sun-protection policies should stipulate that students and adults wear hats when they are outdoors at school [5, 6, 21]. To determine if Townsville primary schools are following through with the hat-wearing expectation of school sun-protection policies, the following research question was developed:

> *What proportions of Townsville (latitude 19.3˚S, longitude 146.8˚E) primary school students, and their adult-role models, wear a hat to school in the morning (as they enter school property, immediately prior to school*

commencement time), during school hours (during recess periods) and at school dismissal time (as individuals exit the school property)?

To address this research question the following study was completed:

An observational study of the proportions of students and adult-role models who wore a hat at Townsville primary schools. The proportions of students and adults who wore hats at school commencement time, during school hours and at school dismissal time were compared overall and at schools grouped according to school characteristics.

We chose to directly observe hat-use at Townsville schools so that we could estimate the 'typical' proportions of adults and students who wore hats before, during and after school hours. We purposely avoided using questionnaires to reduce the potential influence of information bias (for example, recall bias) and selection bias.

While data collection for study 4 was underway, the Courier Mail (an Australian newspaper), printed an article with the title "Welcome to the sun shame state" [23]. This article included photographs of Queensland school students outdoors, during the school day when the ultraviolet index was 'very high', wearing a school uniform but not a hat [23]. The article implied that many Australian school students failed to wear hats when outdoors. It is possible that this newspaper article was read by Townsville school staff, parents and students and consequently prompted them to wear hats more often. Therefore, the proportions of students and adults reported to wear hats during study 4 may have over-estimated hat-use at Townsville schools. Since access to the newspaper article should have been similar for all observed individuals, the potential bias introduced to study 4 as a result of reading the article should have affected all schools equally.

The results of study 4 are presented in the following peer-reviewed manuscript.

6.4 Publications arising from study 4

Article as originally published in **Turner, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2014). "Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure." Preventive Medicine 60: 107-114.

Preventive Medicine 60 (2014) 107–114

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure

Denise Turner [a,*], Simone L. Harrison [a], Petra Buettner [b], Madeleine Nowak [a,c]

[a] Skin Cancer Research Group, School of Public Health, Tropical Medicine and Rehabilitation Sciences, Anton Breinl Centre for Health Systems Strengthening, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, QLD 4811, Australia
[b] Tropical Health Solutions Pty Ltd, Idalia, Townsville, Australia
[c] School of Medicine, James Cook University, Townsville, QLD 4811, Australia

ARTICLE INFO

Available online 29 December 2013

Keywords:
SunSmart
Sun-protection
Ultraviolet radiation
Hat-wearing
Skin cancer

ABSTRACT

Background. Childhood sun exposure is an important risk factor for skin cancer. Anecdotal evidence suggests that hats are under-utilized by Australian primary school students.

Methods. The proportion of students and adult role-models wearing hats was observed at 36 primary schools (63.9% SunSmart schools [SSS]) in Townsville (latitude 19.3°S; high to extreme maximum daily UV-index year round), Queensland, Australia, from 2009 to 2011.

Results. Overall, 52.2% of 28,775 students and 47.9% of 2954 adults were observed wearing a hat. Hat use (all styles) among SSS and non-SunSmart school (NSSS) students was similar before (24.2% *vs* 20.5%; $p = 0.701$), after (25.4% *vs* 21.7%; $p = 0.775$) and during school-hours (93.0% *vs* 89.2%; $p = 0.649$) except SSS students wore gold-standard (broad-brim/bucket/legionnaire) hats during school play-breaks more often in the warmer months (October–March) than NSSS students (54.7% *vs* 37.4%; $p = 0.02$). Although the proportion of adults who wore hats (all styles) was similar at SSS and NSSS (48.2% *vs* 46.8%; $p = 0.974$), fewer adults at SSS wore them before school (3.7% *vs* 10.2%; $p = 0.035$).

Conclusions. SunSmart status is not consistently associated with better hat-wearing behavior. The protective nature of hats and the proportion of school students and adult role-models wearing them could be improved, possibly by offering incentives to schools that promote sun-safety.

Introduction

Solar ultraviolet radiation (UVR) is the major cause of carcinogenesis of the skin (Bauer and Garbe, 2003; Dixon et al., 1999; Ghissassi et al., 2009; Kricker et al., 1994). Queensland, Australia, which has high levels of UVR throughout the year (Berhard et al., 1997) has among the highest rate of cutaneous melanoma (CM) and epithelial skin cancer in the world (Australian Institute of Health and Welfare, 2008; Australian Institute of Health and Welfare and Australasian Association of Cancer Registries, 2010). Exposing skin to UVR, especially during the first 10 years of life, is linked to the development of melanocytic nevi (MN) (Fritschi et al., 1994; Harrison et al., 1994; Harrison et al., 2000; Holman and Armstrong, 1984; Kelly et al., 1994), which are a major risk marker for the development of CM (Bauer and Garbe, 2003; Green et al., 1985; Holman and Armstrong, 1984; Sagebiel, 1993; Skender-Kalnenas et al., 1995). Children raised in high ambient UVR environments develop MN earlier and in higher numbers than children raised elsewhere (Fritschi et al., 1994; Harrison et al., 1994; Harrison et al., 2000; Harrison et al., 2010; Kelly et al., 1994; Sander-Wiecker et al., 2003). Using personal sun-protection including hats, clothing and sunscreen appears to play a role in reducing the development of MN (Autier et al., 1998; Bauer et al., 2005; English et al., 2005; Enta, 1998; Harrison et al., 1994; Harrison et al., 2005; Harrison et al., 2010) and therefore may reduce the risk of developing CM. Studies of the body-site distribution of skin cancer in adults living in Queensland indicate that actinic keratoses, epithelial skin cancer, and CM commonly develop on the chronically sun-exposed areas of the face, ears, neck, and scalp (Green et al., 1993; Heal et al., 2006; Raasch et al., 2006; Youl et al., 2011), making headwear a particularly important form of sun-protection for this high-risk population.

Furthermore, UVR is absorbed by the eye, and can lead to the development of age-related cataracts, cancer of the skin surrounding the eye,

Abbreviations: SSS, SunSmart school; NSSS, Non SunSmart school; GSH, Gold standard hat; MN, Melanocytic nevi; CC, Cancer Council.

* Corresponding author at: Skin Cancer Research Group, School of Public Health, Tropical Medicine and Rehabilitation Sciences, Anton Breinl Centre for Health Systems Strengthening, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, QLD 4811, Australia. Fax: +61 7 44331767.
E-mail address: denise.turner@my.jcu.edu.au (D. Turner).

0091-7435/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ypmed.2013.12.020

corneal degenerative changes and possibly age-related macular degeneration (American Academy of Pediatrics, 1999; The National Society to Prevent Blindness et al., 1993). Eye damage can be reduced by wearing brimmed-hats in addition to protective eyewear. This is particularly important for children, since eye damage tends to accumulate over time (The National Society to Prevent Blindness et al., 1993).

Australian children attend school from approximately 8:30 am to 3 pm which coincides with peak UVR-times, five days a week (approximately 200 days per year) and potentially receive most of their UVR exposure at school (Moise et al., 1999). UVR exposure can be reduced by wearing sun-protective clothing, hats, sunscreen, sunglasses and seeking shade when outside (Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, 2005). Legionnaire, broad-brimmed and bucket hats protect the face and neck more than caps or visors (Diffey and Cheeseman, 1992; Downs and Parisi, 2006; Gies et al., 2006; Kimlin and Parisi, 1999). The ultraviolet protection factor (UPF) of broad-brimmed hats is double that of peaked-caps (UPF 6.4 *vs* 3.2) (Kimlin and Parisi, 1999), with brim-widths of at least 12 cm offering good protection for the forehead (UPF 4–17) (Wong et al., 1997). Bucket hats with a brim-width of at least 7.5 cm protect the forehead, nose, cheeks, chin and posterior neck better than those with narrower brims (Diffey and Cheeseman, 1992) and offer similar sun-protection to broad-brimmed hats (Gies et al., 2006). Legionnaire hats protect the nose and neck better than bucket and broad-brimmed hats, but are less popular among school-aged children (Gies et al., 2006).

In 1988, eight years after the internationally recognized "Slip! Slop! Slap!" campaign began in Australia, the Cancer Council (CC) developed the SSS Program to promote sun-protective behaviors among children and adolescents (Cancer Council Victoria, 2002; Montague et al., 2001; SunSmart Victoria, 2012). The SSS program has operated in Victorian primary schools since 1994, Queensland since 1999 and the other Australian states for over a decade (Cancer Council Queensland, 2009); it has recently gained popularity internationally (Aulbert et al., 2009; Cancer Research UK, 2009; Glanz et al., 1998; Reeder et al., 2012; Reynolds et al., 2012; The Cancer Association of South Africa, 2010).

To register for the National SSS Program, primary schools complete an online application and their sun-protection policy is assessed by the CC. To obtain endorsement as a SSS by the CC, SSS must agree to comply with eleven minimum standards including ensuring that "all students wear a broad-brimmed (≥7.5 cm brim), legionnaire or bucket hat (≥6 cm brim, deep crown) when outside" (enforced year round in Queensland and August–May in temperate Australian states (Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, 2005) and "staff act as role-models by practicing SunSmart behaviors" (Cancer Council Queensland, 2013). Although the sun-protection policies of SSS are re-assessed by the CC every 2–4 years, SSS compliance with behavioral expectations of the program, such as hat-wearing, are not externally audited, presumably due to budgetary constraints, despite suggestions by key stakeholders from the school sector (Radvan, 2006).

This ecological study aimed to determine hat-wearing compliance rates of students attending primary school and their adult role-models in the skin-cancer prone population of Townsville, North Queensland, Australia.

Methods

The proportion of primary school children and adult role-models wearing hats while on school premises was observed at eligible primary schools in Townsville, from May 2009 to June 2011. Townsville (latitude 19.3°S, longitude 146.8°E), North Queensland, Australia, has a tropical climate with hot, humid summers, dry winters (Bureau of Meterology, 2009) and a high to extreme maximum daily UV-index, year round (Table 1).

Study protocol

Schools were eligible if: they educated primary school aged students (generally 5–12 years old); were located within a 15 km radius of Townsville's Central Business District; had ≥60 students enrolled in 2008; and predominantly educated "day" students (not exclusively boarding schools). Thirty-six of the 44 primary (Prep — Grade 7; first eight years of formal education) or combined (Prep — Grade 12; entire formal education) schools located within the Townsville District recognized by Education Queensland met the eligibility criteria. The SunSmart status of each school was verified through contact with the CC Queensland, while demographic information (e.g. school ownership; location; student enrolment figures) was obtained from Education Queensland (Department of Education and Training and Employment, 2009) and the "Index of community socio-educational advantage" (ICSEA) values were retrieved from the Australian "My School" website (Australian Curriculum Assessment and Reporting Authority, 2010). ICSEA is a scale that represents educational advantage and is calculated using student family background data to represent the levels of educational advantage students bring to their studies. Values range from 500 (schools with students from extremely educationally disadvantaged backgrounds) to 1300 (schools with students from highly educated families); the average ICSEA value is set at 1000 (Australian Curriculum Assessment and Reporting Authority, 2012). Each school's sun-protection policy was independently evaluated against 12 pre-determined criteria and a total score was assigned (Turner et al., 2013) (Table 2). The 12 criteria were related to promoting the following: student and staff hat-wearing; sun-protective uniforms; student shade use; role modeling of sun-protective behaviors; student sunscreen use; shade availability at school; shade provision at school events; rescheduling outdoor activities occurring during peak UVR exposure times; sun-safety promotion within the school community; inclusion of sun-safety education in the school curriculum; policy use when planning school events; and a regular review process.

Three observers assessed hat-wearing practices of students, parents, caregivers and teachers before and after school-hours (at school commencement and dismissal times) and students and school staff in the playground during school-hours. A small reliability study was conducted in eight schools. Two observers independently counted students wearing hats at the same time during school-hours for a period of 1–10 min. The concordance coefficient of the two observers for the proportion of hat-wearing students was 0.998 (95%-confidence interval 0.994 to 1.0) indicating very good agreement between the two observers. Observations were conducted from outside the school perimeter by whichever researcher was in the vicinity of the school at the relevant time. Observers used a standardized technique to observe the main entrance to school property during the half hour before (e.g. 8 am–8:30 am or 8:30 am–9 am) and after (e.g. 2:30 pm–3 pm or 3 pm–3:30 pm) school commencement and dismissal times as well as play grounds during supervised play-time within school-hours (e.g. morning tea break, 10:30 am; lunch break, 1 pm). Headwear

Table 1
Median [IQR]; range of recorded weather conditions during the observation period of May 2009 to June 2011.

Condition	Overall (average of all observations)	Warmer months (October–March, inclusive)	Cooler months (April–September, inclusive)
Minimum daily temperature (°C)[a]	20.2 [19.7, 21.1]; 19.0 to 22.4	23.0 [22.5, 23.4]; 20.8 to 27.7	17.7 [17.2, 18.9]; 13.2 to 21.0
Maximum daily temperature (°C)[a]	29.4 [29.0, 29.7]; 28.0 to 30.4	30.6 [30.1, 31.0]; 28.3 to 31.8	28.2 [27.8, 28.6]; 25.1 to 29.5
Maximum UVI[b] index	9.4 [8.5, 9.9]; 6.7 to 11.3	10.5 [9.8, 11.5]; 7.8 to 13.0	8.0 [7.5, 8.7]; 5.0 to 11.0
Cloud cover (eighths)[c]	3.9 [2.8, 4.3]; 1.7 to 6.3	4.0 [3.4, 5.3]; 1.0 to 7.0	3.0 [2.0, 3.9]; 0.8 to 6.0

[a] Temperature data was obtained from the Australian Bureau of Meteorology Townsville, Queensland. Daily weather observations [Online]. (Bureau of Meteorology, 2011).
[b] UVI = ultraviolet radiation-index. This data was obtained from the Bureau of Meteorology and the Australian Radiation Protection and Nuclear Safety Agency. (Bureau of Meteorology, 2011; Australian Radiation Protection and Nuclear Safety Agency, Accessed May 2009 to June 2011).
[c] Cloud cover as recorded as a fraction of eight.

Table 2
Demographic characteristics of 36 participating primary schools located in Townsville, North Queensland: stratified by SunSmart status.

Characteristic		All eligible schools[a] (n = 36)	SunSmart schools (n = 23)	Non-SunSmart schools (n = 13)	P value
		N (%)	N (%)	N (%)	
Ownership	Government	23 (63.9)	13 (56.5)	10 (76.9)	0.227
	Non-government	13 (13.1)	10 (43.5)	3 (23.1)	
School size	Small (≤399 students)	12 (33.3)	7 (30.4)	5 (38.5)	0.398
	Medium (400–799 students)	15 (41.7)	9 (39.1)	6 (46.2)	
	Large (≥800 students)	9 (25.0)	7 (30.4)	2 (15.4)	
ICSEA[b] group	≤ mean (≤1000)	31 (86.1)	18 (78.3)	13 (100)	0.074
	> mean (≥1001)	5 (13.9)	5 (21.7)	0 (0)	
Sun-protection policy score[c]	≤ median (≤3)	21 (58.3)	11 (47.8)	10 (76.9)	0.094
	> median (≥4)	15 (41.7)	12 (52.2)	3 (23.1)	

[a] Schools were eligible if: they educated primary school aged students (generally 5–12 years old); were located within a 15 km radius of Townsville's Central Business District; had ≥60 students enrolled in 2008; and predominantly educated "day" students (not exclusively boarding schools).
[b] ICSEA — index of community socio-educational advantage (Australian curriculum assessment and reporting authority, 2012).
[c] The sun-protection policy score refers to the total score attained by schools when their sun-protection policies were independently evaluated against pre-determined criteria (maximum score possible was 12) (Turner et al., 2013).

was categorized into three categories: no hat; gold-standard hats (GSH) which included wide-brimmed hats, bucket hats and legionnaire hats with a flap covering the posterior neck; or caps and sun-visors.

Every person entering or leaving the school or seen in the playground during the observation period was included in the data collection. As it was not always possible to distinguish parents or care-givers from school staff, any adult accompanying students onto school grounds, leaving school grounds with a student or supervising students during school-hours was considered an "adult role-model". Children were classified as "students" if they wore the school uniform of the school being observed. Observations were made discretely and the purpose of the study was not discussed with study subjects to avoid influencing their hat-wearing behavior.

Observations were categorized according to time of day (before, during or after school-hours) and warmer (October to March, inclusive) or cooler (April to September, inclusive) months. The calendar year was divided into warmer and cooler months rather than season since summer coincides with the major school vacation in Queensland. Cloud cover was recorded as a fraction of eight at the time of each observation since it can change according to location (Bureau of Meteorology; Lagerlund et al., 2006). No observations were made on rainy days.

Statistical analysis

Average hat-wearing rates were calculated per school for each observation period (e.g. before, after and during school-hours) and an overall hat wearing rate per school was calculated as the average of all observations made at a school. Hat-wearing rates are described using median values together with inter-quartile range (IQR) and range (minimum and maximum values) as data were not normally distributed. Non-parametric Mann–Whitney and Kruskal–Wallis tests were used to assess for differences between proportions of children or adult role-models wearing a hat before, during and after school-hours. The concordance coefficient (I-Kuei, 1989) was used to assess the agreement between the assessments of hat-wearing proportions by two independent observers. Spearman's rank correlation coefficient was used to explore the relationship between student and adult hat-wearing rates.

Ethics

Approval to conduct an observational study of sun-protective practices of students and their adult role-models at primary schools in Townsville was

Table 3
Hat wearing rates for SunSmart and Non-SunSmart schools in Townsville, stratified by demographic characteristics.

Characteristic		All eligible schools[a] (n = 36)	SunSmart schools (n = 23)	Non-SunSmart schools (n = 13)	P value
		N	Median [IQR[b]]; range	Median [IQR]; range	
Ownership	Total	36	55.4 [48.8, 60.4]; 21.4 to 89.6	51.0 [43.1, 55.1]; 40.4 to 64.2	0.169
	Government	23	51.6 [42.4, 57.6]; 21.4 to 60.4	50.2 [43.8, 53.4]; 40.9 to 64.2	0.563
	Non-government	13	61.5 [50.4, 72.8]; 44.9 to 89.6	54.8 [40.4, –]; 40.4 to 62.7	0.287
School size	Small (≤399 students)	12	53.9 [40.1, 56.3]; 38.1 to 60.2	52.7 [42.5, 59.1]; 40.4 to 62.7	0.876
	Medium (400–799 students)	15	51.6 [47.6, 59.0]; 44.7 to 73.5	50.3 [45.8, 57.1]; 41.8 to 64.2	0.529
	Large (≥800 students)	9	65.3 [51.6, 72.5]; 21.4 to 89.6	45.9 [40.9, –]; 40.9 to 51.0	0.222
ICSEA[c] group	≤ mean (≤1000)	31	53.5 [47.7, 59.0]; 21.4 to 68.6	51.0 [43.1, 55.1]; 40.4 to 64.2	0.373
	> mean (≥1001)	5	72.5 [49.4, 81.5]; 44.9 to 89.6	–	–
Sun-protection policy score[d]	≤ median (≤3)	21	57.6 [51.6, 65.3]; 40.1 to 73.5	50.2 [43.6, 53.4]; 40.4 to 62.7	0.061
	> median (≥4)	15	53.1 [45.8, 58.1]; 21.4 to 89.6	54.8 [41.8, –]; 41.8 to 64.2	1.000

"–" Data unable to be computed.
[a] Schools were eligible if: they educated primary school aged students (generally 5–12 years old); were located within a 15 km radius of Townsville's Central Business District; had ≥60 students enrolled in 2008; and predominantly educated "day" students (not exclusively boarding schools).
[b] IQR — inter-quartile range.
[c] ICSEA — index of community socio-educational advantage (Australian curriculum assessment and reporting authority, 2012).
[d] The sun-protection policy score refers to the total score attained by schools when their sun-protection policies were independently evaluated against pre-determined criteria (maximum score possible was 12) (Turner et al., 2013).

Table 4
Median [IQR]; range (denominator) of student and adult hat wearing rates at 36 Townsville primary schools overall[a], before, during and after school-hours.

	All schools	SunSmart school			School ownership		
		Yes (n = 23)	No (n = 13)	P value	Non-government (n = 13)	Government (n = 23)	P value
Students							
Overall[a]	52.2 [45.4, 59.8]; 21.4 to 89.6 (n = 28,775)	55.4 [48.8, 60.4]; 21.4 to 89.6 (n = 18,336)	51.0 [43.1, 55.1]; 40.4 to 64.2 (n = 10,439)	0.169	57.6 [49.8, 70.6]; 40.4 to 89.6 (n = 8369)	51.3 [44.5, 56.3]; 21.4 to 64.2 (n = 20,406)	0.026
Before hrs	22.5 [16.8, 33.4]; 8.8 to 88.0 (n = 10,919)	24.2 [16.6, 37.5]; 9.8 to 88.0 (n = 5508)	20.5 [13.8, 35.5]; 8.8 to 58.2 (n = 5411)	0.701	36.3 [12.7, 55.3]; 8.8 to 88.0 (n = 2916)	21.3 [16.8, 29.5]; 9.8 to 51.4 (n = 8003)	0.179
After hrs	23.4 [15.0, 34.6]; 9.9 to 94.4 (n = 10,272)	25.4 [15.6, 35.9]; 10.7 to 88.2 (n = 7455)	21.7 [13.5, 35.2]; 9.9 to 94.4 (n = 2817)	0.775	37.4 [16.5, 61.0]; 11.4 to 94.4 (n = 2741)	21.7 [14.6, 33.1]; 9.9 to 39.8 (n = 7531)	0.092
During hrs	92.9 [84.9, 95.6]; 53.1 to 100.0 (n = 7584)	93.0 [89.4, 95.1]; 66.3 to 99.1 (n = 5373)	89.2 [76.2, 97.5]; 53.1 to 100.0 (n = 2211)	0.649	94.1 [83.7, 96.4]; 53.1 to 100.0 (n = 2712)	92.7 [84.8, 95.1]; 66.3 to 98.8 (n = 4872)	0.58
GSH[b], overall	51.9 [40.8, 58.6]; 20.6 to 89.6 (n = 28,775)	55.4 [45.6, 59.9]; 21.4 to 89.6 (n = 8248)	45.9 [32.6, 55.0]; 20.6 to 64.0 (n = 10,439)	0.051	57.6 [47.0, 70.4]; 39.9 to 89.6 (n = 8369)	50.2 [39.2, 55.7]; 20.6 to 64.0 (n = 20,406)	0.012
GSH, before hrs	20.0 [11.1, 31.9]; 6.0 to 88.0 (n = 10,919)	21.4 [16.6, 36.7]; 6.6 to 88.0 (n = 1643)	19.0 [8.9, 34.5]; 6.0 to 58.0 (n = 5411)	0.362	36.2 [12.7, 55.3]; 5.6 to 88.0 (n = 2916)	19.3 [10.4, 23.4]; 6.0 to 50.7 (n = 8003)	0.136
GSH, after hrs	19.7 [12.5, 33.2]; 0.0 to 94.3 (n = 10,272)	20.4 [16.3, 34.4]; 10.7 to 88.2 (n = 1823)	18.4 [5.3, 34.9]; 0.0 to 94.4 (n = 2817)	0.353	37.4 [16.5, 60.5]; 11.4 to 94.4 (n = 2741)	19.7 [10.9, 28.6]; 0.0 to 37.9 (n = 7531)	0.034
GSH, during hrs	91.5 [83.5, 95.1]; 40.9 to 100.0 (n = 7584)	93.0 [89.4, 95.1]; 66.3 to 99.1 (n = 4782)	84.1 [53.1, 94.7]; 49.9 to 100.0 (n = 2211)	0.060	94.1 [83.7, 96.4]; 53.1 to 100.0 (n = 2712)	90.4 [83.4, 93.4]; 40.9 to 98.5 (n = 4872)	0.190
Adults							
Overall	47.9 [38.1, 58.2]; 10.6 to 100.0 (n = 2954)	48.2 [38.1, 57.6]; 20.8 to 100.0 (n = 1967)	46.8 [30.0, 62.2]; 10.6 to 100.0 (n = 987)	0.974	48.2 [39.5, 62.8]; 10.6 to 100.0 (n = 1054)	46.8 [35.2, 57.4]; 16.7 to 75.0 (n = 1900)	0.434
Before hrs	6.1 [1.0, 10.8]; 0.0 to 26.7 (n = 1761)	3.7 [0.5, 7.7]; 0.0 to 20.0 (n = 1086)	10.2 [5.3, 17.1]; 0.0 to 26.7 (n = 675)	0.035	6.1 [2.0, 10.8]; 0.0 to 26.7 (n = 702)	5.5 [0.3, 11.5]; 0.0 to 18.7 (n = 1059)	0.583
After hrs	19.3 [11.7, 34.2]; 0.0 to 54.6 (n = 768)	15.1 [10.5, 33.8]; 0 to 50.0 (n = 538)	25.2 [14.2, 35.3]; 0.0 to 54.6 (n = 230)	0.490	31.5 [15.1, 50.0]; 5.3 to 54.6 (n = 276)	14.2 [10.5, 28.6]; 0.0 to 37.3 (n = 492)	0.091
During hrs	85.4 [58.5, 100.0]; 0.0 to 100.0 (n = 425)	88.8 [62.5, 100.0]; 50.0 to 100.0 (n = 343)	80.6 [41.7, 94.4]; 0.0 to 100.0 (n = 82)	0.169	87.5 [60.8, 100.0]; 0.0 to 100.0 (n = 76)	81.3 [58.3, 100.0]; 32.5 to 100.0 (n = 349)	0.820

[a] Overall refers to the average hat wearing rate of all observations made at a school before, during and after school hours.
[b] GSH — gold standard hat: includes broad brim, legionnaire and bucket style hats.

obtained from James Cook University (approval H3365), Education Queensland (ref11/54273) and the Catholic Diocese of Townsville.

Results

Overall, 52.2% of the 28,775 students and 47.9% of the 2954 adult role-models observed at 36 Townsville primary schools were wearing a hat (any style) when sighted (based on a median of 9 [IQR = 8, 11] observations per school between 2009 and 2011).

The proportion of students wearing a hat (any kind) was similar at SSS and NSSS overall (Table 3), before, during and immediately after school (Table 4). Adult hat-wearing rates at NSSS were higher than SSS before school-hours ($p = 0.035$) but similar during and after school-hours. Overall, more students attending non-government schools wore a hat (any $p = 0.026$) or a GSH ($p = 0.012$) than students attending government schools (Table 4).

During the warmer months of the year, more SSS students than NSSS students wore a hat (any, $p = 0.031$) or a GSH ($p = 0.02$) during school play-breaks. Similarly, more students from non-government schools than government schools wore a GSH during the warmer months before ($p = 0.049$), during ($p = 0.031$) and after ($p = 0.001$) school-hours. In the cooler months, students from non-government schools were more likely to wear a hat (any) before school ($p = 0.019$) or a GSH overall ($p = 0.047$; Table 5). Neither school ICSEA values nor sun-protection policy scores were associated with improved student or adult hat wearing rates (data not shown).

Spearman's rank correlation coefficient analyses did not suggest a relationship between student and adult hat-wearing proportions overall ($r = 0.129$, $p = 0.454$), before school-hours ($r = 0.182$, $p = 0.371$), during school-hours ($r = 0.183$, $p = 0.285$) or after school-hours ($r = 0.271$, $p = 0.223$).

Discussion

The proportion of primary school children and their adult role-models wearing hats around the school environment in the skin-cancer prone population of Townsville could be improved, particularly on arrival and dismissal from school. Overall approximately half of the students and their adult role-models wore hats. Student hat-wearing rates immediately before school and on dismissal were substantially lower than during supervised play-time. Similarly adult hat-wearing rates were highest during school-hours when teachers comprised most of the sample and lowest before and after school-hours when a mix of teachers, parents and care-givers were observed.

SunSmart status appeared to have little influence on overall hat use among either the school children or their adult role-models, with the difference in rates between SSS and NSSS for adults being 1.4% and for students 4.4%. Where differences were observed between SSS and NSSS, they were not consistent. For example: SSS students were more likely than NSSS students to wear any hat or a GSH during school hours in the warmer months; and NSSS adults were more likely than SSS adults to be seen wearing hats before school hours, especially during the cooler months of the year.

School ownership influenced hat-wearing rates as much as SunSmart status, and contrary to the expectations of the SSS Program, which focuses primarily on policy development, schools with higher sun-protection policy scores did not exhibit better hat-wearing behavior. This indicates that primary schools in tropical Queensland with comprehensive written sun-protection policies in place are no better at enforcing hat-wearing compliance than schools with poorly articulated policies. Although CC expects SSS to ensure that their students wear GSH year round in the school environment (Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, 2005), not all students attending these schools wore them. Similar findings from our recent observations of Brisbane primary schoolchildren (Harrison and Nikles, 2012) and anecdotal evidence from across the state (Hinde, 2009) suggest that hat-use among schoolchildren may be declining across Queensland, the state with the highest skin cancer rates globally (Buettner and Raasch, 1998; Green et al., 1996). More encouragement or incentives from external sources may be required to encourage better compliance with SunSmart regulations so that SSS environment continues to represent the gold-standard in sun-protection. Our team is currently funded by Queensland Health to pilot a program that monitors sun-protection compliance in schools; acknowledges and rewards schools that consistently practice sun-safe behaviors; and provides incentives to encourage schools to strive to achieve and maintain high levels of sun-protection.

Direct observations of hat-wearing during supervised play-time at primary schools in Perth, Western Australia, showed that 87% of students wore a hat of any description which is less than the 92.9% we observed (Milne et al., 1999b). GSH wearing rates at Townsville primary schools were also higher than those observed at Perth primary schools (91.5% *vs* 14%) which may reflect the uniform hat requirements at those schools at the time (Milne et al., 1999b). Most (85.4%) of the adult role-models we observed wore a hat while supervising student play compared to 66% of adults at Western Australian schools a decade earlier (Milne et al., 1999b). Observations of American primary school students also found lower hat-wearing rates during school-hours (30–41%), however, observations were only made during physical education classes and their student denominator was much lower than ours (Hunter et al., 2010).

We observed hat-wearing behavior before and after school-hours when students and adults walked into and out of school grounds. These periods were of interest since they may represent hat-wearing behavior when parents/care-givers have more influence over their child's behavior since they may be accompanying their child to and from school. To our knowledge this is the first study to make observations of hat-wearing behavior at these times. There was no relationship between adult and student hat-wearing rates however less than a quarter of children observed wore a hat before or after school-hours and adult hat-wearing rates before school-hours were also particularly low. Perhaps parents/care-givers need to be reminded of the role they play in promoting sun-safety since research has shown that parents can be enthusiastic role-models for sun-protective behaviors (Turrisi et al., 2004). Children are more likely to adopt personal sun-protection methods if their adult role-models use some form of sun-protection (Dadlani and Orlow, 2008; Hill and Dixon, 1999; O'Riordan et al., 2003). Consistent role-modeling of sun-protective behaviors during the childhood years, a time when children are influenced by adult behaviors, may emphasize sun-safety importance and encourage students to develop good sun-protective habits for life.

GSHs shade the face and neck regions better than cap or visor style hats thereby providing greater photo-protection to these areas (Downs and Parisi, 2006; Gies et al., 2006; Kimlin and Parisi, 1999). Our observations suggest that more students wear a GSH during school-hours in the cooler months than the warmer months (when UVR is higher) which is disappointing and suggests students chose to wear a hat for warmth rather than sun-protection. Enforcing GSH wearing among students throughout the year in regions with high ambient levels of UVR, such as Townsville, should be encouraged as a change in hat style presents a simple way to improve student sun safety behaviors and reduce their risk for developing skin cancer and eye conditions later in life.

Previous observational studies of the sun-protective habits of primary school children have informed school staff and parents about the study in advance (Giles-Corti et al., 2004; Hunter et al., 2010; Milne et al., 1999a; Milne et al., 1999b) which may have altered the behavior of the study participants. We chose to withhold information about observations from study participants to avoid potential bias and obtain hat-wearing data that would be representative of Queensland primary school students. However, we acknowledge that our data may overestimate student hat-wearing rates since Townsville is a geographical region associated with a high risk of developing skin cancer (Buettner and Raasch, 1998) hence parents and care-givers may make more effort to ensure their children wear hats. The study was limited by the small number ($n = 36$) of schools in the region and the associated lack of statistical power. Furthermore, since all observed adults were categorized as "adult role-models" because it was not always possible to distinguish school staff from parents and care-givers, it was not possible to associate student hat-wearing rates specifically with either staff or parent/care-giver hat-wearing rates. However, adult hat-wearing rates during schools hours are likely to reflect those of school staff since parents/care-givers were not usually present during school hours and these rates were higher than those observed before and after school-hours which reflects a period when a mixture of school staff and parent/care-givers were present.

Ethical constraints prevented student and staff hat-wearing behavior from being filmed or photographed thus the total number of individuals and individuals wearing hats may have been under-reported. However such information bias would be similar for all schools and result in a bias towards the null in comparative analyses.

In conclusion, the protective nature of hats and the proportion of Townsville primary school students and adult role-models wearing them could be improved. Hat-wearing rates were poorest immediately before and after school. SunSmart status had a small positive influence on students wearing GSH during school breaks, but this was confined to the warmer half of the year, despite Townsville experiencing high UVR levels year-round.

Grant support

Queensland Health and James Cook University provided funding for this project.

Table 5
Median [IQR]; range (denominator) of student and adult hat wearing rates at 36 Townsville primary schools during the warmer and cooler months of the year.

	All schools	SunSmart school			School ownership		
		Yes (n = 23)	No (n = 13)	P value	Non-government (n = 13)	Government (n = 23)	P value
Students							
Warm months, overall[a]	54.2 [41.0, 60.4]; 8.8 to 98.1 (n = 14,482)	55.5 [51.3, 64.9]; 24.8 to 95.9 (n = 8907)	42.8 [38.1, 57.5]; 8.8 to 98.1 (n = 5575)	0.075	59.5 [52.1, 75.8]; 8.8 to 95.9 (n = 4318)	52.0 [30.1, 56.8]; 24.8, 98.1 (n = 10,164)	0.070
Warm months, before hrs	22.8 [17.1, 40.6]; 8.8 to 95.9 (n = 5947)	24.4 [17.0, 45.4]; 10.8 to 95.9 (n = 2589)	22.2 [17.4, 39.3]; 8.8 to 60.3 (n = 3358)	0.670	40.6 [17.0, 60.3]; 8.8 to 95.9 (n = 1276)	21.1 [17.1, 26.9]; 10.8 to 80.9 (n = 4671)	0.123
Warm months, after hrs	22.6 [13.4, 39.8]; 5.3 to 94.4 (n = 5619)	27.1 [13.3, 41.2]; 8.5 to 88.2 (n = 4230)	14.6 [11.1, 44.1]; 5.3 to 94.4 (n = 1389)	0.322	54.0 [28.0, 82.4]; 11.0 to 94.4 (n = 1838)	14.6 [11.5, 23.8]; 5.3 to 39.8 (n = 3781)	0.001
Warm months, during hrs	95.7 [89.8, 98.2]; 33.2, 100.0 (n = 2916)	96.8 [3.4, 98.4]; 49.6 to 100.0 (n = 2088)	87.8 [67.2, 96.8]; 33.2 to 100.0 (n = 828)	0.031	95.5 [87.8, 98.4]; 33.2 to 100.0 (n = 1204)	96.2 [89.8, 98.1]; 49.6 to 100.0 (n = 1712)	0.959
Warm months, GSH[b] overall	53.2 [35.5, 60.4]; 7.2 to 98.1 (n = 14,482)	54.7 [48.9, 64.1]; 24.8 to 95.9 (n = 8907)	37.4 [22.6, 55.2]; 7.2 to 98.1 (n = 5575)	0.020	59.5 [52.1, 75.8]; 7.2 to 95.9 (n = 4318)	48.9 [28.4, 54.9]; 19.3 to 98.1 (n = 10,164)	0.031
Warm months, GSH before hrs	19.9 [11.1, 40.6]; 0.0 to 95.9 (n = 5947)	23.2 [17.0, 45.4]; 7.4 to 95.9 (n = 2589)	14.3 [7.2, 39.3]; 0.0 to 60.3 (n = 3358)	0.113	40.6 [17.0, 60.3]; 7.2 to 95.9 (n = 1276)	18.0 [11.0, 23.6]; 0.0 to 80.9 (n = 4671)	0.049
Warm months, GSH after hrs	21.7 [9.5, 37.9]; 0.0 to 94.4 (n = 5619)	23.2 [12.4, 39.7]; 7.6 to 88.2 (n = 4230)	13.5 [2.9, 44.1]; 0.0 to 94.4 (n = 1389)	0.176	54.0 [24.3, 79.5]; 11.0 to 94.4 (n = 1838)	13.4 [7.5, 22.1]; 0.0 to 37.9 (n = 3781)	<0.001
Warm months, GSH during hrs	53.2 [35.5, 60.4]; 7.2 to 98.1 (n = 2916)	54.7 [48.9, 64.2]; 24.8 to 95.9 (n = 2088)	37.4 [22.6, 55.2]; 7.2 to 98.1 (n = 828)	0.020	59.5 [52.1, 75.8]; 7.2 to 95.9 (n = 1204)	48.9 [28.4, 54.9]; 19.3 to 98.1 (n = 1712)	0.031
Cool months, overall	56.2 [48.3, 63.2]; 18.7 to 79.2 (n = 14,293)	59.4 [45.6, 65.3]; 18.7 to 79.2 (n = 6964)	56.0 [50.5, 58.7]; 43.4 to 75.5 (n = 7329)	0.721	62.5 [51.2, 65.7]; 40.5 to 79.2 (n = 6003)	56.0 [46.9, 60.4]; 18.7 to 75.5 (n = 8290)	0.149
Cool months, before hrs	24.4 [16.3, 38.7]; 8.4 to 80.0 (n = 4972)	24.4 [14.1, 44.4]; 8.4 to 80.0 (n = 2774)	26.8 [16.9, 38.5]; 9.3 to 56.9 (n = 2198)	0.909	47.3 [22.9, 56.1]; 8.6 to 80.0 (n = 1348)	21.1 [16.2, 31.5]; 8.4 to 43.2 (n = 3624)	0.019
Cool months, after hrs	23.3 [13.3, 32.6]; 0.0 to 61.9 (n = 4653)	19.1 [12.5, 27.2]; 0.0 to 46.0 (n = 1837)	29.0 [16.5, 44.4]; 12.5 to 61.9 (n = 2816)	0.076	12.5 [11.8, 26.5]; 0.0 to 61.9 (n = 2500)	27.2 [14.9, 33.4]; 10.9 to 51.7 (n = 2153)	0.061
Cool months, during hrs	91.3 [79.4, 96.1]; 68.6 to 100.0 (n = 4668)	91.3 [80.9, 94.7]; 68.6 to 98.6 (n = 2353)	92.6 [75.2, 97.2]; 71.5 to 100.0 (n = 2315)	0.515	92.8 [75.3, 97.7]; 70.5 to 100.0 (n = 2155)	90.9 [83.1, 95.1]; 68.6 to 98.9 (n = 2513)	0.558
Cool months, GSH overall	55.5 [45.5, 62.6]; 15.2 to 79.2 (n = 14,293)	58.2 [45.2, 65.3]; 18.7 to 79.2 (n = 6964)	53.7 [39.1, 56.2]; 15.2 to 64.9 (n = 7329)	0.202	62.5 [50.2, 65.7]; 37.7 to 79.2 (n = 6003)	53.7 [36.6, 58.9]; 15.2 to 68.3 (n = 8290)	0.047
Cool months, GSH before hrs	19.9 [10.7, 38.4]; 1.0 to 80.0 (n = 4972)	20.4 [9.1, 42.4]; 4.8 to 80.0 (n = 2774)	19.8 [10.7, 38.4]; 1.0 to 56.9 (n = 2198)	0.982	47.3 [8.5, 56.1]; 4.8 to 80.0 (n = 1348)	19.5 [10.5, 26.2]; 1.0 to 41.5 (n = 3624)	0.105
Cool months, GSH after hrs	18.4 [12.5, 29.6]; 0.0 to 61.9 (n = 4653)	18.4 [12.5, 26.9]; 0.0 to 46.0 (n = 1837)	18.3 [7.6, 44.2]; 2.1 to 61.9 (n = 2816)	0.699	12.5 [9.5, 26.5]; 0.0 to 61.9 (n = 2500)	21.1 [13.4, 32.8]; 2.1 to 51.3 (n = 2153)	0.263
Cool months, GSH during hrs	90.5 [74.3, 94.8]; 22.2 to 100.0 (n = 4668)	91.3 [80.9, 94.7]; 68.6 to 98.6 (n = 2353)	86.2 [68.2, 96.7]; 22.2 to 100.0 (n = 2315)	0.494	92.8 [75.3, 97.7]; 70.5 to 100.0 (n = 2155)	89.9 [72.5, 92.7]; 22.2 to 98.9 (n = 2513)	0.214
Adults							
Warm months, overall	50.0 [27.5, 66.7]; 0.0 to 100.0 (n = 1283)	57.3 [33.7, 67.9]; 0.0 to 100.0 (n = 729)	46.1 [22.2, 61.5]; 11.1 to 75.3 (n = 554)	0.344	66.7 [21.4, 72.9]; 11.8 to 75.3 (n = 453)	50.0 [33.7, 62.5]; 0.0 to 100.0 (n = 830)	0.327

Table 5 (*continued*)

	All schools	SunSmart school			School ownership		
		Yes (n = 23)	No (n = 13)	P value	Non-government (n = 13)	Government (n = 23)	P value
Adults							
Warm months, before hrs	5.6 [0.0, 10.6]; 0.0 to 26.7 (n = 838)	5.2 [0.0, 10.3]; 0.0 to 20.0 (n = 447)	5.6 [0.9, 16.6]; 0.0 to 26.7 (n = 391)	0.742	9.6 [1.4, 17.9]; 0.0 to 26.7 (n = 215)	4.1 [0.0, 6.6]; 0.0 to 19.1 (n = 623)	0.153
Warm months, after hrs	28.6 [18., 47.2]; 0.0 to 100.0 (n = 326)	28.6 [18.9, 47.2]; 15.1 to 50.0 (n = 212)	28.3 [6.3, 82.9]; 0.0 to 100.0 (n = 114)	0.940	31.5 [18.1, 75.0]; 15.1 to 100.0 (n = 197)	26.8 [18.8, 40.7]; 0.0 to 50.0 (n = 129)	0.524
Warm months, during hrs	83.3 [50.0, 100.0]; 0.0 to 100.0 (n = 119)	100.0 [50.0, 100.0]; 0.0 to 100.0 (n = 70)	66.7 [37.5, 95.8]; 0.0 to 100.0 (n = 49)	0.157	75.0 [40.0, 100.0]; 0.0 to 100.0 (n = 41)	100.0 [50.0, 100.0]; 0.0 to 100.0 (n = 78)	0.326
Cool months, overall	41.9 [29.2, 62.9]; 6.2 to 100.0 (n = 1671)	41.4 [25.5, 64.3]; 8.3 to 92.9 (n = 1238)	45.0 [30.5, 62.4]; 6.2 to 100.0 (n = 433)	0.745	44.0 [19.4, 67.7]; 6.2 to 100.0 (n = 601)	41.5 [32.0, 58.7]; 8.3 to 100.0 (n = 1070)	0.871
Cool months, before hr	6.2 [0.0, 13.0]; 0.0 to 23.5 (n = 923)	2.8 [0.0, 9.8]; 0.0 to 16.1 (n = 639)	12.5 [4.2, 17.1]; 0.0 to 23.5 (n = 284)	0.033	2.8 [0.4, 9.6]; 0.0 to 13.0 (n = 487)	9.5 [0.0, 16.1]; 0.0 to 23.5 (n = 436)	0.265
Cool months, after hr	12.1 [7.2, 27.0]; 0.0 to 50.0 (n = 442)	11.6 [1.3, 27.4]; 0.0 to 50.0 (n = 326)	17.4 [11.7, 30.4]; 9.1 to 35.3 (n = 116)	0.383	24.5 [6.3, 47.5]; 5.3 to 50.0 (n = 79)	12.1 [5.3, 24.7]; 0.0 to 35.3 (n =)	0.549
Cool months, during hr	100.0 [71.9, 100.0]; 0.0 to 100.0 (n = 306)	100.0 [73.4, 100.0]; 0.0 to 100.0 (n = 273)	100.0 [50.0, 100.0]; 43.3 to 100.0 (n = 33)	0.866	100.0 [68.8, 100.0]; 0 to 100.0 (n = 35)	100.0 [78.1, 100.0]; 16.7 to 100.0 (n = 271)	0.886

[a] Overall refers to the average hat wearing rate of all observations made at a school before, during and after school hours.
[b] GSH — gold standard hat: includes broad brim, legionnaire and bucket style hats.

Conflict of interest statement

The views presented in this paper do not necessarily represent those of Education Queensland.

The authors declare that they have no conflict of interest.

Acknowledgments

The authors wish to thank Michelle Sinclair for her assistance in data collection.

References

American Academy of Pediatrics, 1999. Ultraviolet light: a hazard to children. Pediatrics 104, 328–333.

Aulbert, W., Parpart, C., Schulz-Hornbostel, R., Hinrichs, B., Kruger-Corcoran, D., Stockfleth, E., 2009. Certification of sun protection practices in a German child day-care centre improves children's sun protection — the 'SunPass' pilot study. Br. J. Dermatol. 161, 5–12.

Australian Curriculum Assessment and Reporting Authority, 2012. My School. Guide to understanding ICSEA, ACARA Sydney, Australia.

Australian Curriculum Assessment and Reporting Authority(ACARA), 2010. My School. ACARA, Sydney, Australia (Accessed from http://www.myschool.edu.au (11/01/2013)).

Australian Radiation Protection and Nuclear Safety Agency. Accessed May 2009 to June 2011. Townsville realtime UV index data [Online]. Available: http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm [Accessed May 2009 to June 2011.

Australian Institute of Health and Welfare (AIHW), 2008. Cancer in Australia: An Overview, 2008, Cancer Series No. 46. AIHW, Canberra.

Australian Institute of Health and Welfare, Australasian Association of Cancer Registries, 2010. Cancer in Australia: An Overview, Cat. No. CAN56. AIHW, Canberra.

Autier, P., Dore, J., Cattaruzza, M.S., et al., 1998. Sunscreen use, wearing clothes, and number of nevi in 6- to 7-year-old European children. J. Natl. Cancer Inst. 90, 1873–1880.

Bauer, J., Garbe, C., 2003. Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data. Pigment Cell Res. 16, 297–306.

Bauer, J., Buttner, P.G., Wiecker, T.S., Luther, H., Garbe, C., 2005. Effect of sunscreen and clothing on the number of melanocytic nevi in 1,812 German children attending day care. Am. J. Epidemiol. 161, 620–627.

Berhard, G., Mayer, B., Seckmeyer, G., Moise, A., 1997. Measurements of spectral solar UV irradiance in tropical Australia. J. Geophys. Res. Atmos. 102, 8719–8730.

Buettner, P.G., Raasch, B.A., 1998. Incidence rates of skin cancer in Townsville, Australia. Int. J. Cancer 78, 587–593.

Bureau of Meteorology, Building your 'weather' skills, Forecasting the weather. Commonwealth of Australia, Bureau of Meteorology. Accessed from http://www.bom.gov.au/info/ftweather/page_30.shtml (27/11/2012)

Bureau of Meterology, 2009. Townsville Area Climate and History. (Accessed from http://www.bom.gov.au/weather/qld/townsville/climate_and_history.shtml (21/07/2009)).

Bureau of Meterology, 2011. Townsville, Queensland. Weather Observations. (Accessed from http://reg.bom.gov.au/climate/dwo/IDCJDW4128.latest.shtml (May 2009 to June 2011)).

Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, 2005. Being SunSmart — A Guide for Primary Schools. The Cancer Council, Australia.

Cancer Council Queensland, 2009. SunSmart Policy Guidelines. (Accessed from http://www.cancerqld.org.au/pdf/SunSmartPolicyGuildelines-Schools.pdf (07/07/2009)).

Cancer Council Queensland, 2013. SunSmart School Application Form. (Accessed from http://www.cancerqld.org.au/page/prevention/skin_cancer/national_sunsmart_schools_and_early_childhood_centres/sunsmart_school_application_form/ (13/06/2013)).

Cancer Council Victoria, 2002. SunSmart Program 2003–2006. Cancer Council Victoria, Victoria.

Cancer Research U.K., 2009. Sun Protection in Schools. SunSmart, Cancer Research UK, London.

Dadlani, C., Orlow, S.J., 2008. Planning for a brighter future: a review of sun protection and barriers to behavioral change in children and adolescents. Dermatol Online J. 14, 1.

Department of Education and Employment and Training, 2009. State School Full-time Enrolment Counts, Census 2005–2009. Queensland Government. (Accessed http://education.qld.gov.au/school/statistics (12/04/2010)).

Diffey, B., Cheeseman, J., 1992. Sun protection with hats. Br. J. Dermatol. 127, 10–12.

Dixon, H., Borland, R., Hill, D., 1999. Sun protection and sunburn in primary school children: the influence of age, gender, and colouring. Prev. Med. 28, 119–130.

Downs, N.J., Parisi, A.V., 2006. Comparing Variations in the UV Facial Exposure Received by School Children in South-East Queensland, Australian Institute of Physics 17th National Congress 2006. Brisbane, Australia.

English, D.R., Milne, E., Simpson, J.A., 2005. Sun protection and the development of melanocytic nevi in children. Cancer Epidemiol. Biomarkers Prev. 14, 2873–2876.

Enta, T., 1998. Melanocytic nevi in sun-protected Canadian Hutterite children. Arch. Dermatol. 134, 379–381.

Fritschi, L., McHenry, P., Green, A.C., MacKie, R.M., Green, L., Siskind, V., 1994. Naevi in schoolchildren in Scotland and Australia. Br. J. Dermatol. 130, 599–603.

Ghissassi, F.E., Baan, R., Straif, K., et al., 2009. A review of human carcinogens — part D: radiation. Lancet Oncol. 10, 751–752.

Gies, P., Javorniczky, J., Roy, C., Henderson, S., 2006. Measurements of the UVR protection provided by hats used at school. Photochem. Photobiol. 82, 750–754.

Giles-Corti, B., English, D.R., Costa, C., Milne, E., Cross, D., Johnston, R., 2004. Creating SunSmart schools. Health Educ. Res. 19, 98–109.
Glanz, K., Chang, L., Song, V., Rommel, S., Muneoka, L., 1998. Skin cancer prevention for children, parents, and caregivers: a field test of Hawaii's SunSmart program. J. Am. Acad. Dermatol. 38, 413–417.
Green, A.C., MacLennan, R., Siskind, V., 1985. Common acquired naevi and the risk of malignant melanoma. Int. J. Cancer 35, 297–300.
Green, A., MacLennan, R., Youl, P., Martin, N., 1993. Site distribution of cutaneous melanoma in Queensland. Int. J. Cancer 53, 232–236.
Green, A., Battistutta, D., Hart, V., Leslie, D., Weedon, D., 1996. Skin cancer in a subtropical Australian population: incidence and lack of association with occupation. The Nambour Study Group. Am. J. Epidemiol. 144, 1034–1040.
Harrison, S.L., Nikles, J., 2012. Preliminary observations of hat wearing in Brisbane schools. Ann. ACTM 13, 38.
Harrison, S.L., MacLennan, R., Speare, R., Wronski, I., 1994. Sun exposure and melanocytic naevi in young Australian children. Lancet 344, 1529–1532.
Harrison, S.L., MacKie, R.M., MacLennan, R., 2000. Development of melanocytic nevi in the first three years of life. J. Natl. Cancer Inst. 92, 1436–1438.
Harrison, S.L., Buettner, P.G., MacLennan, R., 2005. The North Queensland "sun-safe clothing" study: design and baseline results of a randomized trial to determine the effectiveness of sun-protective clothing in preventing melanocytic nevi. Am. J. Epidemiol. 161, 536–545.
Harrison, S.L., Buettner, P.G., MacLennan, R., Woosnam, J., Hutton, J., Nowak, M., 2010. Sun-safe clothing helps to prevent the development of pigmented moles — results of a randomised control trial in young Australian children. Ann. ACTM 11, 49–50.
Heal, C., Buettner, P.G., Raasch, B.A., Browning, S., 2006. Minor skin excisions in general practice in North Queensland. Aust. Fam. Physician 35, 825–828.
Hill, D., Dixon, H., 1999. Promoting sun protection in children: rationale and challenges. Health Educ. Behav. 26, 409–417.
Hinde, S., 2009. Welcome to the Sun Shame State, The Sunday Mail. Queensland Newspapers Pty. Ltd, Brisbane 4–5.
Holman, C.D., Armstrong, B.K., 1984. Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: an analysis separating histogenetic types. J. Natl. Cancer Inst. 73, 75–82.
Hunter, S., Love-Jackson, K., Abdulla, R., et al., 2010. Sun protection at elementary schools: a cluster randomized trial. J. Natl. Cancer Inst. 102, 484–492.
I-Kuei, L., 1989. A concordance correlation coefficient to evaluate reproducibility. Biometrics 45, 255–268.
Kelly, J.W., Rivers, J.K., MacLennan, R., Harrison, S.L., Lewis, A.E., Tate, B.J., 1994. Sunlight: a major factor associated with the development of melanocytic naevi in Australian schoolchildren. J. Am. Acad. Dermatol. 30, 40–48.
Kimlin, M., Parisi, A., 1999. Ultraviolet protective capabilities of hats under two different atmospheric conditions. 2nd Internet Photochemistry and Photobiology Conference.
Kricker, A., Armstrong, B.K., English, D.R., 1994. Sun exposure and non-melanocytic skin cancer. Cancer Causes Control 5, 367–392.
Lagerlund, M., Dixon, H.G., Simpson, J.A., Spittal, M., Taylor, H.R., Dobbinson, S.J., 2006. Observed use of sunglasses in public outdoor settings around Melbourne, Australia: 1993 to 2002. Prev. Med. 42, 291–296.
Milne, E., Corti, B., English, D.R., Cross, D., Costa, C., Johnston, R., 1999a. The use of observational methods for monitoring sun-protection activities in schools. Health Educ. Res. 14, 167–175.
Milne, E., English, D.R., Corti, B., et al., 1999b. Direct measurement of sun protection in primary schools. Prev. Med. 29, 45–52.
Moise, A.F., Buttner, P.G., Harrison, S.L., 1999. Sun exposure at school. Photochem. Photobiol. 70, 269–274.
Montague, M., Borland, R., Sinclair, C., 2001. Slip! Slop! Slap! and SunSmart, 1980–2000: skin cancer control and 20 years of population-based campaigning. Health Educ. Behav. 28, 290–305.
O'Riordan, D.L., Geller, A.C., Brooks, D.R., Zhang, Z., Miller, D.R., 2003. Sunburn reduction through parental role modeling and sunscreen vigilance. J. Pediatr. 142, 67–72.
Raasch, B.A., Buettner, P.G., Garbe, C., 2006. Basal cell carcinoma: histological classification and body-site distribution. Br. J. Dermatol. 155, 401–407.
Radvan, D., 2006. Advances Towards a SunSmart State: Sun Protection in Schools, Advances Towards a SunSmart State — From Research to Practice. Queensland Health and The Cancer Council Queensland, Brisbane, Australia.
Reeder, A.I., Jopson, J.A., Gray, A., 2012. Primary school sun protection policies and practices 4 years after baseline — a follow up study. Health Educ. Res. 27, 844–856.
Reynolds, K.D., Buller, D.B., French, S.A., Buller, M.K., Ashley, J.L., 2012. School sun-protection policies: measure development and assessments in 2 regions of the United States. J. Sch. Health 82, 499–507.
Sagebiel, R.W., 1993. Melanocytic nevi in histologic association with primary cutaneous melanoma of superficial spreading and nodular types: effect of tumor thickness. J. Invest. Dermatol. 100, 322S–325S.
Sander-Wiecker, T., Luther, H., Buettner, P.G., Bauer, J., Garbe, C., 2003. Moderate sun exposure and nevus counts in parents are associated with development of melanocytic nevi in childhood: a risk factor study in 1,812 kindergarten children. Cancer 97, 628–638.
Skender-Kalnenas, T.M., English, D.R., Heenan, P.J., 1995. Benign melanocytic lesions: risk markers or precursors of cutaneous melanoma? J. Am. Acad. Dermatol. 33, 1000–1007.
SunSmart Victoria, 2012. SunSmart. Our History. Cancer Council Victoria, Victoria: Australia (Accessed from http://www.sunsmart.com.au/about_us/our_history (25/01/2013)).
The Cancer Association of South Africa, 2010. Be SunSmart: A Guide for Schools. Bedfordview, South Africa.
The National Society to Prevent Blindness, 1993. The American Optometric Association, Ophthalmology. Statement on Ocular ultraviolet radiation hazards in sunlight. American Optometric Association.
Turner, D., Harrison, S., Buettner, P., Nowak, M., 2013. School Sun-protection Policies — Does Being SunSmart Make a Difference? Unpublished research.
Turrisi, R., Hillhouse, J., Heavin, S., Robinson, J., Adams, M., Berry, J., 2004. Examination of the short-term efficacy of a parent-based intervention to prevent skin cancer. J. Behav. Med. 27, 393–412.
Wong, J.C.F., Cowling, I., Parisi, A., 1997. Reducing Human Exposure to Solar Ultraviolet Radiation. First Internet Conference on Photochem Photobiol.
Youl, P.H., Janda, M., Aitken, J.F., Del Mar, C.B., C, W.D., Baade, P.D., 2011. Body site distribution of skin cancer, pre-malignant and common benign pigmented lesions excised in general practice. Br. J. Dermatol. 165, 35–43.

Refer to contribution statement for my contribution.

The following error was noted in the above publication.

Table 2: The percentage of non-government schools in the first column should have read 36.1%, not 13.1%.

Abstract as originally published in **Trapp*, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "An evaluation of the sun protective practices of Townsville primary school students." Annals of the ACTM 11 (2): 51-52. *Refer to appendix 3.*

* Turner (nee Trapp)

In the above abstract, data were presented for 28 schools at the '100 Years of tropical medicine' conference before data collection for the 36 Townsville primary schools included in the peer-reviewed manuscript was completed.

Refer to contribution statement for my contribution.

6.5 Additional data from study 4

Additional data which resulted from study 4 and a description of these data can be found in Appendix 6.

6.6 Summary and future directions

At Townsville primary schools, most children were observed to wear hats during school hours, however, the majority of students observed before and after school hours did not wear hats. Additionally, we observed that non-GSH styles were worn at Townsville schools, by up to 5% students, which contradicts both the Queensland government's Department of Education and Training sun-safety guidelines and the Australian Cancer Council's SSS guidelines [5, 6, 21]. It is possible that students wore non-GSH styles, such as baseball caps, because they considered non-GSH styles to be more fashionable than GSH styles [24, 25]. Students may not have worn hats before and after school hours because schools staff members were busy supervising student safety at these times and did not have time to remind students to wear hats. For instance, after school hours, staff members may have been responsible for supervising numerous students as they exited school property and entered busy car parks and car loading zones. These staff members may have been preoccupied with ensuring that students were safe around car traffic and were unable to consistently remind students to wear their hat. Students might have forgotten to wear hats before and after school hours because they had placed their hats in their school bags for safe-keeping. These suggestions are only speculations and studies are needed to investigate why many students failed to wear hats before and after school hours.

To ensure that student safety in car traffic areas remains paramount and that students also wear hats, a sun-safety monitor could be introduced to schools. This monitor could be an additional staff member, parent or older student who is responsible for regularly reminding students, and adult role-models, to wear hats when outdoors at school. The potential influence of a sun-safety monitor on sun-protective behaviours at school could be investigated in an intervention study.

Most adults observed at school commencement and dismissal times were not wearing hats. Direct observations of adult hat-use at other Australian locations may be helpful to determine if hats are similarly under-utilised elsewhere. It would be advantageous to complete studies which investigate why adults fail to wear hats at school so that barriers to hat-use can be addressed. For example, perhaps Townsville adults failed to wear hats before and after school hours because they did not own a hat, did not think a hat was necessary and/or considered a hat to be unfashionable or uncomfortable. Barriers to hat-use expressed by Townsville adults may be similar and/or different to those proposed by other Australian adults. For example, Townsville adults might not wear hats to school in the morning because they are on their way to work and do not wish to untidy the appearance of their hair. This barrier to hat-use might be proposed by many working parents in Australia and internationally. Townsville adults might avoid wearing hats because they find hats make their head hot. On the other hand, adults at locations which are associated with cold weather might wear hats to warm their heads. Regardless, schools may need to regularly remind parents to abide by sun-protection policies and role-model hat-use, and other sun-protective behaviours, to students.

6.7 Introduction to following chapter

The findings of study 4 estimated hat-use by primary school students and their adult role-models at Townsville schools before, during and after school hours. To further assess how well these school communities comply with their sun-protection policies, we observed sun-protective behaviours at outdoor events that are held during school hours. In Townsville, inter-primary-school swimming carnivals (that is, competitive swimming races between schools) are held annually and attended by approximately 40 schools [26]. We directly observed student spectator hat-use and shirt-use at these swimming carnivals. The following chapter describes the final study of my thesis (study 5) and discusses the findings of that study.

6.8 List of references

1. Kimlin, M. and A. Parisi, *Ultraviolet protective capabilities of hats under two different atmospheric conditions*, in *2nd Internet Photochemistry and Photobiology Conference*. 1999.
2. Diffey, B. and J. Cheeseman, *Sun protection with hats.* Br J Dermatol, 1992. **127**: p. 10-12.
3. Gies, P., et al., *Measurements of the UVR protection provided by hats used at school.* Photochem Photobiol, 2006. **82**: p. 750-754.
4. Department of Education and Training. *Developing a sun safety strategy*. 2015 10/03/2015]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
5. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group. *Being SunSmart - a guide for primary schools*. 2005; Available from: http://www.sunsmart.com.au.
6. Cancer Council Queensland. *SunSmart school review form*. 2016 27/06/2016]; Available from: https://cancerqld.org.au/cancer-prevention/understanding-risk/being-sunsmart/national-sunsmart-program/sunsmart-school-review-form/.
7. Schofield, M.J., et al., *Solar protection issues for schools: policy, practice and recommendations.* Aust J Public Health, 1991. **15**: p. 135-141.
8. Milne, E., et al., *Direct measurement of sun protection in primary schools.* Prev Med, 1999. **29**: p. 45-52.
9. Milne, E., et al., *Evaluation of an Intervention to Reduce Sun Exposure in Children. Design and Baseline Results.* Am J Epidemiol, 1999. **150**(2): p. 164-73.

10. Milne, E., et al., *The use of observational methods for monitoring sun-protection activities in schools.* Health Educ Res, 1999. **14**(2): p. 167-175.
11. Hunter, S., et al., *Sun protection at elementary schools: a cluster randomized trial.* J Natl Cancer Inst, 2010. **102**: p. 484-492.
12. Jopson, J.A. and A.I. Reeder, *Are NZ primary schools SunSmart?* 2006, University of Otago: Dunedin, New Zealand.
13. Barankin, B., et al., *Effects of a Sun Protection Program Targeting Elementary School Children and Their Parents.* J Cutan Med Surg, 2001. **5**: p. 2-7.
14. Bastuji-Garin, S., et al., *Melanoma prevention. Evaluation of a health campaign for primary schools.* Arch Dermatol, 1999. **135**: p. 936-940.
15. Dobbinson, S.J., et al., *Are Victorian primary schools SunSmart?* Health Promot J Aust, 2000. **10**(1): p. 43-50.
16. Eakin, P., et al., *Sun protection policy in elementary schools in Hawaii.* Prev Chronic Dis 2004. **1**(3): p. A05.
17. Jones, S.B.W., K. Beckmann, and J. Rayner, *Australian primary schools' sun protection policy and practice: evaluating the impact of the National SunSmart Schools Program.* Health Promot J Aust, 2008. **19**(2): p. 86-90.
18. O'Riordan, D.L., et al., *Sunburn reduction through parental role modeling and sunscreen vigilance.* J Pediatr, 2003. **142**(1): p. 67-72.
19. Parrott, R. and A. Duggan, *Using coaches as role models of sun protection for youth: Georgia's "Got youth covered" project.* J Appl Commun Res, 1999. **27**(2): p. 107-119.
20. McNoe, B.M. and A.I. Reeder, *Adolescent sun protection at secondary school athletic sporting events - a misnomer.* Aust NZ J Public Health, 2016. **40**(4): p. 313-315.
21. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.
22. Turner, D., et al., *School sun-protection policies – does being SunSmart make a difference?* Health Educ Res, 2014. **29**(3): p. 367-77.
23. Hinde, S., *Welcome to the sun shame state*, in *The Sunday Mail*. 2009, Queensland Newspapers Pty. Ltd: Brisbane. p. 4-5.

24. Dixon, H., R. Borland, and D. Hill, *Sun protection and sunburn in primary school children: the influence of age, gender, and colouring.* Prev Med, 1999. **28**: p. 119-130.
25. Lowe, J.B., et al., *Sun-safe behaviour among secondary school students in Australia.* Health Educ Res, 2000. **15**(3): p. 271-281.
26. Townsville School Sport. *Swimming*. 2016 14/09/2016]; Available from: https://townsvilleschoolsport.eq.edu.au/Sports/swimming/Pages/swimming.aspx .

Chapter 7
Study 5: An observational study of the proportions of student spectators who wore a hat and/or a shirt at Townsville inter-primary-school swimming carnivals

7.1 Introduction

Outdoor activities that take place at aquatic events present a sun-protection challenge since solar ultraviolet radiation (UVR) can both reflect off and penetrate into water [1, 2]. Therefore, student spectators at school swimming carnivals, which are held outdoors, may be exposed to excessive UVR and should use multiple methods of sun-protection including hats, clothing, sunglasses, shade and sunscreen [3]. In Townsville, inter-primary-school-swimming carnivals are held during the month of March at outdoor swimming pools [4]. Most schools from the Townsville education district attend these swimming carnivals [4]. To accommodate the number of schools that attend Townsville inter-primary-school-swimming carnivals, schools are grouped into six divisions and the carnivals take place over three days [4]. Each swimming carnival typically takes place during a two to three hour period (for example, 9:15am to 11:30am or 12:15pm to 2:15pm), during a school day (9am to 3pm) [4]. In Townsville these carnivals are usually held at pools with few permanent shade structures for spectators to use. Consequently, unless a school has provided portable shade structures for spectator and competitor use, individuals may be positioned in unshaded locations for a considerable amount of time.

In 2008, the Queensland government introduced a 'no shirt, no swim' rule to government owned primary schools [5, 6]. Currently (2016), the 'no shirt, no swim' rule stipulates that students attending Queensland government owned schools wear a shirt while they participate in water-based activities [7, 8]. However, the 'no shirt, no swim' does not apply to students participating in competitive swim races [8]. Australian

Cancer Council SunSmart school (SSS) guidelines suggest students wear T-shirts or rash vests (commonly known as 'rashies' in Australia) when swimming [9]. Therefore SSSs and Queensland government owned schools alike do not enforce shirt-use by competitive swimmers.

The sun-protection guidelines of Queensland government owned schools and SSSs stipulate that children wear hats when outdoors (refer to Chapter 3) [9, 10]. Since Townsville inter-primary-school swimming carnivals are held during school hours and outdoors, all attending students should wear hats.

7.2 Development of the research question

At the time this thesis was written, direct observations of students who wore hats and shirts at inter-primary-school-swimming carnivals in Queensland, and elsewhere in Australia and internationally, were not reported. To determine the proportion of student spectators at Townsville swimming carnivals who wore hats and shirts, the following research question was developed:

> *What proportions of Townsville (latitude 19.3˚S, longitude 146.8˚E) primary school student spectators wear a hat at inter-school swimming carnivals and wear a shirt at inter-school swimming carnivals?*

To address this research question the following study was completed:

> *An observational study of the proportions of student spectators at Townsville inter-primary-school swimming carnivals who wore a hat and/or a shirt. The proportion of these students who wore their hat and/or a shirt was compared overall and at schools grouped according to school characteristics.*

The results of this study are presented in the following peer-reviewed manuscript.

7.3 Publications arising from study 5

Article as originally published in **Turner D,** Harrison SL, and Bates N (2016). "Sun-protective behaviors of student spectators at inter-primary-school swimming carnivals in a tropical region of high ambient solar ultraviolet radiation." Frontiers in Public Health. 4: 168. doi 10.3389/fpubh.2016.00168.

Refer to contribution statement for my contribution.

frontiers in Public Health

ORIGINAL RESEARCH
published: 16 August 2016
doi: 10.3389/fpubh.2016.00168

Sun-Protective Behaviors of Student Spectators at Inter-school Swimming Carnivals in a Tropical Region Experiencing High Ambient Solar Ultraviolet Radiation

Denise Turner[1], Simone Lee Harrison[1,2] and Nicole Bates[1,3]*

[1] Skin Cancer Research Unit, Division of Tropical Health and Medicine, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville, QLD, Australia, [2] Anton Breinl Research Centre for Health Systems Strengthening, Australian Institute of Tropical Health and Medicine (AITHM), James Cook University, Townsville, QLD, Australia, [3] Discipline of Pharmacy, Division of Tropical Health and Medicine, College of Medicine and Dentistry, James Cook University, Townsville, QLD, Australia

OPEN ACCESS

Edited by:
Siegal Sadetzki,
Tel Aviv University, Israel

Reviewed by:
Deborah Elise Kopald,
Harvard University, USA
Ray Kemp,
University of Wollongong, Australia

***Correspondence:**
Denise Turner
denise.turner@my.jcu.edu.au

Specialty section:
This article was submitted to Radiation and Health, a section of the journal Frontiers in Public Health

Received: 01 May 2016
Accepted: 02 August 2016
Published: 16 August 2016

Citation:
Turner D, Harrison SL and Bates N (2016) Sun-Protective Behaviors of Student Spectators at Inter-school Swimming Carnivals in a Tropical Region Experiencing High Ambient Solar Ultraviolet Radiation. Front. Public Health 4:168. doi: 10.3389/fpubh.2016.00168

Skin cancer is the most common cancer in humans and Australia (particularly in Queensland) has the highest incidence globally. Sunlight is a known skin carcinogen and reflects off water, exacerbating the risk of sunburn. In 1988, the "SunSmart Program" was developed to promote sun-protection to Australian children. Within a decade, it evolved to include a voluntary national accreditation program for schools, known as the SunSmart Schools (SSS) Program. Additionally, in 2008, it became compulsory for primary schoolchildren attending Queensland government-funded schools to wear a shirt during all water-based activities, except when competing. We observed the proportion of student spectators from 41 Townsville (latitude 19.3°S) primary schools (65.9% SSS) wearing hats at inter-school swimming carnivals in 2009–2011 and 2015 and the proportion wearing a shirt. Overall, a median of 30.7% student spectators from each school wore a hat [max 46.2% (2009); min 18% (2015)] and 77.3% wore a shirt [max 95.8% (2009); min 74.5% (2015)], suggesting that hats are under-utilized. Students from non-government (private) schools were twice as likely as students from government schools to wear a hat (41 vs. 18.2% $p = 0.003$). Neither the hat nor the shirt-wearing behaviors of student spectators were significantly influenced by their school's size (number of students), educational advantage, sun-protection policy score, or SunSmart status, indicating that other socioeconomic factors, not assessed here, may have influenced the results. Our findings suggest that the mandatory swim-shirt policy introduced in 2008 was very effective, especially initially. However, monitoring and feedback of results to schools may be needed to maintain high levels of compliance in the longer-term. Schoolchildren attending swimming carnivals should not rely on sunscreen or shade

Abbreviations: CM, cutaneous melanoma; ICSEA, index of community socio-educational advantage; IQR, inter-quartile range; MN, melanocytic nevi; RCT, randomized controlled trial; SSS, SunSmart school; UVI, ultraviolet index; UVR, ultraviolet radiation.

alone to protect against direct and reflected-sunlight, and need prompting to put a hat and shirt back on immediately after a race. This responsibility could be delegated to either a parent or a student prefect, if teachers are too busy to encourage and monitor sun-safety compliance among the students in their care.

Keywords: skin cancer, swimming, child, sun-safety, ultraviolet radiation, ultraviolet protection factor, clothing, sun-protection

INTRODUCTION

Australia is an island nation; ~86% of Australians live within 50 km of the coast (1). Swimming is a national past-time and most children learn to swim as babies. Australians love the beach, fishing, swimming, surfing, playing sport, and being in the "great outdoors." Generations of Australians were brought up playing outside; wore little sun-protection; and believed a tan signified good health (2, 3).

The Australian sun-loving culture paired with genetically susceptible Caucasian ancestry has resulted in Australia having among the highest rates of cutaneous melanoma (CM) and epithelial skin cancer in the world (4, 5). Solar ultraviolet radiation (UVR) is a known skin carcinogen and over-exposure, particularly during the childhood years, leads to the proliferation of melanocytic nevi (MN) (6–10), which are a risk factor for CM development (9, 11–13). Actinic keratoses, keratinocyte carcinomas, and CM are extremely common in the Queensland population and often develop on chronically sun-exposed areas of the face, ears, neck, and scalp (14–17).

Sun-protective clothing, especially garments manufactured according to the Australian and New Zealand clothing standard (AS/NZ 4399:1996) with tightly woven fabrics and high ultraviolet protection factor (UPF) ratings (18) provide a physical barrier between the skin and UVR and have been shown to slow the rate of development of MN (19, 20). Legionnaire, broad-brim and bucket hats protect the face, neck, and eyes better than caps and visors (21–24), with bucket hats being the most commonly worn style in north Queensland schools, followed by wide-brim hats (Turner and Harrison, unpublished data). Swimming garments that incorporate longer sleeves and pants present a practical form of sun-protection since, unlike sunscreen, they do not require reapplication (25). Pre-adolescent primary school-aged children have indicated that they find wet-suit type swimming clothes (sun-suits) which cover more of the skin than traditional swimwear visually appealing and would wear them if given the option (26). In spite of this, some schools in the high-risk UVR environment of north Queensland still make boys wear swimming briefs emblazoned with the school emblem, and girls wear a full-piece swimsuit in school colors with the same insignia when participating in swimming lessons and carnivals.

Most primary schoolchildren in Queensland get to participate in some water-based activities each year, such as swimming lessons and carnivals. These generally take place outdoors during the school day (typically between 8:30 a.m. and 3:00 p.m.) during or close to peak daily UVR times (27). At the beginning of the 2008 school year (primary school attendance follows a calendar year pattern in Australia from approximately late January to mid-December), the Queensland Government Department of Education and Training made it compulsory for students attending state-government-funded primary schools to wear either a swim-shirt or a T-shirt when participating in water-based activities and suggested that spectators adopt a range of sun-protection measures too (28). Students are only exempt from wearing a shirt while competing (29, 30). As UVR can both penetrate and reflect off water surfaces (31, 32), the unprotected skin of student competitors and spectators alike is exposed to overhead and reflected UVR that could be intercepted by clothing. Reflected UVR adds to the UVR dose received by spectators at swimming carnivals, making it unwise to rely on shade alone for protection; optimal sun-protection is achieved using several protective measures simultaneously, as exemplified by the Australian Cancer Council's Slip (on a shirt), Slop (on some sunscreen), Slap (on a hat), Seek (shade), and Slide (on some sunglasses) campaign (33).

In 1988, after the internationally recognized "Slip! Slop! Slap!" campaign had been running in Australia for 8 years, the Cancer Council (formerly known as the Anti-Cancer Council of Victoria) developed the SunSmart program to improve the sun-protective behaviors of Australian children (34–37). The SunSmart Program evolved to include a national voluntary accreditation program known as the SunSmart Schools (SSS) Program that has been operating in Victorian primary schools since 1994, Queensland primary schools since 1999 and primary schools in the other Australian states and territories for over a decade (34). The SSS Program now also operates in Australian secondary schools, and has been adopted abroad by a number of other countries, including New Zealand, the United Kingdom, and South Africa (38–42). All Australian schools, regardless of school ownership [government (state-funded schools) or non-government (privately funded schools)] can apply to be SSS. Australian SSS are expected to comply with 12 sun-protection criteria concerning their sun-protection policy (43, 44). SSS are expected to encourage students to wear a T-shirt, sun-suit, or swim-shirt (also known as a rash-vest or "rashie") when involved in swimming activities to give them extra protection in the water (43). Compliance with the behavioral expectations of the SSS program, such as hat and swim-shirt use, are not externally monitored at swimming carnivals or during any other curriculum-based outdoor activities; therefore, we present a unique look at how well schools are following through with their sun-protection policies. Our team has evaluated the sun-protection policies of Queensland primary schools (44–46) and identified the need for a school sun-protection intervention aimed at improving sun-protection policies and practices in Queensland primary schools. Data presented in this paper will be used as a baseline to evaluate changes in policies and behavior over time resulting from the intervention.

This observational study aimed to determine the proportion of primary school students (aged 5–12 years) wearing hats and shirts at inter-school swimming carnivals in the skin cancer prone population of Townsville, north Queensland, Australia (47, 48). Additionally, we suggest practical solutions to improve sun-protection among schoolchildren.

MATERIALS AND METHODS

Participants

The sun-protective clothing-related behaviors exhibited by student spectators from 41 primary schools were observed at inter-school swimming carnivals held in Townsville each March (Early Autumn in the southern Hemisphere). Data were collected for 4 years between 2009 and 2015 ($n = 10$ carnivals; 2,932 students).

Townsville (latitude 19.3°S, longitude 146.8°E) is a coastal city in tropical north Queensland, Australia with a population of ~200,000 inhabitants who are primarily of European descent. This major regional center has a tropical climate with hot, humid summers, dry winters, and a high to extreme Maximum Daily UV-index (UVI), year round (49, 50). The mean UVI recorded on observation days was 10.1 ± 1.6 (51) with mean minimum and maximum temperatures of 22.7 ± 2.7°C and 31.7 ± 1.3°C, respectively (49, 50).

Procedure

Schools present at any of the inter-primary school swimming carnivals held in Townsville in 2009, 2010, 2011, and 2015 were included in the study. At each of the 10 carnivals, an experienced observer (drawn from a pool of 3 observers; i.e., the authors) counted the proportion of students in a school's designated spectator area who were wearing a hat. The process was then repeated to determine the proportion of primary school students from the same school who were wearing a shirt of any description (swim-shirt; T-shirt; school shirt; sun-suit, etc.). The entire process was repeated for each school in attendance. Observations were made discretely and the purpose of the study was not discussed with individuals to avoid influencing their behavior. Observations were conducted from inside the pool complex during the first hour of the carnival, well after all students had time to settle into their school's designated viewing area. Students were assigned to the hat "present" or "absent" group separately to being assigned to the shirt "present" or "absent" group since it was too slow and difficult for a single observer to accurately record hat and shirt usage simultaneously for each student spectator. Students were not always seated in their designated school area; therefore, students were only included in these observations if the school they attended was identifiable by location or uniform. For example, a student attending "School A" may have been observed while in "School B's" seating area but was identifiable as a "School A" student because they were wearing the uniform or hat of that school. Conversely, a student may have been excluded from observation if seated on the boundary of two school areas such that the school they attended was not identifiable from their clothing (e.g., not wearing a school hat or shirt).

The SunSmart status of each school was confirmed by Cancer Council Queensland, while demographic information [e.g., school ownership; location; student enrollments; "Index of community socio-educational advantage" (ICSEA)] was obtained from links provided on the Queensland Government website (52) and the Australian "My School" website (53). Each school's sun-protection policy was independently evaluated against 12 predetermined criteria and a total score was assigned as described previously (44). The distribution of demographic characteristics is shown in **Table 1**.

Data Analysis

Hat and shirt-wearing rates were calculated for each school by combining observations across 4 years of data. Hat and shirt-wearing proportions were summed across years, and described using median values together with inter-quartile range (IQR) and range (minimum and maximum values) as the data were skewed. Non-parametric Mann–Whitney and Kruskal–Wallis tests were used to assess differences in the median proportion of students wearing a hat and the median proportion of students wearing a shirt according to SunSmart status and the other demographic characteristics described in **Table 1**. Differences in student denominators for hat- and shirt-wearing proportions are attributable to students moving around the venue during the carnivals (e.g., students might have been in the pool, bathrooms, away from their designated school areas, etc.) since hat-wearing observations preceded shirt-wearing observations.

RESULTS

The proportion of student spectators from each school observed wearing hats ranged from 0 to 83.3% with a median value of 30.7% (**Table 2**). Students from non-government schools were twice as likely to be seen wearing a hat as government primary school students (41.0 vs. 18.2%; $p = 0.003$). Average ICSEA scores (continuous variable) were higher for non-government schools compared with government schools (977.9 vs. 918.2; $p = 0.009$), suggesting that students from non-government schools may have a socio-education advantage. Student hat-wearing rates did not differ significantly according to any of the other demographic characteristics considered (SunSmart status, sun-protection policy score, and school size), except for school type, where the difference in hat-wearing rates between combined primary-secondary schools (43.9%) and dedicated primary schools (23.1%) was borderline significant ($p = 0.051$; **Table 2**).

The proportion of student spectators observed wearing a shirt ranged from 41.7% for some schools to 100% in others, with a median of 77.3%. Shirt-wearing rates did not differ significantly according to SunSmart status or any of the other demographic characteristics examined (**Table 2**).

Hat-wearing rates were higher among non-government (privately funded) SSS than government-run SSS (48.8 vs. 17.5%; $p = 0.005$) and large and medium SSS (45.2 vs. 38%) compared with small SSS (13%; $p = 0.048$). No other statistically significant differences in hat-wearing or shirt-wearing proportions were found when the other remaining school characteristics were explored within SunSmart status or vice versa (**Table 3**).

TABLE 1 | Demographic characteristics of the 41 schools who attended at least one of the inter-primary-school swimming carnivals held in Townsville, Queensland in 2009, 2010, 2011, and 2015, stratified by SunSmart status).

School characteristic		All schools (N = 41) N (%)	SunSmart schools (SSS)[a] (N = 27) N (%)	Non-SSS (N = 14) N (%)	p-Value[f]
SunSmart School[a]	Yes	27 (65.9)	–	–	–
	No	14 (34.1)	–	–	
School type	Primary[b]	35 (85.4)	23 (85.2)	12 (85.7)	1.000 (Exact)
	Combined[c]	6 (14.6)	4 (14.8)	2 (14.3)	
School ownership	Government	26 (63.4)	16 (59.3)	10 (71.4)	0.443
	Non-government	15 (36.6)	11 (40.7)	4 (28.6)	
Sun-protection policy score[d]	≤ Median score (0–2)	21 (51.2)	12 (44.4)	9 (64.3)	0.228
	> Median score (3+)	20 (48.8)	15 (54.6)	5 (35.7)	
School size	Small (≤399 students)	17 (41.5)	11 (40.7)	6 (42.9)	0.668
	Medium (400–799 students)	15 (36.6)	9 (33.3)	6 (42.9)	
	Large (≥800 students)	9 (21.9)	7 (25.9)	2 (14.3)	
ICSEA group[e]	ICSEA ≤1000	35 (85.4)	21 (77.8)	14 (100.0)	0.079 (Exact)
	ICSEA >1000	6 (14.6)	6 (22.2)	0 (0.0)	

[a]*SunSmart status was verified by contact with the Cancer Council Queensland, as at December 2012.*

[b]*Primary school starts at age 5 (prep year) and continued until Grade 7 (age 12 years) in Queensland up until 2015 when grade 7 became the first year of secondary schooling; first 8 years of formal education.*

[c]*Combined schools enroll students for their entire formal education (Prep – Grade 12).*

[d]*Total score attained by these 41 schools when their sun-protection policies were independently evaluated against pre-determined criteria [maximum possible score was 12 (44)].*

[e]*The index of community socio-educational advantage (ICSEA) is calculated using student family background data to determine the level of educational advantage students bring to their studies. The average ICSEA value is set at 1000 with values ranging from 500 (extremely educationally disadvantaged backgrounds) to 1300 (students from highly educated families).*

[f]*P-value based on Chi-squared test (or two-sided Fisher's Exact test if ≥25% of cells have an expected frequency of ≤5); $p < 0.05$ statistically significant.*

TABLE 2 | The median (IQR); range (*n*) proportion of student spectators per school observed wearing hats and shirts while attending inter-primary-school swimming carnivals in Townsville, Australia over 4 years of observations (2009–2011 and 2015).

		Proportion (%) of students at each school wearing a HAT based on n = 2,916 observations conducted for a sample of N = 41 schools		Proportion (%) of students at each school wearing a SHIRT based on n = 2,932 observations conducted for a sample of N = 41 schools	
		Median% (IQR); range% (*n*)	***P*-value**	**Median% (IQR); range% (*n*)**	***P*-value**
All schools (N = 41)		30.7 (13.2, 46.7); 0.0–83.3		77.3 (70.0, 85.9); 41.7–100.0	
School characteristic SunSmart school[a]	Yes (N = 27)	36.3 (13.0, 48.8); 5.0–83.3 (2,206)	0.422	77.3 (71.0, 85.0); 54.3–100.0 (2,236)	0.559
	No (N = 14)	23.6 (12.3, 37.1); 0–81.0 (710)		76.2 (57.8, 91.8); 41.7–100.0 (696)	
School ownership	Government (N = 26)	18.2 (9.8, 37.9); 0.0–72.2 (1,592)	0.003	77.5 (69.8, 85.9); 41.7–100.0 (1,577)	0.989
	Non-Government (N = 15)	41.0 (30.3, 57.9); 13.3–83.3 (1,324)		76.8 (70.9, 86.8); 54.3–100.0 (1,355)	
Sun-protection policy score[b]	≤ Median score (0–2) (N = 21)	23.1 (12.5, 43.1); 0.0–83.3 (1,223)	0.348	77.6 (66.0, 90.7); 41.7–100.0 (1,247)	0.361
	> Median score (3+) (N = 20)	36.2 (15.7, 47.9); 5.0–81.0 (1,693)		76.4 (70.0, 83.2); 43.8–100.0 (1,685)	
School size	Small (≤399 students) (N = 17)	14.3 (9.7, 47.4); 0.0–83.3 (718)	0.228	85.0 (69.4, 100.0); 41.7–100.0 (725)	0.142
	Medium (400–799 students) (N = 15)	36.3 (20.7, 41.0); 9.1–54.2 (1,242)		75.9 (58.6, 83.0); 43.8–92.3 (1,234)	
	Large (≥800 students) (N = 9)	36.9 (22.7, 49.8); 9.1–57.9 (956)		74.7 (71.1, 77.5); 70.0–86.8 (973)	
ICSEA group[c]	ICSEA ≤1000 (N = 35)	30.3 (13.0, 38.1); 0.0–83.3 (2,345)	0.319	75.9 (69.3, 85.0); 41.7–100.0 (2,351)	0.209
	ICSEA >1000 (N = 6)	49.4 (12.2, 53.1); 6.0–57.9 (571)		82.2 (75.4, 91.4); 71.1–100.0 (581)	
School type	Primary[d] (N = 35)	23.1 (11.9, 41.0); 0.0–83.3 (2,397)	0.051	77.5 (70.0, 85.0); 41.7–100.0 (2,391)	0.679
	Combined[e] (N = 6)	43.9 (34.2, 63.7); 30.3–81.0 (519)		74.0 (57.5, 90.1); 54.3–100.0 (541)	

[a]*SunSmart status was verified by contact with the Cancer Council Queensland, as at December 2012.*

[b]*Total score attained by these 41 schools when their sun-protection policies were independently evaluated against pre-determined criteria [maximum possible score was 12 (44)].*

[c]*The index of community socio-educational advantage (ICSEA) is calculated using student family background data to determine the level of educational advantage students bring to their studies. The average ICSEA value is set at 1000 with values ranging from 500 (extremely educationally disadvantaged backgrounds) to 1300 (students from highly educated families).*

[d]*Primary school starts at age 5 (prep year) and continued until Grade 7 (age 12 years) in Queensland up until 2015 when grade 7 became the first year of secondary schooling; first 8 years of formal education.*

[e]*Combined schools enroll students for their entire formal education (Prep – Grade 12).*

Furthermore, the proportion of student spectators observed wearing a hat appeared to decline over the study, from a median of 46.2% in 2009 to 18.0% in 2015. A similar temporal trend was also evident for the proportion of student spectators observed wearing a shirt which declined from a median of 95.8% in 2009 to 74.5% by 2015 (**Table 4**).

TABLE 3 | Median (IQR); range (*n*) of the proportion of student spectators observed wearing hats and shirts while attending at least one inter-primary-school swimming carnival during the 4 years of observations carried out 2009–2011 and 2015 are shown stratified by SunSmart status within each of the school characteristics considered.

School characteristic		Proportion (%) of students at each school wearing a HAT based on *n* = 2,916 observations conducted for a sample of *N* = 41 schools				Proportion (%) of students at each school wearing a SHIRT based on 2,932 observations conducted for a sample of *N* = 41 schools			
		SunSmart[a] school (SSS) (N = 27)		Non-SSS (N = 14)		SSS[a] (N = 27)		Non-SSS (N = 14)	
		Median% (IQR); range (n) in (N schools)	p-Value within SSS ↓	Median% (IQR); range (n) in (N schools)	p-Value within Non-SSS↓	Median% (IQR); range (n) in (N schools)	p-Value within SSS↓	Median% (IQR); range (n) in (N schools)	p-Value within Non-SSS↓
School ownership	Government, *p*-value[¥] →	17.5 (10.3, 38.0); 5.0–54.2 (975) (*N* = 16)	0.005 ↓ 0.979→	19.9 (9.1, 37.1); 0.0–72.2 (617) (*N* = 10)	0.539↓	80.1 (70.3, 87.6); 60.9–100.0 (970) (*N* = 16)	0.645↓ 0.363→	76.2 (53.0, 85.4); 41.7–100.0 (607) (*N* = 10)	0.539↓
	Non-government, *p*-value[¥] →	48.8 (33.9, 57.9); 16.1–83.3 (1,231) (*N* = 11)	0.343→	29.3 (15.8, 69.6); 13.3–81.0 (93) (*N* = 4)		76.8 (71.1, 83.2); 54.3–100.0 (1,266) (*N* = 11)	0.949→	79.3 (58.4, 100.0); 58.3–100.0 (89) (*N* = 4)	
Sun-protection policy score[b]	≤ Median score (0–2), *p*-value[¥] →	35.1 (13.3, 49.5); 6.0–83.3 (837) (*N* = 12)	0.905↓ 0.247→	15.0 (9.1, 30.5); 0.0–72.2 (386) (*N* = 9)	0.083↓	80.7 (71.7, 91.3); 54.3–100.0 (857) (*N* = 12)	0.373↓ 0.862→	77.6 (57.2, 94.5); 41.7–100.0 (390) (*N* = 9)	0.797↓
	> Median score (3 +), *p*-value[¥] →	36.9 (11.1, 48.8); 5.0–58.0 (1,369) (*N* = 15)	0.745→	35.5 (23.2, 59.6); 15.6–81.0 (324) (*N* = 5)		76.8 (70.9, 83.2); 67.9–94.4 (1,379) (*N* = 15)	0.306→	69.3 (51.2, 89.0); 43.8–100.0 (306) (*N* = 5)	
School size	Small (≤ 399 students), *p*-value[¥] →	13.0 (8.3, 22.7); 5.0–83.3 (607) (*N* = 11)	0.048↓ 0.301→	30.0 (10.0, 74.4); 0.0–81.0 (111) (*N* = 6)	0.385↓	85.0 (70.9, 94.4); 60.9–100.0 (616) (*N* = 11)	0.351↓ 0.884→	92.1 (54.2, 100.0); 41.7–100.0 (109) (*N* = 6)	0.459↓
	Medium (400–799 students), *p*-value[¥] →	38.0 (28.5, 49.4); 10.0–54.2 (811) (*N* = 9)	0.088→	27.5 (14.0, 36.2); 9.1–38.1 (431) (*N* = 6)		77.5 (70.6, 83.5); 54.3–92.3 (810) (*N* = 9)	0.224→	64.0 (53.0, 80.8); 43.8–89.0 (424) (*N* = 6)	
	Large (≥800 students), *p*-value[¥] →	45.2 (33.9, 51.5); 30.3–57.9 (788) (*N* = 7)	0.056→	12.1 (9.1, –); 9.1–15.0 (168) (*N* = 2)		73.9 (71.0, 77.3); 70.0–86.8 (810) (*N* = 7)	0.5→	76.2 (74.7, –); 74.7–77.6 (163) (*N* = 2)	
ICSEA group[c]	ICSEA ≤ 1000, *p*-value[¥] →	33.9 (12.5, 43.1); 5.0–83.3 (1,635) (*N* = 21)	0.345↓ 0.538→	23.7 (12.3, 37.1); 0.0–81.0 (710) (*N* = 14)	–	75.9 (70.5, 84.5); 54.3–100.0 (1,655) (*N* = 21)	0.175↓ 0.702→	76.2 (57.8, 91.8); 41.7–100.0 (696) (*N* = 14)	–
	ICSEA > 1000, *p*-value[¥] →	49.4 (12.2, 53.1); 6.0–57.9 (571) (*N* = 6)		–		82.2 (75.4, 91.4); 71.1–100.0 (581) (*N* = 6)		–	
School type	Primary[d], *p*-value[¥]→	33.9 (11.9, 48.4); 5.0–83.3 (1,739) (*N* = 23)	0.243↓ 0.362→	19.4 (10.2, 35.3); 0.0–72.2 (658) (*N* = 12)	0.132↓	77.5 (71.0, 85.0); 60.9–100.0 (1,745) (*N* = 23)	0.448↓ 0.420→	76.2 (56.7, 87.8); 41.7–100.0 (646) (*N* = 12)	0.659↓
	Combined[e] *p*-value[¥]→	43.9 (31.8, 56.3); 30.3–57.9 (467) (*N* = 4)	0.8→	58.2 (35.5, –); 35.5–81.0 (52) (*N* = 2)		74.0 (58.5, 84.3); 54.3–86.8 (491) (*N* = 4)	0.8→	79.3 (58.6, –); 58.6–100.0 (50) (*N* = 2)	

First p-value compares hat-wearing proportions across categories of a demographic characteristic within a single SunSmart status group (↓direction of comparison is downwards, i.e., within SunSmart status).

[¥]Second p-value compares hat-wearing proportions across SunSmart status groups within a single strata of a demographic characteristic (→direction of comparison is across, i.e., within a single category of demographic characteristic). All p-values comparing hat-wearing proportion at SSS compared to Non-SSS; and shirt-wearing proportion at SSS compared to Non-SSS produced non-significant results (p > 0.05).

[a]SunSmart status was verified by contact with the Cancer Council Queensland, as at December 2012.

[b]Total score attained by these 41 schools when their sun-protection policies were independently evaluated against pre-determined criteria [(maximum possible score was 12 (44)].

[c]The index of community socio-educational advantage (ICSEA) is calculated using student family background data to determine the level of educational advantage students bring to their studies. The average ICSEA value is set at 1000 with values ranging from 500 (extremely educationally disadvantaged backgrounds) to 1300 (students from highly educated families).

[d]Primary school starts at age 5 (prep year) and continued until Grade 7 (age 12 years) in Queensland up until 2015 when grade 7 became the first year of secondary schooling; first 8 years of formal education.

[e]Combined schools enroll students for their entire formal education (Prep – Grade 12).

TABLE 4 | Median (IQR); range of student spectator hat-wearing and shirt-wearing proportion at Townsville inter-primary-school swimming carnivals during the 4 years of observations carried out 2009–2011 and 2015 are shown stratified by year.

Year	Median% of students wearing a hat	Median% of students wearing a shirt
2009	46.2 (39.2,56.0); 36.4–66.7	95.8 (80.6, 96.8); 77.1–97.4
2010	36.7 (16.2, 51.3); 6.9–80.0	80.6 (67.3, 90.4); 35.4–97.2
2011	27.4 (12.7, 39.3); 0.0–100.00	78.0 (66.1, 88.5); 40.0–100.0
2015	18.0 (7.7, 42.5); 0.0–76.9	74.5 (55.9, 90.0); 0.0–100.0

DISCUSSION

To our knowledge, this is the first report to comment on the sun-protective behaviors of student spectators at school swimming carnivals in Australia. We found student hat-wearing rates at Townsville inter-primary-schools swimming carnivals to be poor; a concern in this skin cancer prone population (47, 48). More student spectators were seen wearing a shirt (median 77.3%) than a hat (median 30.7%), confirming our earlier assertions (54, 55) and the anecdotal reports of others (56) that hats are vastly under-utilized by schoolchildren in Queensland. The proportion of student spectators who were observed wearing a shirt was not associated with any of the socio-demographic characteristics we considered, whereas hat-wearing rates differed significantly between government and non-government schools, and to a lesser extent, by school type (primary vs. combined primary–secondary schools). One possible explanation is that of positive role-modeling, where younger students mimic good sun-protective behaviors that are modeled for them by older students during their schooling. Assuming that this is true and that these behaviors become habitual, this phenomenon could result in primary schoolchildren from combined primary–secondary schools exhibiting better hat-wearing compliance at inter-school swimming carnivals than schoolchildren from traditional primary schools. However, we did not collect data describing hat-use among north Queensland secondary school students to support this hypothesis, and others consistently report poor hat-use among secondary students, both within Australia and abroad (2, 56, 57) making this explanation less plausible. It is worth noting that only six of the 41 schools in our study population were "combined" schools, and that all of them were non-government schools. Thus, it is difficult to separate out the influence of school type (i.e., primary vs. combined schools) and school ownership (i.e., government-funded vs. non-government schools) in the present study.

The ICSEA scores of non-government (privately funded) schools were higher than those of government schools in the present study, suggesting that non-government schoolchildren in Townsville have a socioeconomic advantage over children attending government-funded schools in the same district. This may include better access to financial resources (e.g., sufficient discretionary household income to replace a lost school hat) or having more highly educated parents. The latter could potentially result in non-government schoolchildren receiving better education about sun-protection at home than their government-school counterparts. While socioeconomic advantage may be a plausible explanation for hat-wearing being more prevalent among non-government schoolchildren, it fails to explain why the same was not true for wearing a shirt. In fact, we found that swim-shirt rates were almost identical for the non-government (76.8%) and government schools (77.5%) observed in the present study.

When examining temporal trends in shirt-usage among student spectators, we found that shirt-wearing compliance was highest at the beginning of the study in 2009. The "almost perfect" result of 95.8% was achieved soon after the "no shirt, no swim" rule (28), was introduced in Queensland, making it compulsory for primary schoolchildren attending state-government-funded schools to wear a shirt during school water-based activities (except when competing). This result demonstrates just how effective the mandatory swim-shirt policy was at the time of its implementation (29, 30). Anecdotal evidence from the newsletters of non-government schools in the study area suggests that implementation of the swim-shirt policy was not confined to government schools, with a number of non-government schools in Townsville also stating their intention to adopt the "no shirt, no swim" rule (Harrison, unpublished data). This seems to be a plausible explanation for the similarly high shirt-wearing rates that were observed for most schools, irrespective of whether they were government or non-government-run facilities.

Consistent with the mandatory swim-shirt policy hypothesis, we also documented a substantial decrease of 15.2% in shirt-wearing rates between carnivals held in March 2009 (~13-months after introduction of the swim-shirt policy) and those held in March 2010 (25-months post-introduction). Shirt-usage rates continued to decline in the years following 2010, albeit at a slower pace, reaching a minimum of 74.5% by 2015; the final year of the study. This phenomenon is most likely due to a decline in media interest, and possibly also diminished departmental communication with schools about the mandatory swim-shirt policy in the years following its introduction.

SunSmart guidelines also recommend that students wear sun-protective clothing, such as T-shirts or rash-vests when involved in swimming activities and that wet shirts be replaced with dry ones when exiting the pool (43). However, similar proportions of children from SSS and Non-SSS were observed wearing a shirt (77.3 and 76.2%, respectively) in this study, suggesting that the SSS program had little, if any, additional impact on swim-shirt compliance in tropical north Queensland schools.

Student spectators and competitors alike should wear shirts to protect their torso from unnecessary UVR since it is reflected from pool water surfaces and ~60% can penetrate into pool water (31, 32). Drag from shirts can be reduced substantially for competitors if properly fitting rash-vests are worn, and competitive swimmers have actually benefited from reduced drag by wearing all-in-one elastane suits (58). Given that swim-shirt use is optional for competing students, in this climate at this time of year [average recorded UV index for March 2009, 2010, 2011, and 2015 was 9.7 (51)], students can easily exceed the daily UVR exposure limit while lining up several races ahead of their own (often for more than 6 min) event with much/all of their torso exposed. If a shirt is not worn during an event, at the very least, it should be worn up to the time of the event and put back on immediately after exiting the pool.

In 1996, Australia pioneered the relative ranking (UPF) of the sun-protective capabilities of clothing based on the transmission of UVR though fabric. The UPF rating is printed on the swing tags of sun-protective clothing sold in Australia to guide consumers in purchasing sun-protective garments, such as swim-shirts for themselves and their children. However, as minimum body surface coverage is not specified in the current standard (AS/NZS 4399:1996) (59, 60), some swimwear manufacturers have taken advantage of this loop-hole to market elastane (Lycra®) bikinis with UPF 50+ swing tags attached (59). Our randomized controlled trial (RCT) demonstrated that sun-protective clothing that covers more body surface area (BSA) can reduce the development of MN in young children and subsequent melanoma risk (19, 20). Consequently, considerable effort has been invested recently to revise the Australian and New Zealand Standard for sun-protective clothing to address this issue (59, 61). Sun-protective clothing made of high UPF fabric with elbow-length sleeves was well tolerated by children in our previous RCT and prevented a significant proportion of new MN developing on the upper arms (19, 20). Furthermore, co-author (Simone Lee Harrison) has successfully trialed a swim-shirt loan scheme in several north Queensland primary schools in recent years. Preliminary results of this translational research project suggest that it may offer a novel and cost-effective solution to providing schoolchildren with equal access to good quality, long-sleeve sun-protective shirts for use during curriculum-based water activities (Harrison, unpublished data).

UVR is a skin carcinogen and contributes to eye and surrounding tissue damage, age-related cataracts, corneal degenerative changes, and possibly age-related macular degeneration (62, 63). The risk of over-exposure is further exacerbated at outdoor aquatic events as UVR reflects off water, further increasing an individual's exposure; making it especially important that children use multiple methods of sun-protection, including hats, shade, sunscreen, and sunglasses to protect skin on the face and neck in aquatic environments (32). In response to the dangers associated with over-exposure, the International Radiation Protection Association recommends that an individual's daily UVR exposure does not exceed 30 J m^{-2} (64). However, recent research shows that during summer, Queensland teachers can exceed their weekly UVR dose in a single day between 8:30 a.m. and 3:15 p.m. (average daily exposure: 115 J m^{-2}) since they are required to spend a considerable amount of time outdoors during peak UVR exposure times supervising students during lunch breaks, physical education classes, sporting events, etc. (65, 66). Additionally, Downs and Parisi (67) report considerable variability within student UVR dose during the school day at South East Queensland; the median student exposure during a typical school day was found to be 1.6 SED (standard erythema dose; 1 SED = 100 J/m^2 of erythemally effective UV exposure) while students at school swimming carnivals were exposed to almost 50 SED. On a clear day, when the UVI is 12–14 (a typical Spring/Summer day for the study location), it takes only 6–7 min for a unprotected individual to receive their daily UVR limit (64). Individuals can easily determine the appropriate level of sun-protection required for their environmental conditions via the Australian Radiation Protection and Nuclear Safety Agency website (provides up-to-the-minute UVR reports for Australian capital cities) (51) or via the Australian Cancer Council's mobile phone application (uses the Bureau of Meterology to report UVI) (68).

Hats shade the face and neck from excessive sun exposure (24). Queensland Government schools and SunSmart accredited schools have sun-safety guidelines that stipulate that students are expected to wear a hat when outdoors (34, 69). However, evidence from the present study (18% hat-wearing rates in 2015) and research conducted previously by our team (54, 55) suggests that hats are still under-utilized by primary schoolchildren living in north Queensland's intense ambient UVR climate.

We expected a significantly higher proportion of students from SSS than non-SSS to be observed wearing a hat, since SunSmart guidelines specify that all primary schoolchildren should wear a broad-brimmed (≥7.5 cm brim), legionnaire or bucket hat (≥6 cm brim, deep crown) when outside (43). The difference in median hat-wearing proportions between SSS and non-SSS was 12.7%, but was not substantial enough to reach statistical significance in the present study of 41 schools (SSS 36.3 vs. 23.6%; $p = 0.422$). When the results were further stratified, some hat-wearing rates seemed higher for SSS than for non-SSS. For example, a higher proportion of students attending large SSS wore hats compared to their peers at large non-SSS (45.2 vs. 12.1%; $p = 0.056$). This result was only borderline significant, but had limited statistical power to detect a difference as it was based on just nine schools (only two of which were large non-SSS). Similarly, while the effect of SunSmart status on hat-wearing within government schools was negligible (2.4% difference; $p = 0.979$), the difference in hat-wearing proportions across categories of SunSmart status in non-government (privately funded) schools was almost 20% (non-government SSS 48.8% vs. non-government non-SSS 29.3%; 0.343). Again, this failed to reach statistical significance, most likely due to the small sample size (there were only four non-government non-SSS in the study region) and the lack of statistical power. Although SunSmart status may have some degree of influence over spectator hat-wearing compliance that was difficult to quantify in this relatively small study of 41 schools, it was apparent that school ownership (a likely indicator of socioeconomic status) exerted more influence over hat-wearing prevalence than SunSmart status, as suggested by the finding that significantly more students from non-government SSS than government SSS were observed wearing a hat (48.8 vs. 17.5%, respectively; $p = 0.005$).

Accordingly, we suggest that while SunSmart status may have some influence on hat-wearing compliance among primary student spectators compliance, the hat-wearing proportions observed for the 27 SSS in this study were far from remarkable at a median of 36.3%. This is a concern since these schools are provided with sun-safety resources; encouraged to develop a comprehensive school sun-protection policy; and make a written commitment to improve sun-safety in their school environment. Considered as a whole, these observations demonstrate that the expectations of the SSS Program are not being closely adhered to in this high-risk population, since most of the students we observed at SSS and non-SSS alike failed to wear their hat. Consistent with the suggestions of key stakeholders about increasing the external accountability of schools (70) our research group is trialing a school-based sun-protection program that monitors sun-protection compliance and feeds this information to individual primary schools.

Our results also suggest that the sun-protective behaviors of primary schoolchildren from this skin cancer prone region declined over the period of the study. Almost two decades have passed since the SSS Program was introduced in Queensland, and 8 years have passed since it became mandatory for primary schoolchildren from government schools in Queensland to wear a shirt during all water-based activities except swimming races. Consequently, all Queensland schools catering to primary students should be aware of the dangers associated with over-exposure to UVR, yet it seems that the sun-safety message is failing to reach a significant proportion of its target audience. It is not known whether this is because the message has little or no effect, or whether teachers and students from primary schools under-estimate the long-term effects of over-exposure to UVR. We could not measure sunscreen application cost-effectively as part of the baseline phase of this trial, so it is possible that some of the students who were observed were wearing sunscreen, however, it is not advisable to rely on sunscreen alone since it does not provide full protection; needs to be applied 20 min before going outdoors and reapplied every 2 h (more frequently when participating in water-based activities) (71). More prompting, education, guidance, and monitoring may be required to improve hat-wearing compliance at school sporting events since it is likely that sun-protective behaviors lapse as spectators settle into watching events or fail to retrieve their hat (and/or shirt if swimming) after competing in an event. Additionally, numerous schools and students are present at swimming events and school staff may be preoccupied with organizing events, recording results and preparing students for races, and forget to prompt the children they are supervising to put their hats and shirts back on. All of the schools that we observed had one or more parents present at the carnival. Therefore, this problem could be alleviated by having each school assign one such parent to champion sun-protection (or several parents could fill this role in succession) for the duration of the carnival. Alternatively, staff could charge a school prefect or sports captain with this responsibility. This would ensure that someone is focused on supervising the sun-safety practices of students, and prompting them to put their hats and shirts back on after an event, and to apply sunscreen and return to shaded areas where available. Senior primary schoolchildren could be encouraged to conduct their own observations of sun-protective behavior; use their mathematic skills to interpret the data; and encouraged to present their findings to their class and school staff and management using graphs and charts, etc. This would also benefit the students by demonstrate to them how skills learnt in the classroom can be applied to everyday life. Additionally, students could help institute change in sun-protective behaviors by taking periodic photos of their school spectator areas then retrospectively calculate hat- and shirt-wearing proportions and this information could be used by schools to commend/reward sports houses/teams who consistently demonstrate appropriate sun-protective behavior. Recent discussions with school principals involved in our ongoing interventional research have highlighted some of the innovative strategies that they have used to improve sun-protection compliance at outdoor sporting events. One non-government school (Annandale Christian College, Townsville, QLD, Australia) provides students with adhesive disposable wristbands which are “ticked” every time students re-apply sunscreen at the “sunscreen station” provided by the school. Students cannot participate in their nominated event unless their wristband indicates they have applied sunscreen hourly. This strategy could be adapted for use at swimming carnivals by using waterproof adhesive wristbands suitable for aquatic use and by using stickers instead of indelible pen markings each time sunscreen is applied. Two Townsville schools also rescheduled their swimming carnivals to the evening to avoid excessive sun exposure, however one school experienced poor student and parental attendance after doing so, and had to revert back to holding their swimming carnival during school hours. Rescheduling outdoor activities to avoid peak UVR periods is advantageous, but can be problematic in tropical locations where sun-protection is often required (i.e., the UVI is 3 or above) from 8:30 a.m. until 3.30 p.m. since this would mean school staff, students, and parents would be required to attend outside usual school hours.

The aforementioned approaches could be used by primary schools for other outdoor sports carnivals and even excursions and are synonymous with the views shared at a workshop attended by teachers, education policy makers, and other key stakeholders from Queensland during which, strong support was shown for monitoring sun-protection compliance, increasing external accountability, and working toward cultivating internal champions to assist with the implementation of sun-protection in Queensland schools(70). Since this report was published (70), the Queensland Government Department of Education and Training has introduced policies governing the attendance of Queensland government schools at swimming carnivals and other aquatic activities. Teachers arranging for students to attend these events are expected to conduct a Curriculum Activity Risk Assessment to manage all foreseeable risks (72) and follow these guidelines for swimming carnivals (73) These guidelines currently mention that the event must comply with the school’s sun-safety strategy in regard to competitors and spectators (69); state that adequate shade should be available; and specify that, “for events longer than 2 h, provide regular reminders to stay in the shade as much as possible, wear hats and sunglasses, re-apply sunscreen,….” These guidelines are quite explicit and suggest designating roles to adults, such as a first aid officer and lifeguard. These guidelines could be improved by suggesting that a designated sun-safety officer be assigned for swimming carnivals and mention that a parent or student prefect could fill this role. Policy guidelines, such as this, especially once refined, may provide a useful model worthy of adoption in school communities in high ambient UVR environments in the northern Hemisphere.

In-service education for school staff and education policy makers in high-risk regions might also be useful in making them aware of how quickly children can burn in regions with high levels of ambient UVR. They also need to be made aware that it is possible for students to sustain a sunburn even while in the shade in aquatic settings, if personal sun-protection is not used, as the reflectance of UVR off the surface of water can be substantial. It is especially important to remain vigilant about personal sun-safety since UVR is not visible to the naked eye; making it easy to dismiss. The causative link between UVR over-exposure and skin cancer development is well established, yet our schoolchildren seem to be at risk of over-exposure. To better understand why observed sun-protective behaviors were inadequate, it would be advantageous to meet with school staff, parents, and caregivers to discuss the value of multiple methods of personal sun-protection; and learn why observed behaviors were poor. Perhaps the sun-safety message is misunderstood; the dangers of over-exposure to UVR are under-estimated; sun-protective behaviors are perceived as inconvenient; or schoolchildren consider school hats and swim-shirts/t-shirts to be "uncool," therefore, chose not to wear them.

This unique research presents data obtained from direct observations of shirt and hat-wearing behaviors at primary school swimming carnivals. Our research is limited by the small number of schools operating in the region ($n = 41$) and the associated lack of statistical power. As students could not be filmed or photographed due to ethical restrictions, it is possible that the total number of individuals and proportion wearing hats and shirts may have been slightly over or under-reported. However, such information bias would be similar for all schools and result in a bias toward the null in comparative analyses. Our research is strengthened by the use of observational data that were collected without informing study participants of the nature of the research. Collecting data this way provides a truer representation of student sun-protective behaviors that were not influenced by our presence. While we wanted to present data on the sun-protection practices of adult role-models as well, in practice, we found it difficult to accurately group the adults we observed (particularly parents and other spectators) with specific schools since adults did not always sit in designated school areas. Future reports may benefit from grouping all observed adults together rather than categorizing adults according to individual schools. Student sun-protective behaviors may be influenced by the same behaviors of all staff, parents, caregivers, and other adult spectators present at a swimming carnival (or other school sporting event) and not only by the adults associated with their particular school.

CONCLUSION

Sun-protection during the childhood years is important for reducing the risk of developing skin cancer later in life. We found that primary school student hat-wearing rates at inter-school swimming carnivals in a region with intense ambient UVR and high skin cancer rates were poor and that shirt-wearing rates, while quite good, could still be improved. School demographics, including student enrollment numbers, sun-protection policy evaluation score, and SunSmart status were not found to remarkably impact sun-protective behaviors. The value of using multiple forms of sun-protection at school swimming carnivals needs to be emphasized, especially as spectators and competitors are exposed to both reflected and direct UVR. A single form of sun-protection rarely provides adequate protection against over-exposure to sunlight under these circumstances and one can receive their daily UV exposure limit in a matter of minutes when insufficiently protected, particularly in tropical and sub-tropical locations.

ETHICS APPROVAL

The study was approved by James Cook University (approvals H3365; H5279; H6088), Education Queensland (ref 11/54273; 550/27/1112; 550/27/1497), and the Catholic Diocese of Townsville (2011-06; 2015-07).

AUTHOR CONTRIBUTIONS

DT – Data collection, data analysis, manuscript preparation, and submission. Dr. SH – Data collection and manuscript preparation. NB – Data collection and manuscript preparation. All authors have approved the final article prior to submission.

ACKNOWLEDGMENTS

The authors wish to thank Annandale Christian School, Townsville, Queensland, Australia for sharing the innovative approach they use to monitor sunscreen application by students during school sporting carnivals. We also thank A/Prof. Petra Buettner and Dr. Madeleine Nowak for statistical advice and editorial assistance, respectively, and Ms Hilla Cohen for her assistance with data entry.

FUNDING

This work was supported by funds acquired from Queensland Health (Project ID 57543); The Parkes Bequest to James Cook University; The Alf and Winifred Murgatroyd Perpetual Charitable Trust; a Research Infrastructure Block Grant from James Cook University; and the Rotary Club of Thuringowa.

REFERENCES

1. Brooke BP, Harris PT, Nichol SL, Sexton J, Arthur WC, Haese RR, et al. Living on the edge – waterfront views. In: Blewett R, editor. *Shaping a Nation: A Geology of Australia*. Canberra: Geoscience Australia (2012). p. 277–81.
2. Lowe JB, Borland R, Stanton WR, Baade P, White V, Balanda KP. Sun-safe behaviour among secondary school students in Australia. *Health Educ Res* (2000) 15(3):271–81. doi:10.1093/her/15.3.271
3. Perez D, Kite J, Dunlop SM, Cust AE, Goumas C, Cotter T, et al. Exposure to the 'dark side of tanning' skin cancer prevention mass media campaign and its association with tanning attitudes in New South Wales, Australia. *Health Educ Res* (2015) 30(2):336–46. doi:10.1093/her/cyv002
4. Australian Institute of Health and Welfare. *Cancer in Australia: An Overview*. Canberra: Australian Institute of Health and Welfare (2008). 46 p.
5. Australian Institute of Health and Welfare and Australasian Association of Cancer Registries. *Cancer in Australia: An Overview*. Canberra: Australian Institute of Health and Welfare (2010).
6. Fritschi L, McHenry P, Green AC, MacKie RM, Green L, Siskind V. Naevi in schoolchildren in Scotland and Australia. *Br J Dermatol* (1994) 130(5): 599–603. doi:10.1111/j.1365-2133.1994.tb13106.x

7. Harrison SL, MacKie RM, MacLennan R. Development of melanocytic nevi in the first three years of life. *J Natl Cancer Inst* (2000) 92(17):1436–8. doi:10.1093/jnci/92.17.1436
8. Harrison SL, MacLennan R, Speare R, Wronski I. Sun exposure and melanocytic naevi in young Australian children. *Lancet* (1994) 344(8936):1529–32. doi:10.1016/S0140-6736(94)90348-4
9. Holman CD, Armstrong BK. Cutaneous malignant melanoma and indicators of total accumulated exposure to the sun: an analysis separating histogenetic types. *J Natl Cancer Inst* (1984) 73(1):75–82.
10. Kelly JW, Rivers JK, MacLennan R, Harrison SL, Lewis AE, Tate BJ. Sunlight: a major factor associated with the development of melanocytic naevi in Australian schoolchildren. *J Am Acad Dermatol* (1994) 30(1):40–8. doi:10.1016/S0190-9622(94)70005-2
11. Bauer J, Garbe C. Acquired melanocytic nevi as risk factor for melanoma development. A comprehensive review of epidemiological data. *Pigment Cell Res* (2003) 16(3):297–306. doi:10.1034/j.1600-0749.2003.00047.x
12. Green AC, MacLennan R, Siskind V. Common acquired naevi and the risk of malignant melanoma. *Int J Cancer* (1985) 35(3):297–300. doi:10.1002/ijc.2910350303
13. Sagebiel RW. Melanocytic nevi in histologic association with primary cutaneous melanoma of superficial spreading and nodular types: effect of tumor thickness. *J Investig Dermatol* (1993) 100:322S–5S. doi:10.1111/1523-1747.ep12470218
14. Green A, MacLennan R, Youl P, Martin N. Site distribution of cutaneous melanoma in Queensland. *Int J Cancer* (1993) 53:232–6. doi:10.1002/ijc.2910530210
15. Heal C, Buettner PG, Raasch BA, Browning S. Minor skin excisions in general practice in North Queensland. *Aust Fam Physician* (2006) 35(10):825–8.
16. Raasch BA, Buettner PG, Garbe C. Basal cell carcinoma: histological classification and body-site distribution. *Br J Dermatol* (2006) 155(2):401–7. doi:10.1111/j.1365-2133.2006.07234.x
17. Youl PH, Janda M, Aitken JF, Del Mar CB, Whiteman DC, Baade PD. Body site distribution of skin cancer, pre-malignant and common benign pigmented lesions excised in general practice. *Br J Dermatol* (2011) 165:35–43. doi:10.1111/j.1365-2133.2011.10337.x
18. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). *Australian Clothing Standard*. (2012). Available from: http://www.arpansa.gov.au/uv/labelling.cfm
19. Harrison SL, Buettner PG, MacLennan R. The North Queensland "sun-safe clothing" study: design and baseline results of a randomized trial to determine the effectiveness of sun-protective clothing in preventing melanocytic nevi. *Am J Epidemiol* (2005) 161(6):536–45. doi:10.1093/aje/kwi081
20. Harrison SL, Buettner PG, MacLennan R, Woosnam J, Hutton J, Nowak M. Sun-safe clothing helps to prevent the development of pigmented moles – results of a randomised control trial in young Australian children. *Ann ACTM* (2010) 11(2):49–50.
21. Diffey B, Cheeseman J. Sun protection with hats. *Br J Dermatol* (1992) 127:10–2. doi:10.1111/j.1365-2133.1992.tb14816.x
22. Downs NJ, Parisi AV. *Comparing Variations in the UV Facial Exposure Received by School Children in South-East Queensland*. Brisbane, Australia: Australian Institute of Physics 17th National Congress 2006 (2006).
23. Gies P, Javorniczky J, Roy C, Henderson S. Measurements of the UVR protection provided by hats used at school. *Photochem Photobiol* (2006) 82:750–4. doi:10.1562/2005-10-27-RA-727
24. Kimlin M, Parisi A. Ultraviolet protective capabilities of hats under two different atmospheric conditions. *2nd Internet Photochemistry and Photobiology Conference*. (1999).
25. Gambichler T, Dissel M, Altmeyer P, Rotterdam S. Evaluation of sun awareness with an emphasis on ultraviolet protection by clothing: a survey of adults in Western Germany. *J Eur Acad Dermatol Venereol* (2009) 24(2):155–62. doi:10.1111/j.1468-3083.2009.03368.x
26. Dixon H, Borland R, Hill D. Sun protection and sunburn in primary school children: the influence of age, gender, and colouring. *Prev Med* (1999) 28:119–30. doi:10.1006/pmed.1998.0392
27. Moise AF, Buttner PG, Harrison SL. Sun exposure at school. *Photochem Photobiol* (1999) 70(2):269–74. doi:10.1111/j.1751-1097.1999.tb07999.x
28. Bligh A. *Media Statements (Release Date 5 Nov 2007). No Shirt, No Swim As Schools Get Sun Smarter*. (2007). Available from: http://statements.qld.gov.au/Statement/Id/54906
29. Department of Education Training and Employment. *Sun Safety*. (2012). Available from: http://education.qld.gov.au/schools/healthy/swim-shirts-sunscreen.html
30. Department of Education and Training. *Student Dress Code*. (2016). Available from: http://ppr.det.qld.gov.au/education/management/Pages/Student-Dress-Code.aspx
31. Diffey BL. Sources and measurement of ultraviolet radiation. *Methods* (2002) 28:4–13. doi:10.1016/S1046-2023(02)00204-9
32. Holman CDJ, Gibson IM, Stephenson M, Armstrong BK. Ultraviolet irradiation of human body sites in relation to occupation and outdoor activity: field studies using personal UVR dosimeters. *Clin Exp Dermatol* (1983) 8(3):269–77. doi:10.1111/j.1365-2230.1983.tb01779.x
33. Cancer Council Australia. *Slip Slop Slap Seek Slide*. (2013). Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/campaigns-and-events/slip-slop-slap-seek-slide.html
34. Cancer Council Queensland. *SunSmart Policy Guidelines*. (2009). Available from: http://www.cancerqld.org.au/icms_docs/54253_SunSmart_policy_guidelines.pdf
35. Cancer Council Victoria. SunSmart program 2003–2006. In SunSmart Victoria, editor. Victoria: Cancer Council Victoria (2002). Available from: http://www.sunsmart.com.au/
36. Montague M, Borland R, Sinclair C. Slip! Slop! Slap! and SunSmart, 1980-2000: skin cancer control and 20 years of population-based campaigning. *Health Educ Behav* (2001) 28:290–305. doi:10.1177/109019810102800304
37. SunSmart Victoria. *SunSmart. Our History*. (2012). Available from: http://www.sunsmart.com.au/about_us/our_history
38. Cancer Research UK. Sun protection in schools. *SunSmart*. (2009). Available from: http://sunsmart.org.uk/schools
39. Cassel KD, Burns JA. "Sun safe kids", implementing a low cost, school-based public policy to protect Hawaii's children from skin cancer risks. *Hawaii Med J* (2010) 69:274–7.
40. Reeder AI, Jopson JA, Gray A. Primary school sun protection policies and practices 4 years after baseline – a follow up study. *Health Educ Res* (2012) 27(5):844–56. doi:10.1093/her/cys092
41. Reynolds KD, Buller DB, French SA, Buller MK, Ashley JL. School sun-protection policies: measure development and assessments in 2 regions of the United States. *J Sch Health* (2012) 82:499–507. doi:10.1111/j.1746-1561.2012.00729.x
42. The Cancer Association of South Africa. (2010). Be SunSmart: a guide for schools. In: Cancer Association of South Africa, editor. *Be SunSmart: A Guide for Schools*. Bedfordview, South Africa: The Cancer Association of South Africa (CANSA).
43. Cancer Council Australia's Skin Cancer Committee's National Schools Working Group. *Being SunSmart: A Guide for Primary Schools*. Canberra (2005).
44. Turner D, Harrison S, Buettner P, Nowak M. School sun-protection policies – does being SunSmart make a difference? *Health Educ Res* (2014) 29(3):367–77. doi:10.1093/her/cyu010
45. Harrison SL, Nikles J, Turner D, Cohen H, Nowak M. An evaluation of sun protection policies in Queensland primary schools. *Ann ACTM* (2013) 14(1):26.
46. Harrison SL, Garzon-Chavez DR, Nikles CJ. Sun protection policies of Australian primary schools in a region of high sun exposure. *Health Educ Res* (2016) 31(3):416–28. doi:10.1093/her/cyw020
47. Buettner PG, Raasch BA. Incidence rates of skin cancer in Townsville, Australia. *Int J Cancer* (1998) 78(5):587–93. doi:10.1002/(SICI)1097-0215(19981123)78:5<587::AID-IJC10>3.0.CO;2-E
48. Buettner PG, Raasch BA. Erratum in: Buettner PG, Raash BA. Incidence rates of skin cancer in Townsville, Australia. *Int J Cancer* (2001) 93(2):302–3. doi:10.1002/ijc.1320
49. Bureau of Meteorology. *Townsville, Queensland. Daily Weather Observations*. (2015). Available from: http://reg.bom.gov.au/climate/dwo/IDCJDW4128.latest.shtml
50. Bureau of Meteorology. *Climate of Townsville*. (2015). Available from: http://www.bom.gov.au/qld/townsville/climate_Townsville.shtml
51. Australian Radiation Protection and Nuclear Safety Agency. *Townsville Realtime UV Index Data*. (2015). Available from: http://www.arpansa.gov.au/uvindex/realtime/tow_rt.htm

52. Department of Education and Training and Employment. *State School Full-Time Enrolment Counts, Census 2005-2009*. (2009). Available from: http://education.qld.gov.au/schools/statistics
53. Australian Curriculum Assessment and Reporting Authority. *My School*. (2010). Available from: http://www.myschool.edu.au
54. Harrison SL, Nikles J. Preliminary observations of hat wearing in Brisbane schools. *Ann ACTM* (2012) 13(2):38.
55. Turner D, Harrison S, Buettner P, Nowak M. Does being a "SunSmart School" influence hat-wearing compliance? An ecological study of hat-wearing rates at Australian primary schools in a region of high sun exposure. *Prev Med* (2014) 60:107–14. doi:10.1016/j.ypmed.2013.12.020
56. Hinde S. Welcome to the sun shame state. *The Sunday Mail*. QLD, Australia: Courier Mail Newspaper (2009). p. 4–5. Available from: http://www.couriermail.com.au/news/queensland/welcome-to-the-sun-shame-state/story-e6freoof-1225787859278
57. Coogan PF, Geller A, Adams M, Benjes LS, Koh HK. Sun protection practices in preadolescents and adolescents: a school-based survey of almost 25,000 Connecticut schoolchildren. *J Am Acad Dermatol* (2001) 44:512–9. doi:10.1067/mjd.2001.111621
58. Chatard J-C, Wilson B. Effect of fastskin suits on performance, drag, and energy cost of swimming. *Med Sci Sports Exerc* (2008) 40(6):1149–54. doi:10.1249/MSS.0b013e318169387b
59. Harrison SL, Downs N. Development of a reproducible rating system for sun protective clothing that incorporates body surface coverage. *World J Eng Technol* (2015) 3:208–14. doi:10.4236/wjet.2015.33C031
60. Standards Australia/Standards New Zealand. *Sun Protective Clothing – Evaluation and Classification. AS/NZS 4399*. Sydney: Standards Australia (1996).
61. Gies P, Slevin T. Revision of the sun protection clothing standard AS/NZS 4399. *Conference Proceedings, Presented at the 3rd International UV and Skin Cancer Prevention Conference*. Melbourne, Australia (2015).
62. American Academy of Pediatrics. Ultraviolet light: a hazard to children. *Pediatrics* (1999) 104:328–33. doi:10.1542/peds.104.2.328
63. The National Society to Prevent Blindness, The American Optometric Association, The American Academy of Ophthalmology. *Statement on Ocular Ultraviolet Radiation Hazards in Sunlight*. St Louis, MO: American Optometric Association (1993).
64. Australian Radiation Protection and Nuclear Safety Agency. *Occupational Exposure to Ultraviolet Radiation*. Canberra: Australian Government (2006). Available from: http://www.arpansa.gov.au/pubs/rps/rps12.pdf
65. Downs N, Harrison SL, Parisi A. Queensland teacher sun survey: measurements and procedures for recording occupational UV exposures in Townsville and Toowoomba. *Annals of the ACTM* (2015) 17(2):8.
66. Downs NJ, Parisi AV, Igoe D. Measurements of occupational ultraviolet exposure and the implications of timetabled yard duty for school teachers in Queensland, Australia: preliminary results. *J Photochem Photobiol B* (2014) 131:84–9. doi:10.1016/j.jphotobiol.2014.01.012
67. Downs NJ, Parisi AV. Ultraviolet exposures in different playground settings: a cohort study of measurements performed in a school population. *Photodermatol Photoimmunol Photomed* (2009) 25:196–201. doi:10.1111/j.1600-0781.2009.00441.x
68. Cancer Council Australia. *UV Alert*. (2016). Available from: http://www.cancer.org.au/preventing-cancer/sun-protection/uv-alert/
69. Department of Education and Training. *Developing a Sun Safety Strategy*. (2015). Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html
70. Radvan D. Advances towards a SunSmart state: sun protection in schools. *Paper Presented at the Advances Towards a SunSmart State – From Research to Practice*. Brisbane, Australia (2006).
71. Cancer Council Victoria. *Slop on Sunscreen*. (2016). Available from: http://www.sunsmart.com.au/uv-sun-protection/slop-on-sunscreen
72. Department of Education and Training. *Managing Risks in School Curriculum Activities. Version 5.2. DETE Policy and Procedure Register 5.2*. (2015). Available from: http://ppr.det.qld.gov.au/education/management/Pages/Managing-Risks-in-School-Curriculum-Activities.aspx
73. Department of Education Training and Employment. Swim: carnivals and other activities in pools. *Curriculum Activity Risk Assessment Activity Guidelines*. (2014). Available from: http://education.qld.gov.au/curriculum/carmg/pdf/swim-instruction-activities.pdf

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Abstract as originally published in **Turner, D.**, Bates, N., and Harrison, S (2015). "Sun-protective behaviours of primary school students at swimming carnivals in Townsville." Annals of the ACTM 16 (2): 18. *Refer to appendix 3.*

The above reference refers to an abstract and oral presentation at the 'Townsville Health Research Week' symposium. Data reported in the above peer-reviewed manuscript were included in this abstract.
Refer to contribution statement for my contribution.

7.4 Summary and future directions

Most of the student spectators observed at Townsville inter-primary-school swimming carnivals wore a shirt, however, less than a third of them wore hats. It is possible that school staff members were preoccupied with organising swimming events or supervising student safety around the water and did not have time to remind students to wear their hats and shirts. It is also possible that while student spectators were seated, they removed their hats for comfort and then forgot to put these hats back on. Similarly students may have removed their shirts for comfort or in preparation for a swim race, and then forgotten to replace their shirt post-race.

A sun-safety monitor, as suggested in the previous chapter, could be introduced at inter-primary-school swimming carnivals, and other school sporting events, to remind students to wear hats and shirts. It may be possible to increase compliance with the sun-protective behavioural aspects of school sun-protection policies if school communities consistently remind their students to be sun-safe and are pro-active in doing so. For instance, if a school introduced a sun-safety monitor and rewarded students that were consistently sun-safe, student sun-protective behaviours may improve. Studies that investigate the potential influence of a sun-safety monitor on sun-protective behaviours at school would be required to assess the effectiveness of a monitor. It might also be helpful to investigate the usefulness of a real-time ultraviolet index (UVI) display at outdoor swimming events, and other outdoor events, for motivating individuals to use sun-protection. For example, school teachers at swimming carnivals might see a visual aide which displays real-time UVI and this might prompt them to remind students to wear their hat and a shirt.

Currently (2016) the Queensland government's 'no shirt, no swim' rule does not mandate that students wear a shirt during competitive races [8]. It may be advantageous to change this rule so that all students, even those competing in swimming races, are required to wear shirts. Or, if the Department of Education and Training was unwilling to modify the rule, it may be helpful to engage with schools and encourage them to enforce shirt-use by all students despite the rule. Since primary schoolchildren may apply inadequate quantities of sunscreen [11], the value of clothing, such as shirts, as practical sun-protective aides should be emphasised to schools, school children and parents/care-givers alike. It may be helpful to articulate regularly the need for sun-protection during school hours via newsletters, parent information sessions and school assemblies.

7.5 Introduction to following chapter

Townsville primary schools may not be adequately following through with the sun-protective behavioural aspects of their sun-protection policy which we directly observed. We observed many students without hats on before, during and after school hours (Chapter 7) and without hats and shirts on at inter-primary-school swimming carnivals (Chapter 8). Data presented in Chapters 7 and 8 are intended to serve as a baseline from which changes in hat-use and shirt-use over time at Townsville primary schools (before, during and after school hours and at swimming carnivals/other sports events) can be monitored. The following chapter discusses the implications of the studies presented in this thesis. Suggestions for future research directions are also introduced in Chapter 8.

7.6 List of references

1. Diffey, B.L., *Sources and measurement of ultraviolet radiation.* Methods, 2002. **28**: p. 4-13.
2. Holman, C.D.J., et al., *Ultraviolet irradiation of human body sites in relation to occupation and outdoor activity: field studies using personal UVR dosimeters.* Clin Exp Dermatol, 1983. **8**(3): p. 269-277.
3. Cancer Council Victoria. *Slip, slop, slap, seek & slide: Sid Seagull*. SunSmart 2016 10/09/2016]; Available from:

http://www.sunsmart.com.au/tools/videos/current-tv-campaigns/slip-slop-slap-seek-slide-sid-seagull.html.

4. Townsville School Sport. *Swimming*. 2016 14/09/2016]; Available from: https://townsvilleschoolsport.eq.edu.au/Sports/swimming/Pages/swimming.aspx.

5. Department of Education and Training. *Student dress code*. 2016 01/07/2016]; Available from: http://ppr.det.qld.gov.au/education/management/Pages/Student-Dress-Code.aspx.

6. Bligh, A. *Media statements. No shirt, no swim as schools get sun smarter*. 2007 01/07/2016]; Available from: http://statements.qld.gov.au/Statement/Id/54906.

7. Giles, D., *No shirt, no swim at school*, in *The Sunday Mail (Qld)*. 2008, News Corp.

8. Department of Education Training and Employment. *Developing a sun safety strategy*. 2016 10/01/2016]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.

9. The Cancer Council Australia's Skin Cancer Committee's National Schools Working Group, *Being SunSmart - a guide for primary schools*, The Cancer Council South Australia, Editor. 2005, The Cancer Council: Carlton. p. 22.

10. Department of Education and Training. *Developing a sun safety strategy*. 2015 10/03/2015]; Available from: http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/sun-safety.html.

11. Diaz, A., et al., *The children and sunscreen study. A crossover trial investigating children's sunscreen applicatin thickness and the influence of age and dispenser type.* Arch Dermatol, 2012. **148**(5): p. 606-612.

Chapter 8
Conclusions, future directions and recommendations

The studies included in my thesis were conducted in north Queensland, which is a geographical region associated with high levels of ambient ultraviolet radiation (UVR) and high skin cancer incidence rates [1-3]. The main aims of this thesis were to objectively investigate which sun-protection related criteria are included in north Queensland primary school policies and to estimate how well the behavioural aspects of sun-protection policies that can be observed inconspicuously are abided by at Townsville primary schools. An additional aim was to develop and evaluate a remote method of estimating shade-availability at schools since established methods of measuring shade are expensive and laborious [4, 5].

The research questions which led to the development of the five studies included in my thesis are presented and addressed below:

> Question 1 (study 1): How comprehensive are the sun-protection policies at north Queensland primary schools in the geographical regions of Townsville (latitude 19.3˚S, longitude 146.8˚E), Cairns (latitude 16.87˚S, longitude 145.75˚E) and The Atherton Tablelands (Atherton: latitude 17.26˚S, longitude 145.48˚E)?

The main finding of study 1 was that the majority of north Queensland primary school sun-protection policies were under-developed since they addressed only two of the 12 criteria included in a comprehensive policy. The total policy score attained by schools was not found to be significantly influenced by the school grouping variables considered, such as SunSmart status and geographical location.

The results of study 1 revealed that studies are needed to explore barriers to sun-protection policy development at north Queensland primary schools. To achieve this, it may be advantageous to use qualitative research methods such as interviews or focus groups. Previous studies have identified that school sun-protection policies are under-developed because school staff members have insufficient time to develop them, policies are a low priority and/or because inadequate funding and resources were available [6-9]. However, school staff members can be receptive to developing comprehensive sun-protection policies [9]. It would be useful to investigate the SunSmart school (SSS) review process to determine why the sun-protection policies at SSSs were not more comprehensive.

> Question 2 (study 2): What body surface area (BSA) is covered by regulation school uniforms at primary schools in Townsville, Cairns and the Atherton Tablelands?

The results of study 2 showed that the BSA covered by most school uniforms was found to be approximately 62% from a possible 93.4%. The BSA covered by school uniforms was found to be significantly influenced by school properties, such as school ownership, SunSmart status and sun-protection policy total score. However the differences in terms of BSA coverage were small and might not translate to a real reduction of skin cancer risk later in life.

Uniform modifications, such as an increased shirt sleeve length to the elbows and an increased pant hem length to below the knees could increase the BSA covered by most school uniforms assessed by about 9%. We did not investigate the type of materials used to construct school uniforms however it would be advantageous to do so. School uniforms could be sun-protective garments if they were constructed with materials rated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to have an ultraviolet protection factor (UPF) of 50+ and covered more skin [10, 11]. Qualitative studies that use interviews and focus groups may be useful to determine how willing school communities were to modify their uniforms this way, and to investigate how willing parents were to purchase a sun-safe uniform if it were provided as an alternative to the current uniform.

> Question 3 (study 3): Can a method to remotely measure shade availability at schools be developed?

The results of study 3 showed that there was poor agreement between the data calculated using the remote shade-estimation methodology we developed and the data calculated using the thorough WebShade® shade-audit methodology. Agreement between these methods did not improve when schools were grouped according to school features we anticipated might influence the adequacy of the remote methodology. Additional studies are needed to determine if a methodology to remotely measure shade availability at schools can be developed which calculates accurate shade-related data. The measurement errors identified during study 3, which are further discussed in Chapter 5, may prove useful when developing an alternative remote shade-estimation methodology.

We chose to use the remote shade-estimation method without consulting with schools to confirm school boundaries, building features (such as under-croft areas and balconies) etc. Our intention was to develop and test a shade-estimation methodology that could be conducted from any location by any trained individual, for any school, for any period of time without disrupting school routine or inconveniencing school staff. We had hoped that this methodology would be less laborious than the thorough WebShade® shade-audit approach yet result in the calculation of similar shade-related data. The remote shade-estimation method we tested could be modified, so that schools are consulted to obtain data which are critical to shade-estimation (for example, school boundary location, building height values etc), and re-tested. More studies are required to investigate the capabilities of a remote shade-estimation approach that uses WebShade® and/or alternative shade-estimation software.

> Question 4 (study 4): What proportions of Townsville primary school students, and their adult-role models, wear a hat to school in the morning (as they enter school property, immediately prior to school commencement time), during school hours (during recess periods) and at school dismissal time (as individuals exit the school property)?

The results of study 4 revealed that less than a quarter of Townsville primary school students wore hats (any style, including cap styles) before (22.5%) and after (23.4%) school hours while most students wore a hat during (92.9%) school hours. Few adults wore hats before (6.1%) and after (19.3%) school hours, although most adults (85.4%) wore their hat during school hours. School grouping variables, such as SunSmart status, school ownership and sun-protection policy total score, were not consistently associated with higher student or adult median hat-wearing proportions.

Most of the sun-protection policies assessed in study 1 included a ‘no hat, no play’ rule and specified that gold-standard hat (GSH) styles be worn by students when outdoors.

However, the results of study 4 showed that most students at Townsville primary schools observed during the study failed to wear a hat before and after school hours, and that non-GSH styles were worn by students. The ‘no hat, no play’ rule may not be actively enforced at Townsville schools or school staff members may not be aware that students are not wearing hats when outside.

School sun-protection policies should stipulate that adults at school wear hats however few adults wore hats at Townsville schools before and after school hours. Additionally, school staff did not always role-model hat-use to students during recess breaks. Qualitative studies which include interviews or focus groups could be used to investigate barriers to hat-use, especially GSH styles, in Townsville. Non-GSH styles may have been worn because GSH styles were considered uncomfortable, unfashionable or unnecessary by students and adults alike. Research supports that students wear cap style hats because they consider them to be more fashionable than GSH styles [12, 13]. The time an individual expects to spend outdoors may predict the type of sun-protection they use [14]. Therefore, the parents observed in study 4 without hats on before and after school hours may have chosen not to wear hats because they did not think hats were necessary for the time they expected to be at school. Hats may have been under-utilised before and after school hours because students placed their hats in their bags/school lockers so they wouldn’t be forgotten or misplaced. Parents may not have worn hats before because they did not own a hat or because they did not want to wear a hat and mess up their appearance on their way to work. However, these are only speculations and respective studies are required to understand sun protective behaviours better. Previous studies have shown that the sun-protective behaviours of children may be positively influenced by the same behaviours of their parents and caregivers [15, 16]. Therefore it is especially important to investigate what parents consider to be barriers to hat-use so that more parents, and potentially more students, might wear hats at school.

> Question 5 (study 5): What proportions of Townsville primary school student spectators wear a hat at inter-school swimming carnivals, and wear a shirt at inter-school swimming carnivals?

The results of study 5 revealed that a median proportion of 30.7% of student spectators wore hats and a median proportion of 77.3% of student spectators wore shirts at Townsville inter-primary-school swimming carnivals. Neither proportion of students wearing a hat nor those wearing a shirt were found to be influenced by school SunSmart status, sun-protection policy total score or socio-educational advantage score. Students at non-government owned schools were significantly more likely to wear their hats than students at government owned schools (41.0% vs 18.2%, p=0.003), although a compliance rate of 41% is not remarkable.

We directly observed hat-use and shirt-use at inter-primary-school swimming carnivals that took place outdoors, during school hours, at locations with limited permanent shade structures. Therefore we expected schools to implement their sun-protection policies accordingly (for example, enforce hat-use and shirt-use) to reduce student UVR exposure. Also, since numerous schools attended these events simultaneously, we expected student spectators to be encouraged to represent their school by wearing their school uniform, including hats, correctly.

Hat-use at swimming carnivals may have been poor because students forgot to wear them or chose not to wear hats for comfort. Alternatively, staff members may have been preoccupied with organising swim races and events therefore could not regularly remind students to wear hats. Studies that investigate these potential barriers to hat-use at school swimming carnivals are required. The results of a recent study suggest that female school students may be less likely to wear hats than males but are more likely to stay in the shade [17]. Therefore it might be helpful if future studies included observations of student sun-protective behaviours at school swimming carnivals, grouped by gender. Students who attended inter-primary-school swimming carnivals might not have worn hats or shirts because they regularly participated in other sports during which sun-protection may be unpractical or even prohibited. For example, triathletes may be prohibited from applying sunscreen to certain body sites (for example, the thighs and upper arms) which need to be marked with permanent marker for identification purposes, surfers may be encouraged to wear minimal clothing, and soccer and hockey players might be prohibited from wearing hats during games [18]. If hats are discouraged or unpractical at other sports, students may habitually forget to wear hats at school sporting events as a result. However, further studies are required to investigate this speculation.

8.1 Summary of studies presented in thesis

The results of studies 1, 2, 4 and 5 revealed the sun-protection policies and procedures at north Queensland primary schools could improve. School uniform BSA coverage (study 2), student and adult hat-use at school (study 4) and hat-use and shirt-use at swimming carnivals (study 5) were not found to be consistently better at schools which achieved a total policy score (calculated during study 1) that was higher than the median score for all schools. School communities may need encouragement, guidance and appropriate resources to improve sun-protection policies. A school based sun-protection program which evaluates sun-protection polices and monitors sun-protective behaviours at regular, unannounced times with direct observations (as described in studies 4 and 5) may be one way that schools could be encouraged to improve student compliance with sun-protection policies.

Data presented in this thesis, from studies 1, 2, 4 and 5, will be used to evaluate the effectiveness of a sun-protection intervention at north Queensland primary schools. Further attempts to develop a remote methodology to estimate shade availability at schools may benefit from consulting with schools and shade-estimation software developers. The availability of a valid methodology to measure shade in a cost-effective and simple way may be useful for schools, and similar organisations, and could be an important tool for future school-based sun-protection programs. The following section provides some suggestions for future studies to evaluate sun-protection policies and monitor sun-protective practices at primary schools.

8.2 Future directions

8.2.1 Study designs

The studies of my thesis did not include any individual data based on questionnaires or interviews completed by, or administered to, parents, students or school staff because we wanted to reduce the potential influence of information bias (for example, recall bias) and selection bias (for example, volunteer bias). Data collected during studies 1, 2, 4 and 5 were intended to serve as a baseline from which changes in sun-protection policies and procedures over time could be evaluated. Therefore we chose to independently assess the sun-protection policies and uniform guidelines of north Queensland primary schools because we believed this would provide the best estimate of policy inclusions and uniform guidelines. We chose to directly observe hat-use at Townsville primary schools and hat-use and shirt-use at inter-primary-school swimming carnivals since we believed this would allow us to better estimate typical hat-use and shirt-use. Limitations of studies 4 and 5 were that we only observed hat-use or shirt-use at one point in time and we did not observe sunscreen use, for the reasons described in Chapter 2. Therefore we could not present data which described how well individuals used multiple methods of sun-protection.

Qualitative studies which include interviews and focus groups designed to investigate the barriers perceived by schools to developing comprehensive sun-protection policies and implementing these policies may be advantageous now that we have baseline data of sun-protection related policies and procedures. Longitudinal studies designed to periodically evaluate sun-protection policy comprehensiveness and regularly monitor policy implementation (with direct observations of sun-protective behaviours at schools) should be conducted to investigate if comprehensive policies translate to effective sun-protective procedures at schools. Future studies should consider the potential influence of school properties such as 'index of community socio-educational advantage' (ICSEA) score, school size, school ownership and SunSmart status, as described below.

8.2.2 School socio-educational advantage

It is possible that students at schools with high ICSEA scores come from educationally advantaged backgrounds which include well educated parents who are gainfully employed [19]. Therefore these students may have better access to school uniforms, than students at schools with lower ICSEA scores, because their parents can afford to purchase new and replacement uniforms as required [20, 21]. For example, children from schools with high ICSEA scores may have access to a uniform hat to wear at school and may also have a spare hat at school to use if required. These children may also have better access to swim shirts for use at inter-primary-school swimming carnivals. Well educated parents may encourage and remind their children to be sun-safe if they are aware of the dangers associated with excessive UVR exposure [20, 22]. Since it is possible that some students from educationally disadvantaged backgrounds attend schools with high ICSEA scores, a parental survey at a large sample of schools which includes many schools with high and low ICSEA scores may be useful to determine if parents educate their children about sun-safety at home and if they encourage their children to use sun-protection both at home and at school. Parent surveys could be used to investigate potential predictors of student sun-protective behaviours at school. However, these surveys would not necessarily be useful for determining school-related predictors of student sun-protective behaviours.

8.2.3 School size

Schools with large land areas may provide students with more opportunities to be ‘hidden’ from staff view. For example, at a large sized school, students may play outdoors during school recess breaks without hats on their heads because they know that they cannot be seen, and consequently reprimanded, by a school staff member who is responsible for supervising numerous students from a centralised location. Large sized schools may also have several locations through which students can enter and exit the school property therefore it may be impossible for school staff to be positioned at all entry/exit points to remind students to wear hats before and after school hours. The introduction of a sun-safety monitor may be especially advantageous at schools where staff cannot easily view all students at one time, or leave their position to reprimand students not wearing hats. Direct observation of hat-use at schools where a sun-safety monitor regularly reminds students and adults to wear hats, and at a control group of schools, would be useful to evaluate the potential usefulness of a monitor for this purpose. Also, direct observations of student and adult hat-use at schools with large land areas may serve to identify if students who are hidden from staff view are more likely not to wear hats than those students easily seen.

8.2.4 School ownership

Student and adult hat-wearing proportions were higher at non-government owned schools than government owned schools, although the differences failed to reach statistical significance for most comparisons. Additional studies in different geographical locations which include more schools (to increase statistical power) are required to investigate if school ownership influences hat-use at school. For example, it might be helpful to survey staff members at government and non-government owned schools to investigate how sun-protection policies are enforced at these schools, respectively.

Educationally advantaged parents may choose to send their children to private schools [23, 24]. Therefore it may be helpful to survey parents at public and private schools to investigate if parental knowledge of sun-protective behaviours influences their child's sun-protective behaviours at school. However, parental surveys may be more useful for investigating student predictors of sun-predictive behaviours than school-related predictors of the same behaviours.

8.2.5 SunSmart status

Schools voluntarily apply to be accredited by the Australian Cancer Council as a SSS, and SSSs are provided with sun-safety resources. However the sun-protection policies and sun-protective behaviours at SSSs and non-SSSs were usually statistically similar. Therefore the sun-safety resources provided to SSSs and the SSS review process should be investigated since the SSS program might not be as effective as it could be.

Qualitative study methods, such as focus group discussions and interviews, could be used to investigate the SSS sun-safety resources and how these resources are used by school communities. Regular audits of school compliance with SSS sun-protection policies may encourage schools to follow through with sun-protection policies. The Cancer Council may not have the resources to audit school compliance with SSS criteria. A collaborative approach between the Cancer Council and another organisation, research body, volunteer group etc. may enable such audits to be incorporated in the SSS program.

8.2.6 Sun-protection interventions

A school-based sun-protection program alone might not be sufficient to improve the sun-protective practices of Townsville primary school children. Schools may even be unwilling to participate in a sun-protection intervention if they feel that they are targeted for inadequately enforcing sun-protection at their school. Students might benefit from educational campaigns designed to encourage them to change their attitudes towards sun-protection. For example, appearance based sun-protection interventions may improve the sun-protective behaviours of adolescents and adults [25-

29]. One appearance-based intervention involved showing American adolescents photographs of their faces, on which UVR damage to skin tissue was highlighted, and explaining to them the importance of sun-protection [26]. It was explained that the UVR-related skin damage evident on the photographs would worsen if sun-protection was not used and that wrinkles and age-spots would likely result [26]. Sun-protective practices reportedly improved post-intervention and it was also suggested that participants would be more likely to encourage their friends and family to use sun-protection as a result of the intervention [26]. Studies which investigate the effectiveness of appearance-based sun-protection interventions in a primary school aged childhood population would be useful.

In Australia, graphic health warnings that remind cigarette smokers of the detrimental effects of smoking have been on cigarette packages since 2006 [30, 31]. These warnings serve to influence people's beliefs and attitudes towards smoking [30, 31]. The results of several Australian and international studies have revealed that graphic health warnings on cigarette packages, instead of text only warnings such as 'smoking may cause harm', may encourage individuals to cease smoking since they are exposed to the images every time they retrieve a cigarette and consequently are motivated to change their behaviour [30, 32-35]. An American study of high risk smokers found that very graphic warnings, for example images of gangrenous feet, are more likely to motivate individuals to cease smoking, than less graphic images, for example an image of a happy male who had quit smoking [36]. However, graphic health warnings may not be understood by young children and therefore might not achieve the desired effect [37].

Additional studies which investigate the effectiveness of graphic health warnings and appearance-based interventions among young child populations would be useful. However, the effects of such interventions would likely be at the individual level, rather than the school level. If appearance-based interventions or graphic health warnings were introduced to primary school children at schools participating in a school-based sun-protection intervention, the potential effects of these separate interventions could be confused.

Additional studies which investigate the effectiveness of ultraviolet index (UVI) displays at outdoor sport events for motivating individual sun-protective behaviors would be useful. It might also be helpful to investigate if students, particularly young primary school aged students, and staff understood the relationship between the UVI and the requirement for sun-protection (that is, sun-protection is recommended when the UVI is three or greater [38]). For example, UVI displays might not motivate young students to use sun-protection if they do not understand what the UVI is, or how it is related to skin damage. On the other hand, school staff might be encouraged to remind students to use sun-protection at outdoor sport events if a real-time UVI display serves to regularly remind them of the dangers associated with high UVR. Studies are required to investigate these speculations.

The following recommendations are intended to be used to improve the sun-protection policies and practices at primary schools.

8.3 Recommendations

- Investigate the SunSmart school application and renewal process since the SunSmart program might not be having the desired effect.
- Investigate the appropriateness of the sun-safety resources provided to primary schools.
- Use qualitative research methods, for example focus groups, to investigate why sun-protection policies were under-developed.
- Work with school communities to develop their sun-protection policies, possibly by ensuring they have access to suitable sun-safety resources and incentives (for example, a reward scheme) to develop and implement thorough policies.
- Encourage school communities to use their updated (comprehensive) sun-protection policies when planning outdoor activities at school (for example, outdoor physical activity classes) and at school related events (for example, swimming carnivals).
- Consult with clothing manufacturers and school communities to design a sun-protective school uniform (for example, garments constructed with very high ultraviolet protection factor rated materials which include longer sleeve and pant hem lengths).

- Encourage primary schools to include sunglasses as part of their uniform. Durable, UVR protective sunglasses suitable for use at schools are available from the Australian Cancer Council and others [39-41].
- Investigate the practicalities of introducing a sun-protective school uniform, including sunglasses, at north Queensland primary schools. This might involve using qualitative research methods, such as focus group discussions, to investigate if school communities would be willing to introduce a sun-safe uniform and if parents would be willing to purchase a sun-safe uniform.
- Continue to observe and report the sun-protective behaviours of Townsville primary school students and their adult role-models at schools and at school sport events.
- Observe and report the sun-protective behaviours of students and their adult role-models in other locations, including regions other than north Queensland.
- Introduce and evaluate a school-based sun-protection program at Townsville primary schools that includes regular unannounced observations of sun-protective behaviours and rewards school communities who demonstrate a commitment to sun-safety.
- Design an improved remote method for measuring shade at schools based on the data and knowledge accumulated during this thesis.
- Evaluate the agreement of the improved shade-estimation method against established methods of measuring shade.
- Use qualitative study methods, such as focus groups, to investigate the potential role of graphic health messages and appearance-based campaigns for improving the attitudes of children and their adult role-models at school toward sun-protection.
- Use qualitative study methods, such as focus groups, to investigate the potential role of UVI displays at outdoors sport events.

8.4 List of references

1. Buettner, P.G. and B.A. Raasch, *Erratum in: Buettner PG, Raash BA. Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 2001. **93**(2): p. 302-303.

2. Buettner, P.G. and B.A. Raasch, *Incidence rates of skin cancer in Townsville, Australia.* Int J Cancer, 1998. **78**(5): p. 587-593.
3. Buettner, P.G. and R. MacLennan, *Geographical variation of incidence of cutaneous melanoma in Queensland.* Aust J Rural Health, 2008. **16**(5): p. 269-277.
4. Milne, E., et al., *Direct measurement of sun protection in primary schools.* Prev Med, 1999. **29**: p. 45-52.
5. Schofield, M.J., et al., *Solar protection issues for schools: policy, practice and recommendations.* Aust J Public Health, 1991. **15**: p. 135-141.
6. Reeder, A.I., J.A. Jopson, and A. Gray, *Primary school sun protection policies and practices 4 years after baseline - a follow up study.* Health Educ Res, 2012. **27**(5): p. 844-856.
7. Horsley, L., A. Charlton, and C. Wiggett, *Current action for skin cancer risk reduction in English schools: a report on a survey carried out for the Department of Health.* Health Educ Res, 2000. **15**(3): p. 249-259.
8. Buller, D.B., et al., *Sun protection policies and environmental features in US elementary schools.* Arch Dermatol, 2002. **138**: p. 771-774.
9. Geller, A.C., et al., *Multiple levels of influence in the adoption of sun protection policies in elementary schools in Massachusetts.* Arch Dermatol, 2008. **144**(4): p. 491-496.
10. Australian Radiation Protection and Nuclear Safety Agency. *UPF trademark information*. 2015 04/07/2016]; Available from: http://www.arpansa.gov.au/uv/UPFTrademark.cfm.
11. Gies, P. and T. Slevin. *Revision of the sun protection clothing standard AS/NZS 4399*. in *3rd International UV and skin cancer prevention conference*. 2015. Melbourne, Australia.
12. Dixon, H., R. Borland, and D. Hill, *Sun protection and sunburn in primary school children: the influence of age, gender, and colouring.* Prev Med, 1999. **28**: p. 119-130.
13. Lowe, J.B., et al., *Sun-safe behaviour among secondary school students in Australia.* Health Educ Res, 2000. **15**(3): p. 271-281.
14. Dixon, H.G., et al., *Use of sun-protective clothing at outdoor leisure settings from 1992 to 2002: Serial cross-sectional observation survey.* Cancer Epidemiol Biomarkers Prev, 2008. **17**(2): p. 428-434.

15. Lowe, J.B., et al., *Behavior of caregivers to protect their infants from exposure to the sun in Queensland, Australia.* Health Educ Res, 2001. **17**(4): p. 405-414.
16. Dobbinson, S., et al., *Children's sun exposure and sun protection: prevalence in Australia and related parental factors.* J Am Acad Dermatol, 2012. **66**(6): p. 938-947.
17. Pettigrew, S., et al., *Predictors of sun protection behaviours and sunburn among Australian adolescents.* BMC Public Health, 2016. **16**(1).
18. Jinna, S. and B.B. Adams, *Ultraviolet radiation and the athlete: risk, sun safety, and barriers to implementation of protective strategies.* Sports Med, 2013. **43**(7): p. 531-537.
19. Australian Curriculum Assessment and Reporting Authority, *My School. Guide to understanding ICSEA*, Australian Curriculum Assessment and Reporting Authority, Editor. 2012, ACARA Sydney, Australia.
20. Klostermann, S., G. Bolte, and GME Study Group, *Determinants of inadequate parental sun protection behaviour in their children - Results of a cross-sectional study in Germany.* International Journal of Hygiene and Environmental Health, 2014. **217**: p. 363-369.
21. Kenway, J., *Challenging inequality in Australian schools: Gonski and beyond.* Discourse: Studies in the Cultural Politics of Education, 2013. **34**(2): p. 286-308.
22. Garbutcheon-Singh, K., et al., *Assessment of attitudes towards sun-protective behaviour in Australians: A cross-sectional study.* Australas J Dermatol, 2015. **57**(2): p. 102-107.
23. Yaacob, N.A., M.M. Osman, and S. Bachok, *Factors influencing parents' decision in choosing private schools.* Procedia - Social and Behavioral Sciences, 2014. **155**: p. 242-253.
24. Goldring, E.B. and J.R. Phillips, *Parent preferences and parent choices: the public-private decision about school choice.* J Educ Policy, 2008. **23**: p. 209-230.
25. Mahler, H.I.M., et al., *Long-term effects of appearance-based interventions on sun protection behaviors.* Health Psychol, 2007. **26**: p. 350-360.
26. Mahler, H.I.M., et al., *Social norms information enhances the efficacy of an appearance-based sun protection intervention.* Soc Sci Med, 2008. **67**: p. 321-329.

27. Williams, A.L., et al., *Appearance-based interventions to reduce ultraviolet exposure and/or increase sun protection intentions and behaviours: A systematic review and meta-analyses.* Br J Health Psychol, 2013. **18**: p. 182-217.
28. Morris, K.L., et al., *Improving the efficacy of appearance-based sun exposure interventions with the terror management health model.* Psychol Health, 2014. **11**: p. 1245-1264.
29. Williams, A.L., et al., *Men's experiences of an appearance-focussed facial-ageing sun protection intervention: a qualitative study.* Body Image, 2013. **10**(2): p. 263-266.
30. Miller, C.L., et al., *The impact of Australia's new graphic cigarette packet warnings on smokers' beliefs and attitudes.* Australasian Marketing Journal, 2011. **19**: p. 181-188.
31. Australian Government Department of Health. *Health warnings*. 2016 24/10/2016]; Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/tobacco-warn.
32. O'Hegarty, M., et al., *Reactions of young adult smokers to warning labels on cigarette packages.* Am J Prev Med, 2006. **30**(6): p. 467-476.
33. Zhao, X., et al., *Cigarette warning labels: graphics, framing and identity.* Health Education, 2014. **114**(2): p. 101-117.
34. Borland, R., et al., *How reactions to cigarette packet health warnings influence quitting: findings from the ITC four-coutry survey.* Addiction, 2009. **104**(4): p. 669-675.
35. Nan, X., et al., *Effectiveness of cigarette warning labels: examining the impact of graphics, message framing, and temporal framing.* Health Commun, 2015. **30**: p. 81-89.
36. Mead, E.L., et al., *The influence of graphic warning labels on efficacy beliefs and risk perceptions: a qualitative study with low-income, urban smokers.* Tob Induc Dis, 2016. **14**: p. online.
37. Borzekowski, D.L. and J.E. Cohen, *Young children's perceptions of health warning labels on cigarette packages: a study in six countries.* Z Gesundh Wiss, 2014. **22**(2): p. 175-185.
38. Bureau of Meteorology. *About UV and sun protection times*. 2016 6/11/2016]; Available from: http://www.bom.gov.au/uv/.

39. Cancer Council. *School sunglasses*. 2016 14/10/2016]; Available from: https://www.cancercouncilshop.org.au/shop_sunglasses/summer05_sunglasses_children1/pg2110.
40. Idol Eyes Australia. *School sunglasses*. 2016 14/10/2010]; Available from: http://home.exetel.com.au/idoleyes/school%20sunglasses.htm.
41. School shades. *Protective eyewear*. 2016 14/10/2016]; Available from: http://www.schoolshades.com.au/.

Appendix 1. Ethics approval documentation.

The following ethical approval letters and associated documentation are provided:

- James Cook University, approval number 3365
- Education Queensland, reference number 11/54273
- Catholic Education, Diocese of Townsville, dated 9 June 2011
- James Cook University, approval number H5279
- James Cook University, information sheet
- James Cook University, informed consent form
- Cancer Council, letter of support

This administrative form
has been removed

This administrative form has been removed

This administrative form has been removed

This administrative form
has been removed

INFORMATION SHEET
Sun protection pilot intervention program for North Queensland (NQ) & Far North Queensland (FNQ) primary schools.

In 2009, photographs and media coverage of the sun-protective practices of Queensland school children raised concerns about the potential decline in sun-safe behaviours in our schools (Hinde 2009: Welcome to the 'Sun Shame state'). As a positive response to these criticisms, a pilot program has been established and funded by the Queensland Government to encourage sun-safe behaviours and reward schools who are committed to improving sun-protection in line with the Q2 target of 'reducing unsafe sun exposure by one-third by 2020'.

Skin cancer is Australia's most common cancer and is caused by over-exposure to sunlight. Queensland children develop pigmented moles earlier and in higher numbers than children raised elsewhere, putting them at higher lifetime risk of melanoma. Our recent randomised controlled trial showed that a considerable number of moles can be prevented by regularly wearing sun-protective clothing and preventing over-exposure to sunlight. Therefore in this project we aim to work in partnership with you to help you ensure that students can be physically active at school without risking the long-term consequences of over-exposure to sunlight.

You are invited to participate in a program that monitors changes in shade infrastructure and sun-protection practices of Far North Queensland and North Queensland primary schools over time. The study is being conducted by Drs Simone Harrison and Madeleine Nowak, A/Prof Petra Buettner, Vincent Mantio and Denise Turner from the Skin Cancer Research Group at James Cook University Townsville in conjunction with the Cancer Council of Australia and Queensland Health. The study will commence in term 3 of 2011 and we are looking to make arrangements to **conduct this research in Townsville schools between Monday 1st August and 8th August 2011.**

Interested schools will be contacted by the researchers to arrange access to the school grounds to conduct an on-site assessment of the quantity and quality of existing built and natural shade. The researchers will make on-foot measurements of the school perimeter, and buildings, as well as recording the height, diameter and position of all trees above 1.5m high (approx 2-3 hours).The WebShade software program will be used to analyse the field data we collect. Participating schools will receive a shade assessment summary and recommendations specific to their school to facilitate better utilisation of existing shade infrastructure (i.e. without requiring additional capital expenditure). Participating schools will be contacted by the researchers one year later to determine whether they found the shade assessment information and recommendations useful and whether this resulted significant changes in (1) the utilisation of existing shade and/or (2) the school's ability to attract funding to provide additional shade infrastructure. The data collected at your school should also enable us to develop and validate a new method of evaluating the amount of shade available at primary schools without needing to make on-site measurements in the future. We will also collect sun-protection policy and school uniform information from your school handbook and/or website and compare the data by district. Constructive feedback will be provided for your consideration and all results will remain confidential.

Your participation will involve informing your school community about the study so that students, staff and caregivers are aware of our presence, but understand that they will not be approached by research staff. Your assistance will be sought to locate building plans that detail the dimensions of buildings/structures. The on-site measurements will be performed by blue card certified researchers and will be scheduled to take place at a mutually agreeable time to minimise disruption to staff and students.

There are no foreseeable risks associated with the study as it only involves supervised on-site measurements of the school area by appropriately trained blue card approved researchers. In addition to DET approval, this study has received ethics clearance from James Cook University's Human Research Ethics Committee. Participation in this study is completely voluntary and you can stop taking part in the study at any time without reprisal, penalty or loss of benefits. You have the right to voluntary participation and that refusal to participate will involve no penalty or loss of benefits or services, and will not affect academic achievement or relationship with the school.

The data and contact details of each school and observed individuals will be kept strictly confidential. All data collected will be de-identified and stored in a locked filing cabinet in accordance with the NHMRC/Universities Australia "Australian code for the Responsible Conduct of Research", 2007 and Queensland State Archives legislation (6.8.3.). The data from the study will be used in research publications and reports to Education Queensland so that any required amendments can be made to the current sun protection protocols. Publications will be made available in the academic literature which can be accessed by participants if desired. **Individual persons and schools will not be identified in any publications or reports arising from this research.**

Please keep a copy of this information sheet for your records and refer to it if you require further information or wish to withdraw participation. If you have any questions about the study, please contact Dr Simone Harrison or Vincent Mantio (details below).

Yours truly,

Principal Investigator:
Dr Simone Harrison
Principal Research Fellow
Director of the Skin Cancer Research Group
School of Public Health, Tropical Medicine and Rehabilitation Sciences
James Cook University

Vincent Mantio
Research Assistant
School of Public Health, Tropical Medicine and Rehabilitation Sciences
James Cook University

1. Hinde S. Welcome to the Sun Shame State. Sunday Mail (Qld), 18 October 2009;4-5. Available from: http://www.couriermail.com.au/news/queensland/ welcome-to-the-sun-shame-state/story-e6freoof-1225787859278. Accessed 24 Feb 2010.)

This administrative form
has been removed

This administrative form
has been removed

Appendix 2. Permission to include published materials in this thesis.

Approvals obtained from

- Preventive Medicine
- Health Education Research
- Photochemistry and Photobiology
- Frontiers in Public Health
- The annals of the ACTM

This administrative form
has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form has been removed

This administrative form has been removed

This administrative form has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form
has been removed

This administrative form has been removed

Appendix 3. Published abstracts.

- **Trapp, D.,** Harrison, S. L., Buettner, P. and Nowak, M. (2010). "An evaluation of the sun protective practices of Townsville primary school students." Annals of the ACTM 11 (2): 51-52.
- Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and Nowak, M. (2013). "An evaluation of sun protection policies in Queensland primary schools" Annals of the ACTM 14 (1): 26.
- Harrison, S., Nikles, J., **Turner, D**., Cohen, H., and Nowak, M. (2013). "An evaluation of body surface area covered by school uniforms in Queensland primary schools." Annals of the ACTM 14 (1): 26.
- **Turner, D**., Bates, N., and Harrison, S (2015). "Sun-protective behaviours of primary school students at swimming carnivals in Townsville." Annals of the ACTM 16 (2): 18.

An Evaluation of the Sun Protective Practices of Townsville Primary School Students

Denise Trapp[1], Simone Harrison[2], Madeleine Nowak[3], Petra Buettner[4]

[1]Skin Cancer Research Group, School of Public Health Tropical Medicine & Rehabilitation Sciences, James Cook University, Townsville, Queensland, Australia; [2]Skin Cancer Research Group, School of Public Health Tropical Medicine & Rehabilitation Sciences, James Cook University, Townsville, Queensland, Australia; [3]Skin Cancer Research Group, School of Public Health Tropical Medicine & Rehabilitation Sciences, James Cook University, Townsville, Queensland, Australia; [4]Skin Cancer Research Group, School of Public Health Tropical Medicine & Rehabilitation Sciences, James Cook University, Townsville, Queensland, Australia

Background: Skin cancer is the most commonly diagnosed cancer in Australia and North Queensland (NQ) has amongst the highest rates of this cancer in the world. Exposure to ultraviolet radiation (UVR) particularly that which results in sunburn, during one's childhood years is an important risk factor for skin cancer. Thus the use of personal sun-protective items, such as broad brimmed hats and high UV protection factor clothing when outside, present a

simple way for school children to reduce their risk of developing skin cancer later in life. **Methods:** In Townsville (a geographical region of high ambient UVR) students attending 28 primary schools (32.1% independent and 67.9% public) were observed for hat wearing behaviour as they entered and exited school grounds for school commencement and end times. Primary school students who attended inter-school swimming carnivals at public pools in 2010 were also observed. **Results:** The median proportion of hat wearing as students entered and exited school grounds was found to be 25.3% although only 18.4% of these were gold-standard hats such as broad-brimmed or legionnaire style. Independent schools were shown to have significantly better hat wearing proportions compared to public schools ($p<0.015$) whilst schools participating in the SunSmart schools program were not shown to have significantly greater hat wearing practices ($p<0.557$). Where paired data was available for a school at a swimming carnival and at school start and end times it was compared. The proportion of students who wore a hat during swimming carnivals was not found to be significantly greater than those who wore hats as they entered and exited school grounds (40.98 % Vs 30.48%; $p<0.080$). **Conclusions:** The results of our pilot study suggest that sun-protective practices in Townsville primary schools are not being adequately enforced. We suggest there is a need to better evaluate, promote and encourage sun-protective behaviour and policies in the school environment to improve sun-safe behaviours among school aged children and thus reduce their risk of developing skin cancer later in life.

An Evaluation of Body Surface Area Covered by School Uniforms in Queensland Primary Schools

Simone Harrison, Jane Nikles, Denise Turner, Hilla Cohen, and Madeleine Nowak

Skin Cancer Research Group, James Cook University, Townsville, Queensland

Background / Aims: To conduct a baseline assessment of body surface area coverage of school uniforms in primary schools in five Queensland regions. **Methods:** In 2012/2013, the surface area (SA) of the body covered by the most prominent regulation summer school uniform was assessed using body maps, allocating a percentage for each section of the body, excluding the head. **Results:** 482 uniforms (243 boys and 239 girls uniforms) from 244 primary schools (Mackay 40, Rockhampton 37, Mt Isa 21, Toowoomba 60 and Sunshine Coast 86) were assessed. 222 (91.0%) schools were metropolitan/urban and 22 (9.0%) were rural/remote. Ninety-nine (20.5%) private and 383 (79.1%) state school uniforms were assessed. The total SA ranged from 58.3% to 65%, with 91.5% covering a SA of 61.9%. The majority of dresses (81.8%) covered 50.9% of the body. Skorts, shorts, culottes, ruggers and skirts covered around 20%, shirts around 30%, and shoes/socks around 12%. The proportion of uniforms covering 62.4-65% of body SA was very low, and there were significant differences between locations: Toowoomba (12%), Rockhampton (9.6%); Mackay (6.2%), Sunshine Coast (3.5%) and Mt Isa (0%) (p=0.014), There were no significant differences in SA between boys and girls uniforms (p=0.273). 19.2% of private schools had a SA of 62.4-65%, compared to 3.4% of public schools. (p=0.000). **Conclusion:** The body surface area covered by summer school uniforms did not provide children with adequate protection from ultraviolet radiation and skin cancer risk. Further work with primary schools in Queensland is needed to improve sun protection afforded by school uniforms.

An Evaluation of Sun Protection Policies in Queensland Primary Schools

Jane Nikles, Simone Harrison, Denise Turner, Hilla Cohen, and Madeleine Nowak

Skin Cancer Research Group, James Cook University, Townsville. Queensland

Background / Aims: To conduct a baseline assessment of sun-protection policies in primary schools in seven Queensland regions. **Methods:** Sun protection policies were obtained from primary schools in Queenslands 7 largest population centres. They were evaluated according to criteria developed from The Cancer Councils guide to being SunSmart. Points were awarded for each criterion up to a maximum total score of 12. **Results:** In 2012/2013, sun protection policies were obtained from 533 primary schools (Brisbane 230, Sunshine Coast 84, Gold Coast 72, Toowoomba 51, Mackay 41, Rockhampton 36, Mt Isa 19). 512 (96.1%) schools were metropolitan/urban; 21 (4.0%) were rural/remote; 528 (99.1%) were co-educational; 485 (91%) were primary only; and 335 (62.9%) were public. Sun protection policy scores ranged from 0-12 (with 12 the highest score); median score was 2.0. 69.8% of policies scored 0, 1 or 2. SunSmart hats and clothing were mentioned in the majority (87.8% and 95.1%) but all 10 other elements suggested by The Cancer Council were mentioned in less than 23%. The worst performing element was the sun protection policy is used when planning all outdoor events at 4.3%. 26 of 35 policies that scored 11 or 12 (74.3%) were from public schools, 31 (88.6%) from primary only, 32 (91.4%) from co-educational, and 33 (94.2%) from urban schools. **Conclusion:** Generally, quality of sun protection policies was poor. Further work with Education Queensland and Queensland primary schools is needed to improve the quality of sun protection policies, and better protect school children from risk of skin cancer.

Sun-protective behaviours of primary school students at swimming carnivals in Townsville

Denise Turner, Nicole Bates and Simone Harrison

Skin Cancer Research Group, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville

Background/Aims: It is well known that ultraviolet radiation (UVR) is the primary environmental factor for the development of skin cancer. Queensland government primary school students are expected to wear swim-shirts when participating in water-activities but these are not compulsory when competing. Hat and shirt-wearing behaviours of primary school students in Townsville were observed at swimming carnivals. Method: Inter-school swimming carnivals held in March each year from 2009 to 2015 inclusive were observed. Of the 41 schools observed, 66% were Cancer Council Queensland-accredited SunSmart Schools (SSS). **Results:** Less than a third of all students observed wore a hat and only 77% wore a shirt while not competing. Students attending non-government schools were more than twice as likely to be seen wearing a hat compared to public students, although the proportions for both groups were low at 41% vs 18.2% respectively. The proportion of student spectators wearing a hat and shirt were similar, irrespective of their SunSmart status (hats: SSS 36.3% vs. non-SSS 23.6%; shirts: SSS 77.3% vs. non-SSS 76.2%). **Conclusion:** Student spectators at swimming carnivals need encouragement to wear a hat and shirt, particularly since UVR reflected off pool water presents an additional risk factor for over-exposure. SunSmart status was not associated with improved sun-protective behaviours. Voluntary use of swim-shirts may be a significant barrier to the uptake of sun-protection at swimming carnivals, where the risk of sunburn is high. A comprehensive, school community-based sun-protection intervention is being trialled in Townsville schools to improve declining sun-protection practices.

Appendix 4. Additional uniform-related data from study 2.

Notes:

School descriptive information is presented in Table 1 below (from chapter 4) for reference regarding the number of schools within each characteristic.

- BSA = body surface area
- SSS = SunSmart school

Table 1: School demographic characteristics for reference purposes

Characteristic		N (%)
Ownership	Public (government owned schools)	75 (65.8)
	Private (non-government owned schools)	39 (34.2)
SunSmart school	No	44 (38.6)
	Yes	70 (61.4)
School size	Small (0-399 students)	57 (50.0)
	Medium (400-799 students)	43 (37.7)
	Large (≥800 students)	14 (12.3)
ICSEA status	≤ mean (0-1000)	86 (75.4)
	> mean (1001+)	28 (24.6)
Locality	Urban	73 (64.0)
	Rural	37 (32.5)
	Remote	4 (3.5)
Sun-protection policy evaluation score	≤ median (0-2)	68 (60.7)
	> median (3+)	44 (39.3)
Region	Townsville (latitude 19.25°S, longitude 146.77°E)	44 (38.6)
	Cairns (latitude 16.87°S, longitude 145.75°E)	46 (40.4)
	The Atherton Tablelands (latitude 17.26°S, longitude 145.48°E)	24 (21.1)

Most schools were public schools (65.8%) and located in urban areas (64.0%) (Table 1).

Table 2. Mean (standard deviation) body surface area (BSA) covered by regulation school uniforms: stratified by school ownership within SunSmart school (SSS) status

		School ownership					
		Non-government			Government		
	BSA	non-SSS	SSS	P value	non-SSS	SSS	P value
MALE	Sum	63.1 (3.3)	63.6 (2.7)	0.571	62 (1)	62.1 (0.7)	0.485
	Upper body	31.1 (1.3)	30.9 (1)	0.292	30.6 (0)	30.6 (0)	
	Mid-section	21.5 (1.6)	21 (1.4)	0.069	20.4 (1)	20.5 (0.7)	0.485
	Lower body	10.5 (1.8)	11.7 (2.3)	0.568	11 (0)	11 (0)	
FEMALE	Sum	63.4 (3.8)	62.7 (1.4)	0.002	62.1 (1.2)	61.9 (1)	0.175
	Upper body	31.1 (1.3)	30.7 (0.5)	0.014	30.6 (0)	30.5 (0.6)	0.014
	Mid-section	21.8 (2)	21 (1.4)	0.004	20.5 (1.2)	20.5 (0.7)	0.097
	Lower body	10.5 (1.8)	11.1 (0.3)	0.012	11 (0)	11 (0)	

Male uniforms at non-government owned (privately funded schools) SSSs and non-SSSs covered similar proportions of the body as did these uniforms from government owned (publicly funded schools) SSS and non-SSS. Female uniforms at non-government owned non-SSSs covered more of the total body, upper body and mid-section compared to female uniforms at non-government SSSs. The BSA covered by female uniforms were similar at government owned non-SSSs and SSSs, except those form non-SSSs covered more of the torso (Table 2).

Table 3. Mean (standard deviation) body surface area (BSA) covered by regulation school uniforms: stratified by school 'Index of community socio-educational advantage' (ICSEA) score within SunSmart school (SSS) status

		ICSEA group					
		≤ average ICSEA score			> average ICSEA score		
	BSA	**non-SSS**	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
MALE	**Sum**	62.4 (1.7)	62.2 (1)	0.043	61.9 (3.3)	63.5 (2.9)	0.653
	Upper body	30.8 (0.8)	30.6 (0.3)	0.056	30.6 (0)	30.8 (1)	0.221
	Mid-section	20.7 (1.2)	20.6 (0.9)	0.168	21.3 (1.7)	20.8 (1.2)	0.141
	Lower body	11 (0)	11 (0)		10.1 (2.5)	11.9 (2.6)	0.948
FEMALE	**Sum**	62.5 (2)	62.1 (1)	0.014	62.7 (3.8)	62.5 (1.6)	0.024
	Upper body	30.8 (0.8)	30.6 (0.6)	0.169	30.7 (0.2)	30.5 (0.7)	0.455
	Mid-section	20.7 (1.4)	20.5 (0.8)	0.015	21.9 (2.1)	21 (1.4)	0.021
	Lower body	11 (0)	11 (0)		10.1 (2.5)	11.1 (0.3)	0.001

Male uniforms at non-SSSs with below average ICSEA scores covered more of the body compared to the same uniforms from SSSs with below average ICSEA scores. Female uniforms of non-SSSs with below average ICSEA scores covered more of the total body and mid-section compared to SSSs with below average ICSEA scores (and this was also true for the same comparison within schools with above average ICSEA scores) (Table 3).

Table 4. Mean (standard deviation) body surface area (BSA) covered by regulation school uniforms: stratified by school sun-protection policy score within SunSmart school (SSS) status

		Sun-protection policy score					
		≤ median policy score			> median policy score		
	BSA	non-SSS	SSS	P value	non-SSS	SSS	P value
MALE	Sum	62.2 (2)	62.3 (1.1)	0.191	62.8 (2.1)	63 (2.5)	0.545
	Upper body	30.7 (0.3)	30.6 (0)	0.032	31 (1.3)	30.8 (0.9)	0.366
	Mid-section	20.7 (1.4)	20.7 (1.1)	0.268	20.8 (1.2)	20.6 (1)	0.383
	Lower body	10.8 (1.1)	11 (0)	0.032	11 (0)	11.6 (2.1)	0.051
FEMALE	Sum	62.3 (2.1)	62.1 (1.1)	0.062	63.2 (2.8)	62.4 (1.4)	0.02
	Upper body	30.7 (0.3)	30.5 (0.5)	0.732	31 (1.3)	30.6 (0.7)	0.084
	Mid-section	20.8 (1.5)	20.6 (1)	0.046	21.3 (1.8)	20.7 (1.1)	0.023
	Lower body	10.8 (1.1)	11 (0)	0.032	11 (0)	11.1 (0.3)	0.216

Male uniforms at non-SSSs with below median sun-protection policy scores covered more of the torso than male uniforms at SSSs from the same group. Male uniforms at non-SSSs and SSSs with higher sun-protection policy scores were similar. Female uniforms at non-SSSs with poorly developed policies covered more of the mid-section compared to female uniforms at SSSs from the same group (Table 4).

Appendix 5.1. WebShade® fieldwork sheets

WebShade

Remote Fieldwork Guide – HSC

Oct 2010

1 Collecting information about the site

Shade structures

Shade structures include shade sails, pergolas, gazebos and all other structures that are not fully enclosed, such as verandahs, covered outdoor learning areas (COLA) and picnic shelters.

The amount of UVR blocked by the shading material and its condition are critical to shade effectiveness.

For each shade structure, note on Worksheet 1:

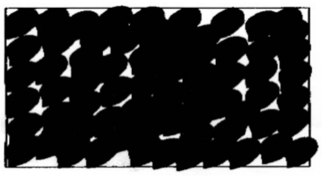
- whether the shade cover material has a rating of 94% UVR blockout or more (opaque materials such as timber, metal or tiles have 100% rating – the suppliers of other materials can provide the ratings)
- the condition of the shade material and the structure
- whether it is easily able to be climbed onto and any other potential safety hazards you observe.

Your report may include recommendations to repair, upgrade or replace some shade structures.

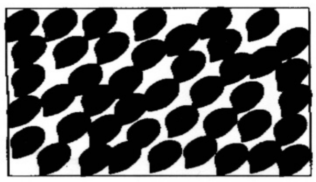
Trees

When recording shaded areas, only include trees that are more than 1.5m high - short shrubs don't generate much shade but can assist in reducing indirect UVR. For each tree, or group of similar trees, record on Worksheet 2:

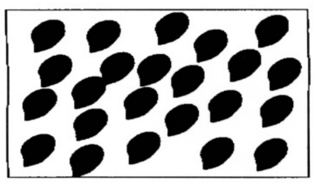
- density of the canopy - look up into the tree canopy or at the shade on the ground and match the density to one of the diagrams on the canopy density guide below. Only trees with a heavy canopy provide effective UV protection.
- evergreen or deciduous (deciduous trees drop their leaves in winter allowing for winter warmth and UV for Vitamin D)
- ☐ maturity of the tree - will it grow much larger?
- ☐ its condition - is it healthy?
- ☐ is the tree suitable - does it have thorns, drop berries or is it poisonous?
- ☐ are the areas under your trees accessible - would trimming low branches allow better use of shade?



Heavy
over 90%UVR block



Medium
approx 60%UVR block



Light
less than 30%UVR block

Shade use + usability

How easy is it to use the existing shade at the site?

It's important to consider whether shade is potentially useful but not accessible. For example:

- a building casts good shade, but it falls on an area filled with bicycle racks which can't be used
- good shade falls on the car park or other 'out-of-bounds' areas
- low tree branches prevent people from getting into the full shade.

Shaded areas that are currently un-usable are important as they may provide opportunities to reduce UV exposure without building new shade. Note them on and mark them on a site plan.

Are there well shade areas on the site that are not being used?

Note these areas and mark them on a site plan. Keep them in mind when observing activities - you may be able to move high risk activities to these protected areas.

• 2 How people use the site

Activities + shade

- Identify all activities that take place on the site from the beginning of September to the end of April. Include passive activities such as watching sport or sitting and talking. You may need to split activities so that they are more descriptive eg. 'basketball' may be better described as playing basketball and watching basketball.
-

Observe the way the site is actually used and for each activity, record on Worksheet 3:

- name of the activity, eg.sitting eating lunch, playing handball, playing on climbing structure
- typical number of people involved
- the start time and how long the activity takes
- whether there is enough shade for all the people undertaking the activity, disregarding shade created by materials with less than 94% UVR protection and trees with only medium or light canopies
- the ground surface in the area of the activity (eg bitumen, grass, paving, sand, soft-fall)

WebShade

School Name:

date	page

Worksheet 1: **Shade structures**

	Name / number of structure	**94% UV block?** (Yes/No)	**Condition**	**Accessibility**
Mark up a site plan with names or numbers (SS1, SS2 etc) of each shade structure. Include shade sails, pergolas, gazebos and all other structures that are not fully enclosed, such as verandahs, covered outdoor learning areas (COLA) and picnic shelters. Record notes about the condition of the structure and the shade material. Note whether the shade structure is easily able to be climbed onto.	*EXAMPLE SS1*	*Unknown*	*Shade fabric weathered - needs replacing, steel structure good.*	*Not easily accessed.*

WebShade

project

Worksheet 2: **Trees**

date

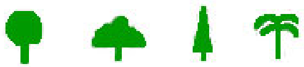
page

Mark up a site plan with numbers of each tree or group of trees.

Only include trees that are more than 1.5m high–short shrubs, don't generate much shade.

Remember to include any trees near your site that cast usable shade on your side of the boundary.

Type of tree

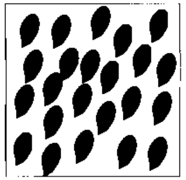


A B C D

Density

heavy

light



Notes

Number	**Tree type**	**Diameter** (m)	**Height** (m)	**Evergreen** or **Deciduous**	**Heavy** or **Light**	**Notes**
T1	*B*	*4.0*	*6.5*	*E*	*H*	*Lower branches need trimming*

• maturity of the tree - will it grow much larger? • its condition - is it healthy? • could you make better use of the shade by installing seating under the tree? • is the tree suitable - does it have thorns, drop berries or is it poisonous?							

WebShade

project

Worksheet 3: **Activities**

date

page

Identify all activities that take place in 1st December. Observe each activity and record details. **Remember:** • you will need to be on site at the times each of the activities takes place • disregard shade created by materials with less than 94% UVR protection and trees with only medium or light canopies when assessing whether there is enough shade for all users. Record the ground surface in the area of the activity (eg bitumen, lawn, paving, soft-fall) as this may effect the amount of reflected UVR. If possible, photograph (with consent) the activities for your report.	**Name**	**No. of users**	**Start time**	**How long**	**Enough shade for all users?**	**Ground surface(s)**	**Ideas/opportunities to reduce risk**

Appendix 5.2. Scatter plots and Bland-Altman plots used during study 3.

WebShade® shade-audit (SA).

WebShade® remote shade-estimation (RS).

Each scatterplot below includes a line of equality and a linear regression line of RS against SA data for visual reference. Pearson's correlation coefficient (r) and the associated 95% confidence interval (CI) were calculated to assess the strength of the association between RS and SA data. In the respective figures of these scatterplots, these lines are represented by black (line of equality) and red (regression line) colour. On each scatterplot, X-axis values corresponded to the SA shade proportion (%) values and Y-axis values corresponded to the RS shade proportion (%) values. In addition, Bland-Altman plots were created to assess agreement of the RS and SA values further (1, 2). The difference between the RS and SA data were plotted against the average values as Bland-Altman plots. Reference lines which correspond to the regression line of differences in values against the averages, the mean of differences value, lower and upper agreement limits (mean difference +/- 2 multiplied by the SD) and the zero difference line were added to visually assess the agreement between the RS and GS methods. In the respective figures of the Bland-Altman plots below, these reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line). In each Bland-Altman plot, X-axis values corresponded to the mean of differences values and the Y-axis corresponded to the difference between the SA and RS data values. Further, Pearson's correlation coefficient (r) was calculated to assess the strength of the association between differences and averages. If the data calculated using the RS method were similar to those calculated using the GS method, one would expect the differences of the values to be approximately distributed at random around the zero line, the agreement limits to be within a small range, and r to be close to zero and not statistically significant.

Schools grouped according to 'the proportion of built structures that were single-storey'

Schools at which ≤89% of built structures were single-storey

<u>Combined shade:</u>

Figure 1. Scatter plot: Schools at which ≤89% of built structures were single-storey – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

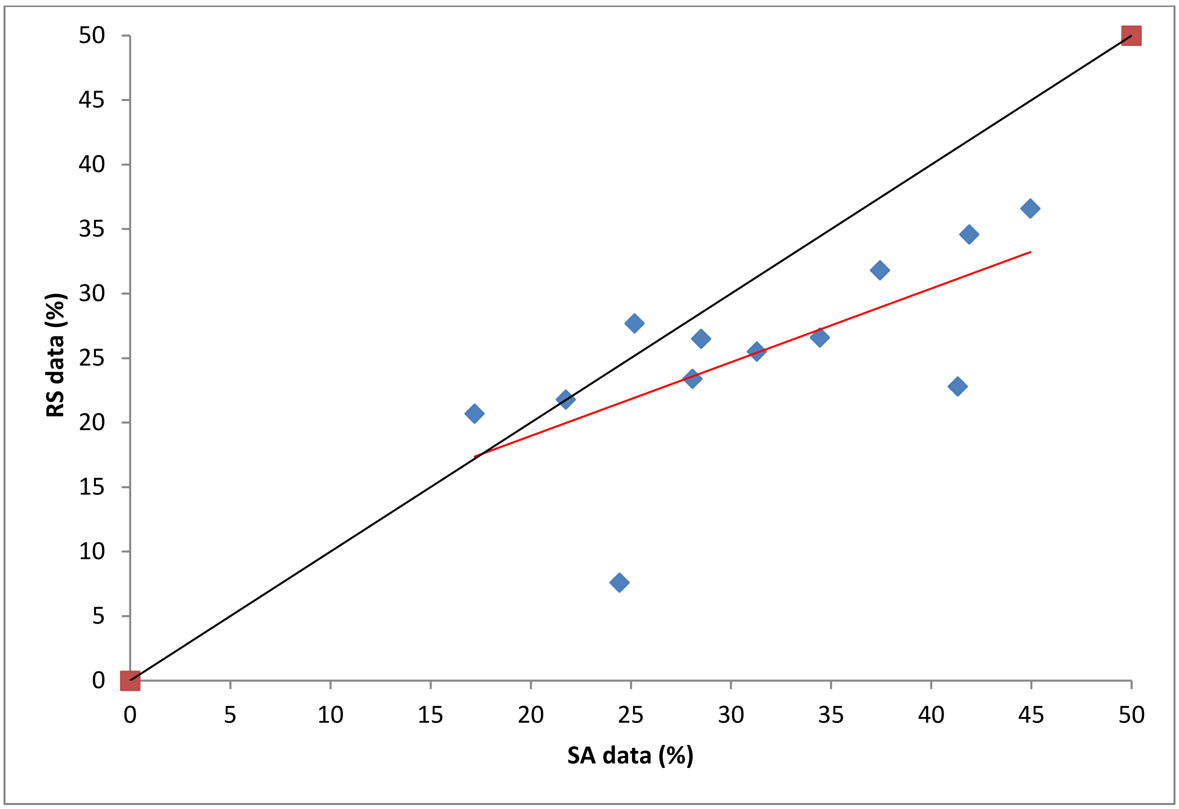


Figure 1 shows that the RS method under-estimated built shade availability for almost all of the schools compared to the SA method. For the RS data and the GS data, a significant correlation was found (r = 0.664, p=0.019).

Figure 2. Bland-Altman plot: Schools at which ≤89% of built structures were single-storey – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

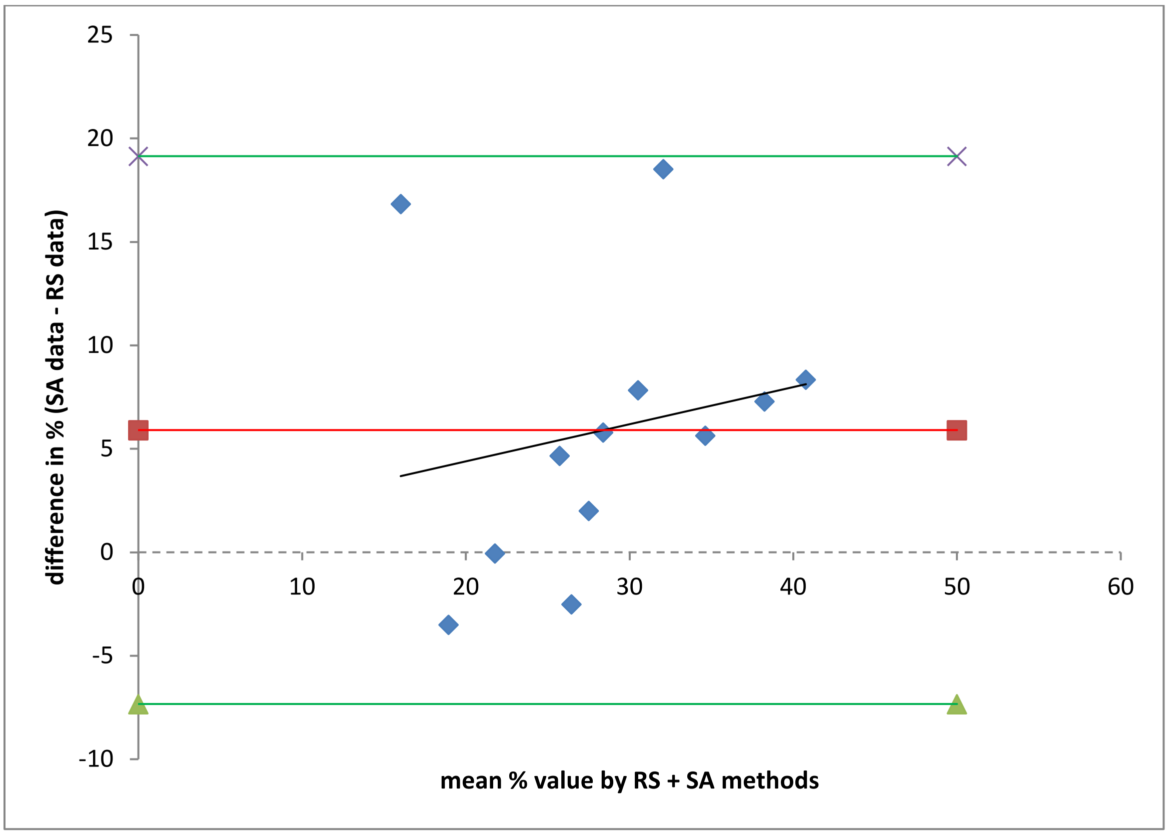


Figure 2 shows that the RS method under-estimated built shade at the schools by 5.91% (lower limit: -7.60%, upper limit: 19.41%) compared to the SA method. For the mean values and the difference values, negligible correlation was found (r= 0.197, p=0.539).

Natural shade:

Figure 3. Scatter plot: Schools at which ≤89% of built structures were single-storey – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

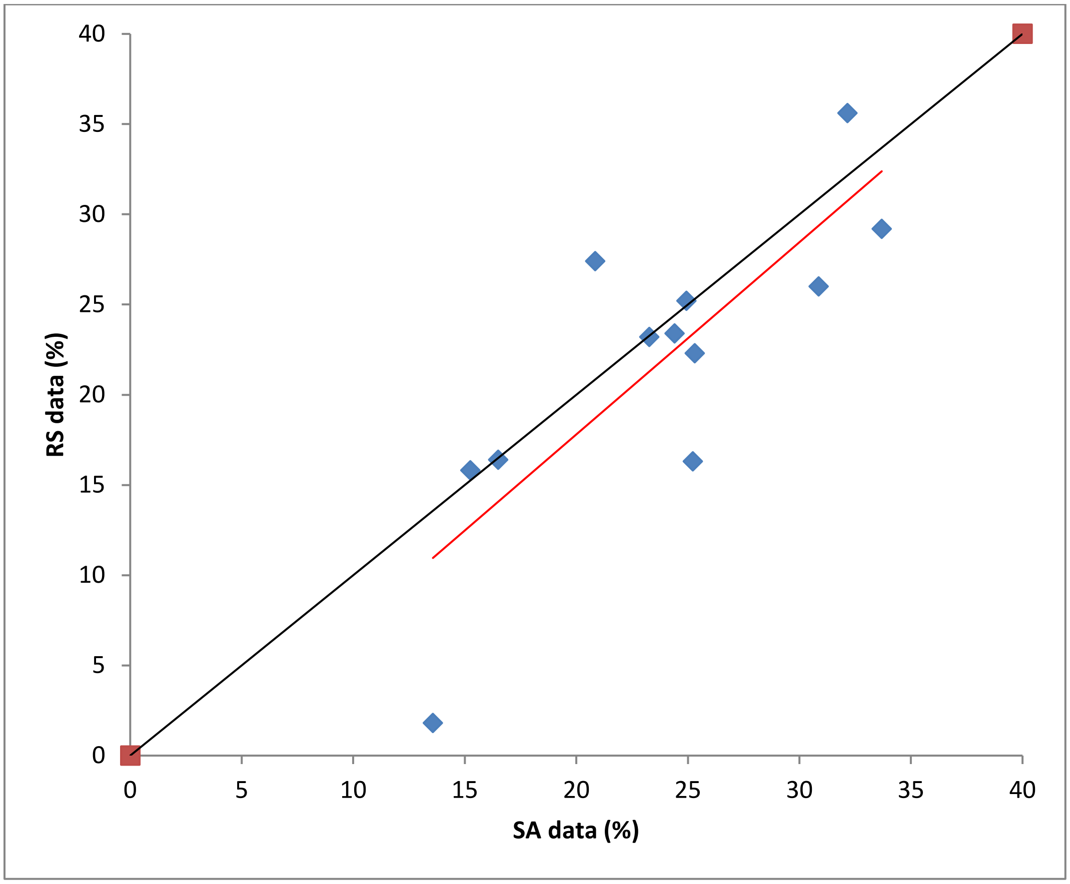


Figure 3 shows that the RS method under-estimated natural shade for most schools compared to the SA method. For the SA and the RS data, high correlation was found (r=0.808, p=0.001).

Figure 4. Bland-Altman plot: Schools at which ≤89% of built structures were single-storey – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

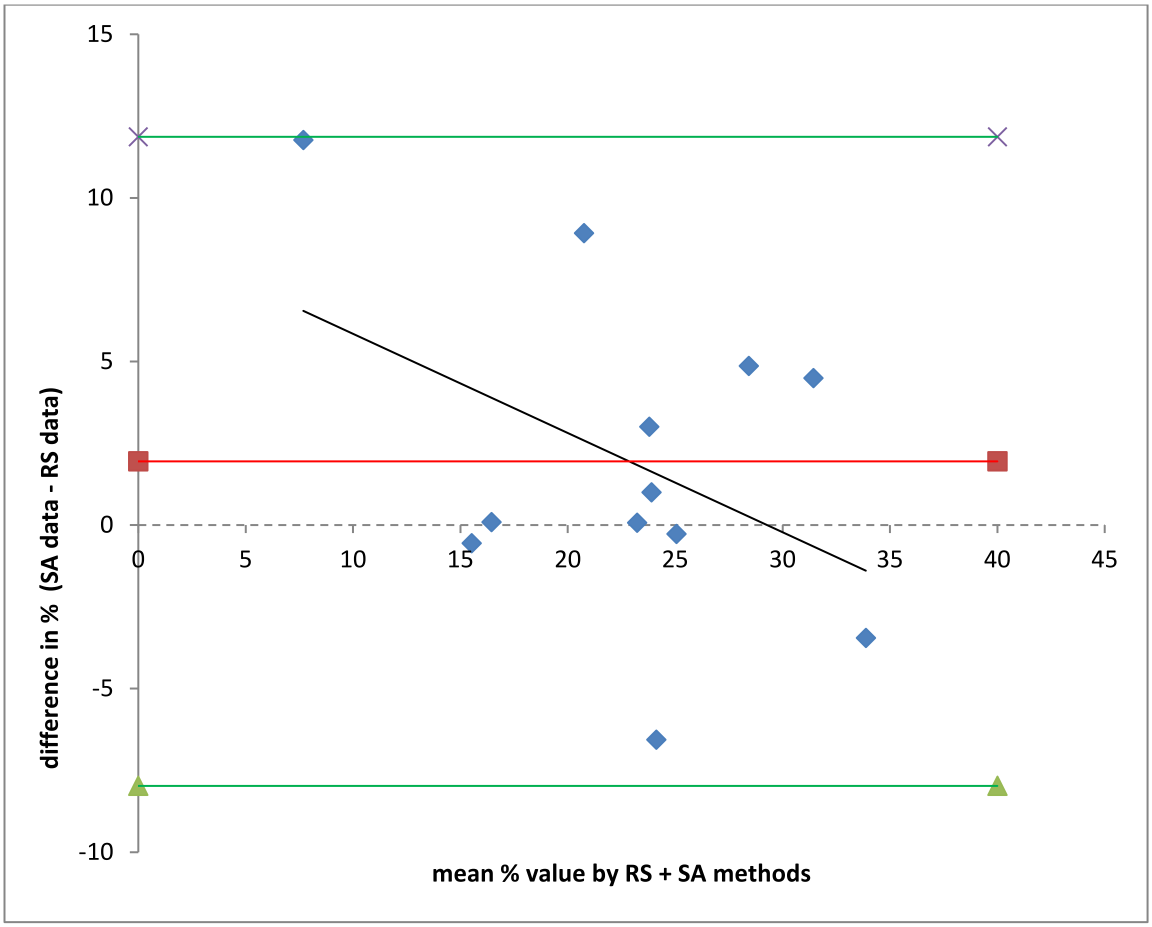


Figure 4 shows that the RS method under-estimated natural shade by 1.95% (lower limit: -8.18%, upper limit: 12.07%) compared to the SA method. For the mean values and the difference values, a non-significant correlation was found (r=0.429, p=0.164).

Built shade:

Figure 5. Scatter plot: Schools at which ≤89% of built structures were single-storey – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

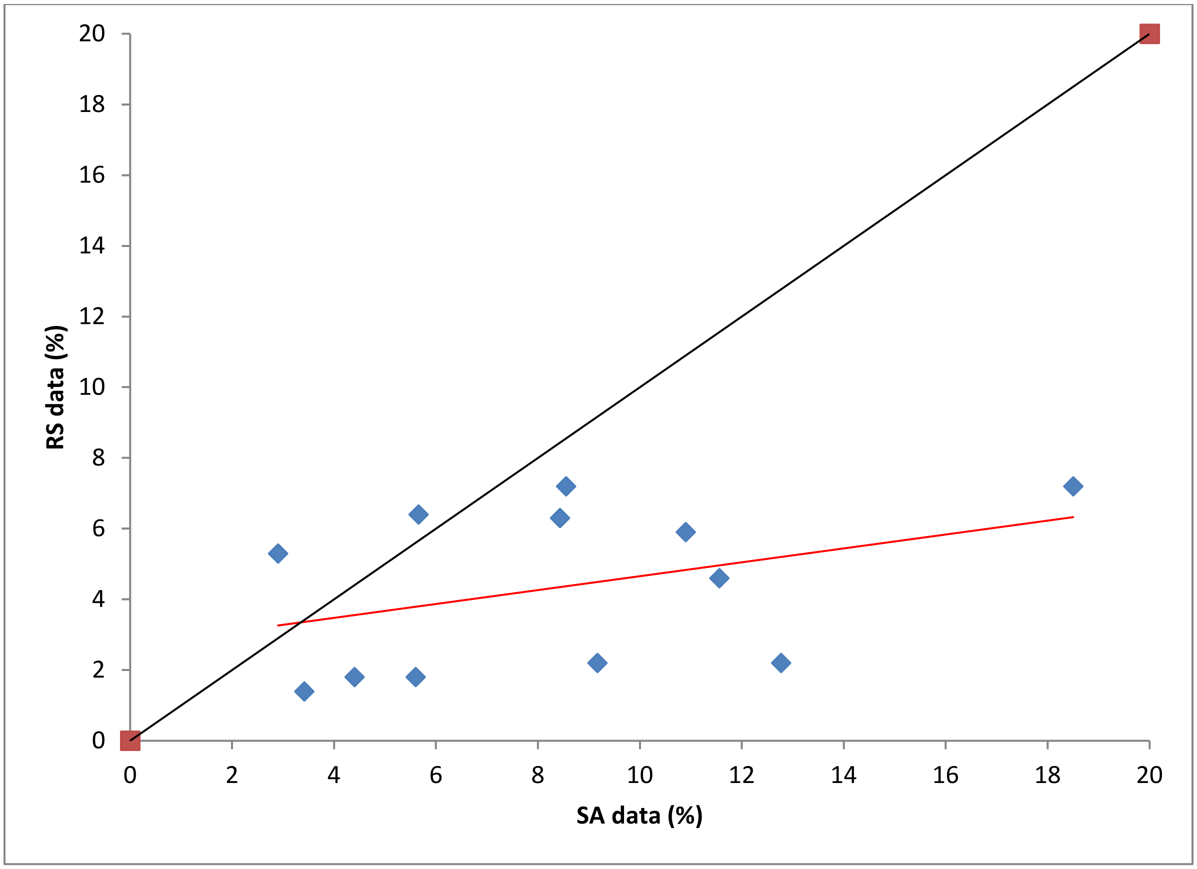


Figure 5 shows that the RS method under-estimated built shade at most schools compared to the SA method. For SA and RS data, low correlation was found (r=0.384, p=0.217).

Figure 6. Bland-Altman plot: Schools at which ≤89% of built structures were single-storey – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

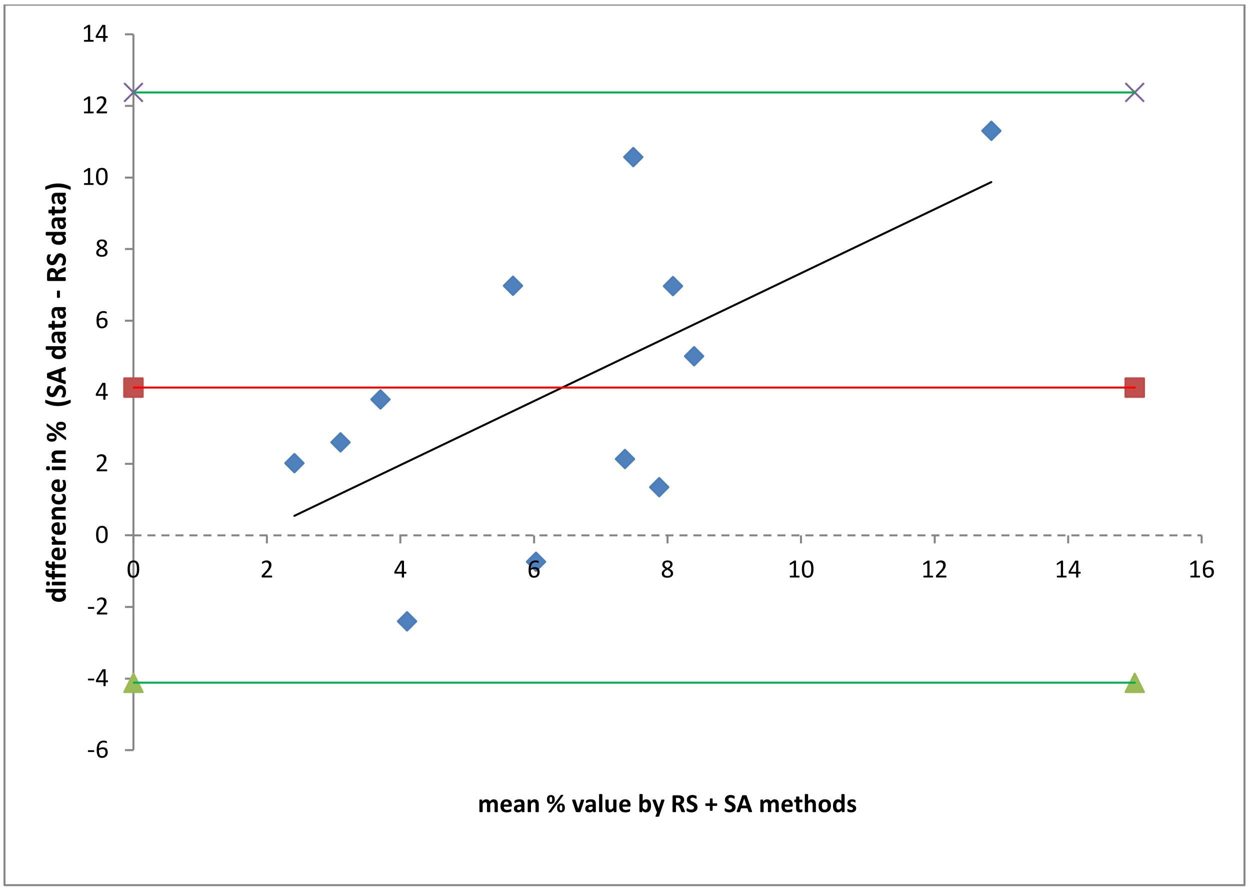


Figure 6 shows that the RS method under-estimated built shade data by 4.13% (lower limit: -4.28%, upper limit: 12.54%) compared to the SA method. For the mean values and the difference values, a significant positive correlation was found (r=0.617, p=0.033).

Schools at which ≥90% of built structures were single-storey

<u>Combined shade:</u>

Figure 7. Scatter plot: Schools at which ≥90% of built structures were single-storey – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

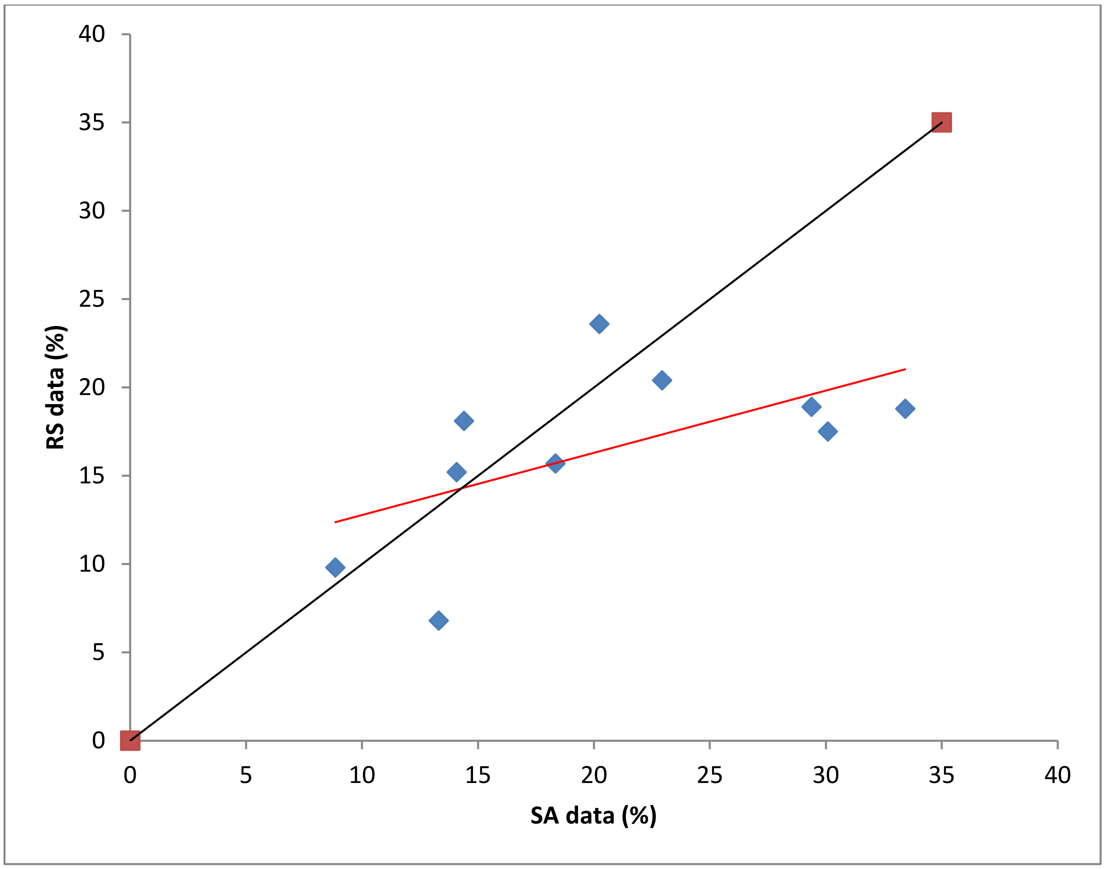


Figure 7 shows that the RS method under-estimated combined shade data at most schools compared to the SA method. For the RS and the SA data, a non-significant positive correlation was found ($r=0.587$, $p=0.075$).

Figure 8. Bland-Altman plot: Schools at which ≥90% of built structures were single-storey – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

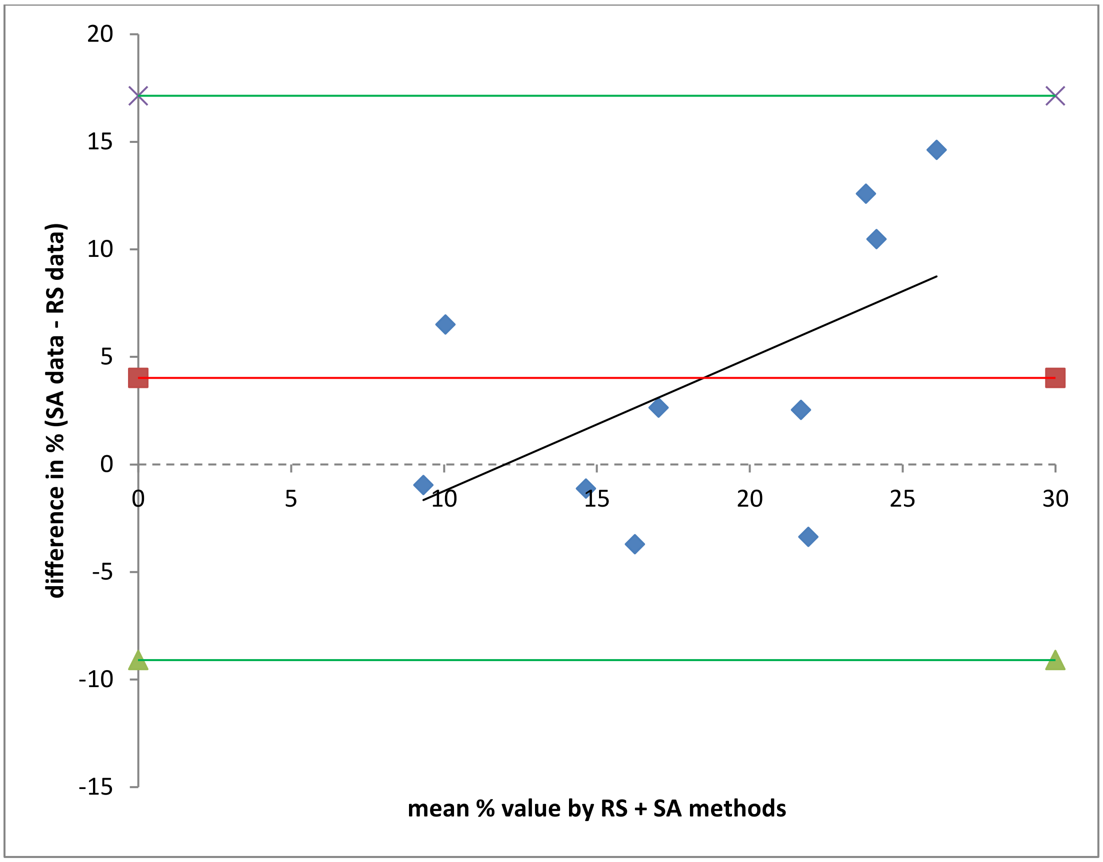


Figure 8 shows that the RS method under-estimated combined shade by 4.02% (lower limit: -9.36%, upper limit: 17.40%) compared to the SA method. For the mean values and the difference values, a non-significant correlation was found (r=0.549, p=0.100)

Natural shade:

Figure 9. Scatter plot: Schools at which ≥90% of built structures were single-storey – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

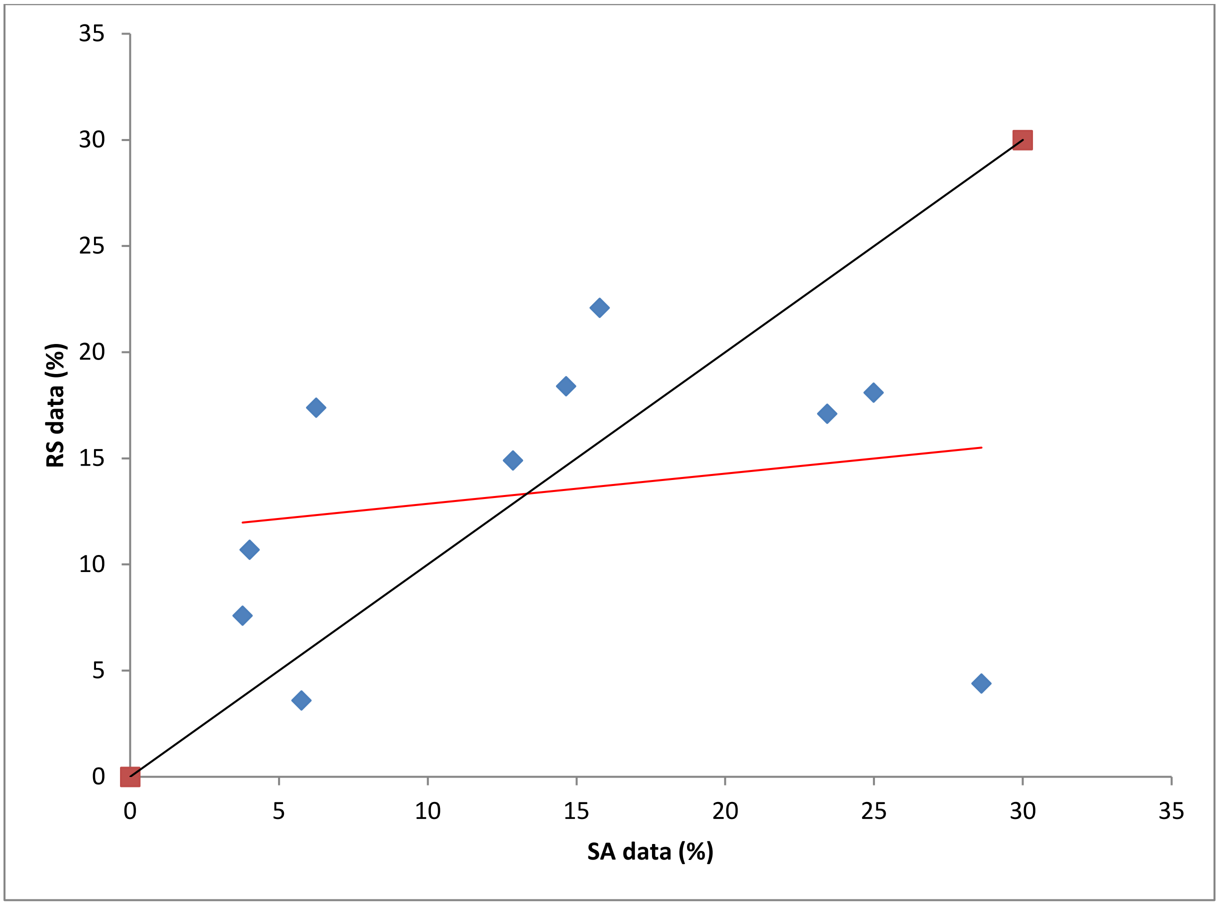


Figure 9 shows that the RS method over-estimated natural shade at most schools compared to the SA method. For RS and SA data, negligible correlation was found (r=0.203, p=0.574).

Figure 10. Bland-Altman plot: Schools at which ≥90% of built structures were single-storey – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

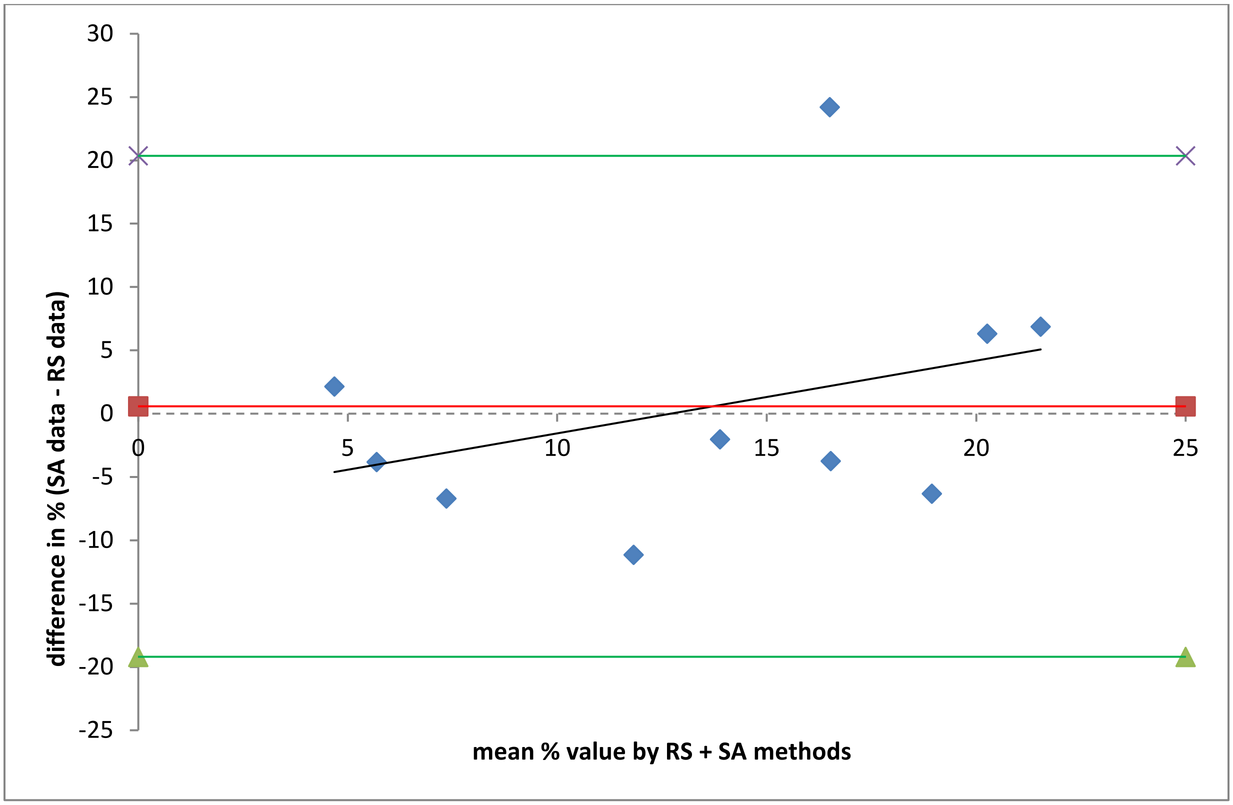


Figure 10 shows the RS method under-estimated natural shade by 0.58% (lower limit: -19.60%, upper limit: 20.76%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.348, p=0.324).

Built shade:

Figure 11. Scatter plot: Schools at which ≥90% of built structures were single-storey – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

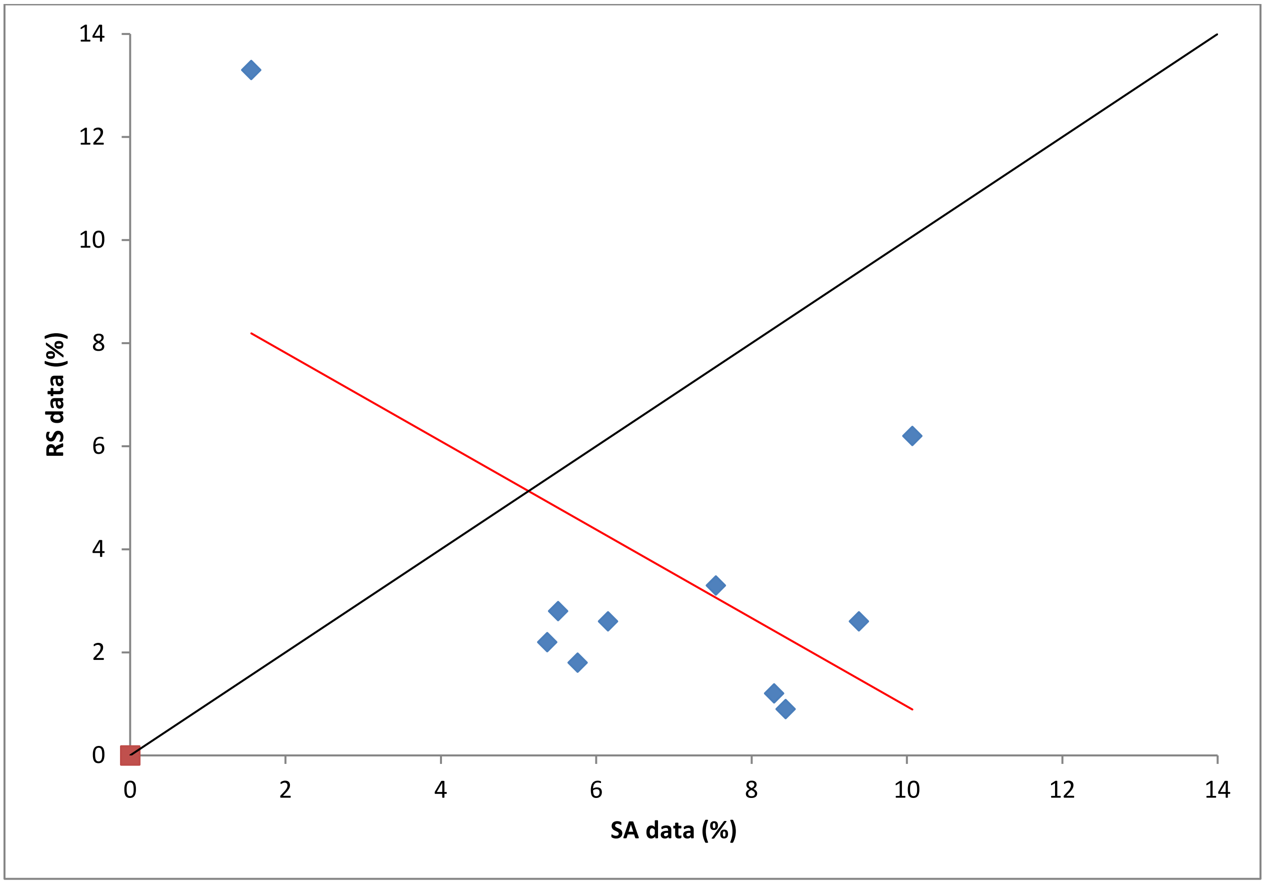


Figure 11 shows that the RS method under-estimated built shade at all schools, except for one, compared to the SA method. For SA and RS data, a non-significant correlation was found (r=0.579, p=0.079).

Figure 12. Bland-Altman plot: Schools at which ≥90% of built structures were single-storey – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

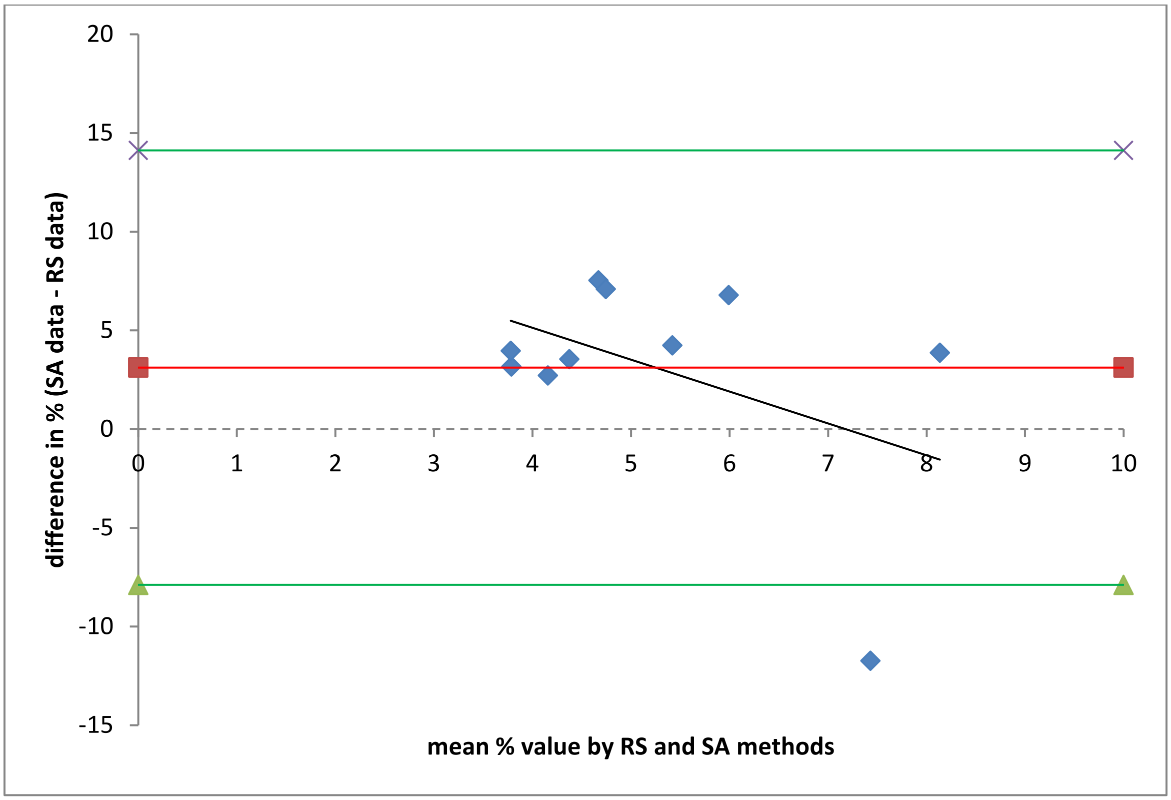


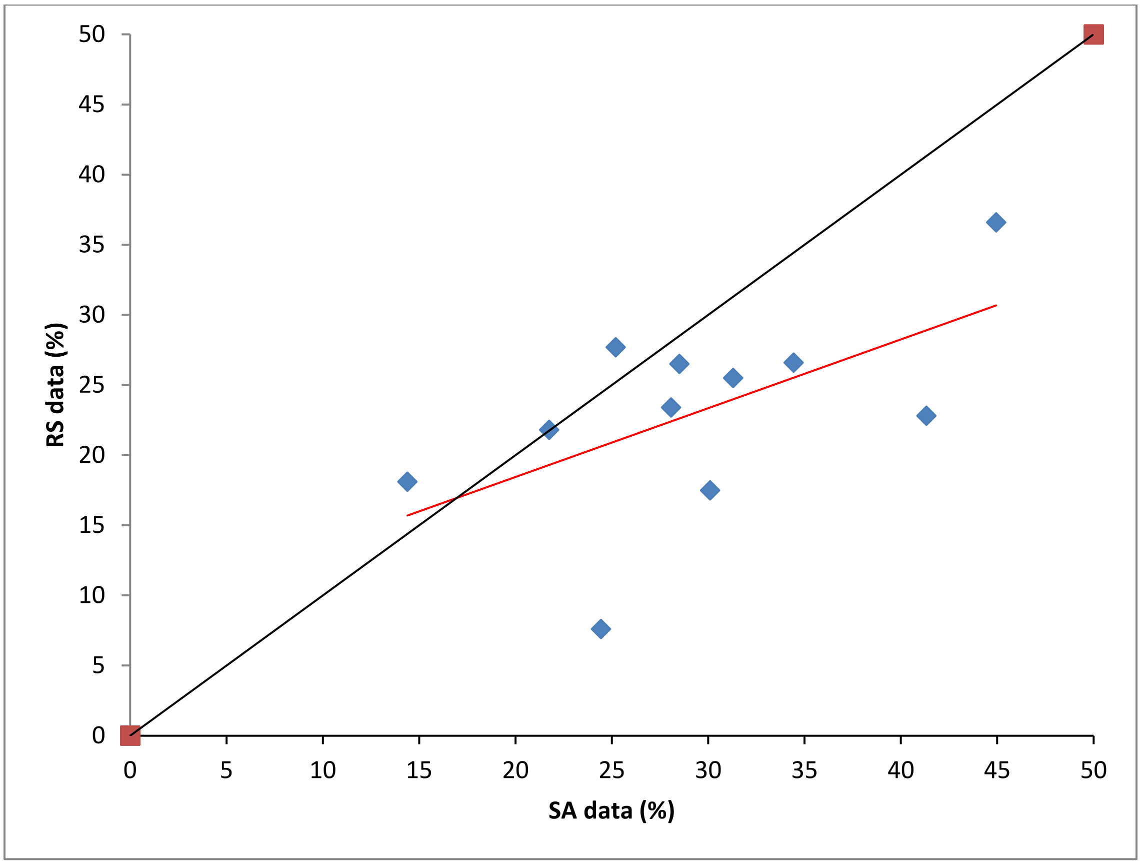
Figure 12 shows that the RS method under-estimated built shade by 3.12% (lower limit: -7.89%, upper limit: 14.12%) compared to the SA method. For the mean values and the difference values, a non-significant correlation was found ($r=0.309$, $p=0.064$).

Schools grouped according to 'the proportion of classroom buildings that were single-storey'

Schools at which ≤89% of classroom buildings were single-storey

<u>Combined shade:</u>

Figure 13. Scatter plot: Schools at which ≤89% of classroom buildings were single-storey – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.



The RS method under-estimated combined shade at most schools compared to the SA method. For SA and RS data, a non-significant correlation was found (r=0.579, p=0.062).

Figure 14. Bland-Altman plot: Schools at which ≤89% of classroom buildings were single-storey – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

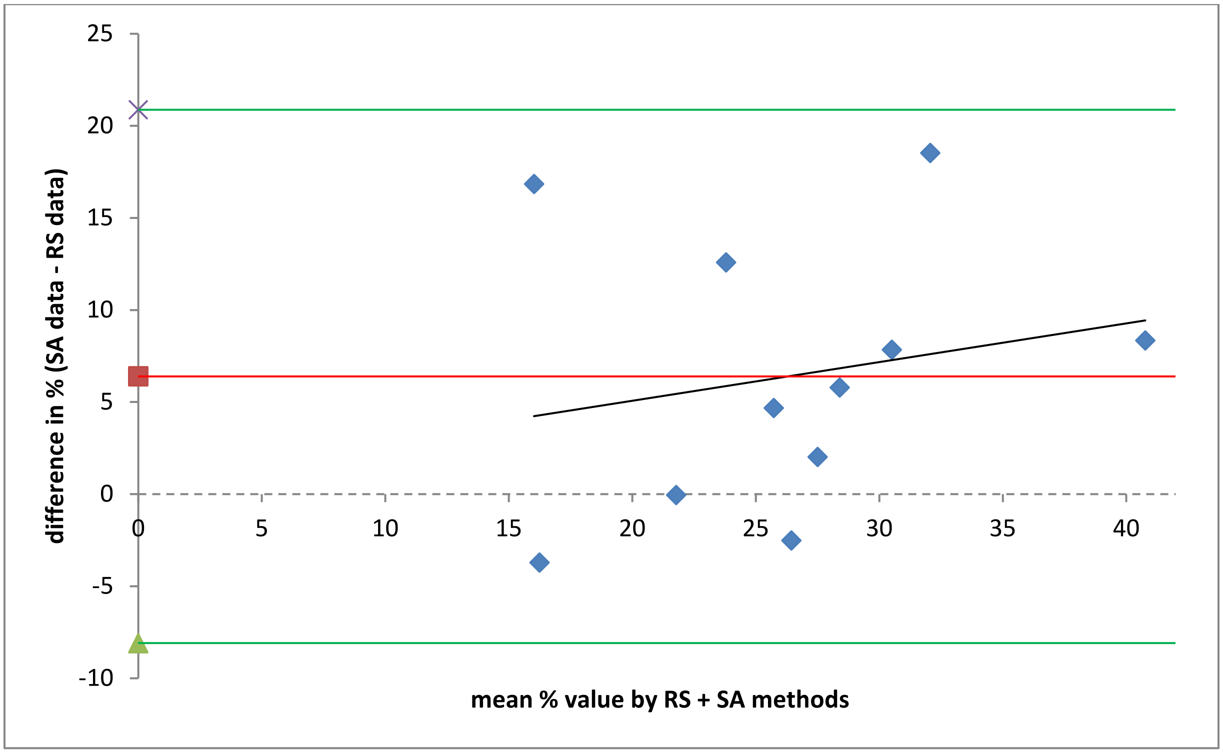


Figure 14 shows the RS method under-estimated combined shade by 6.39% (lower limit: -8.38%, upper limit: 21.17%) compared to the SA method. For mean values and difference values, a non-significant correlation was found ($r=0.201$, $p=0.553$).

Natural shade:

Figure 15. Scatter plot: Schools at which ≤89% of classroom buildings were single-storey – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

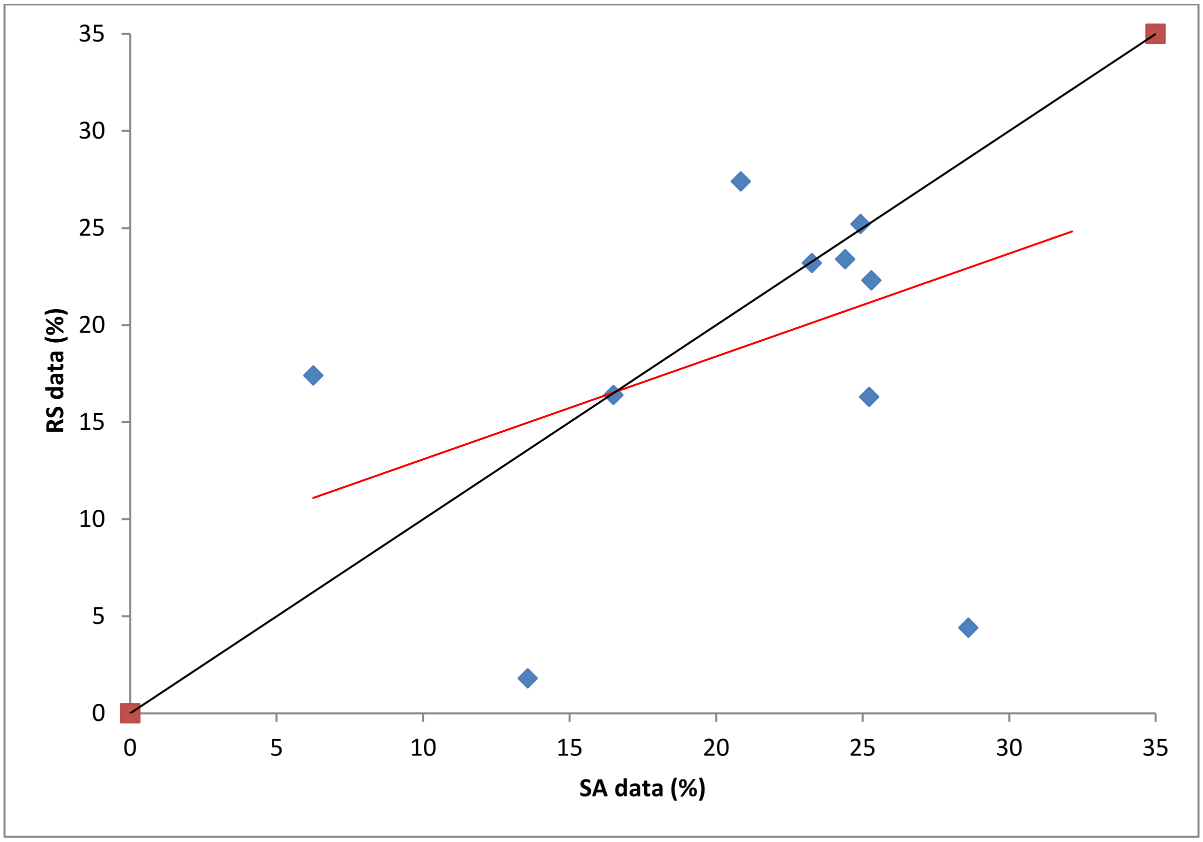


Figure 15 shows the RS method under-estimated natural shade at most schools compared to the SA method. For RS and SA data, low correlation was found (r=0.396, p=0.228).

Figure 16. Bland-Altman plot: Schools at which ≤89% of classroom buildings were single-storey – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

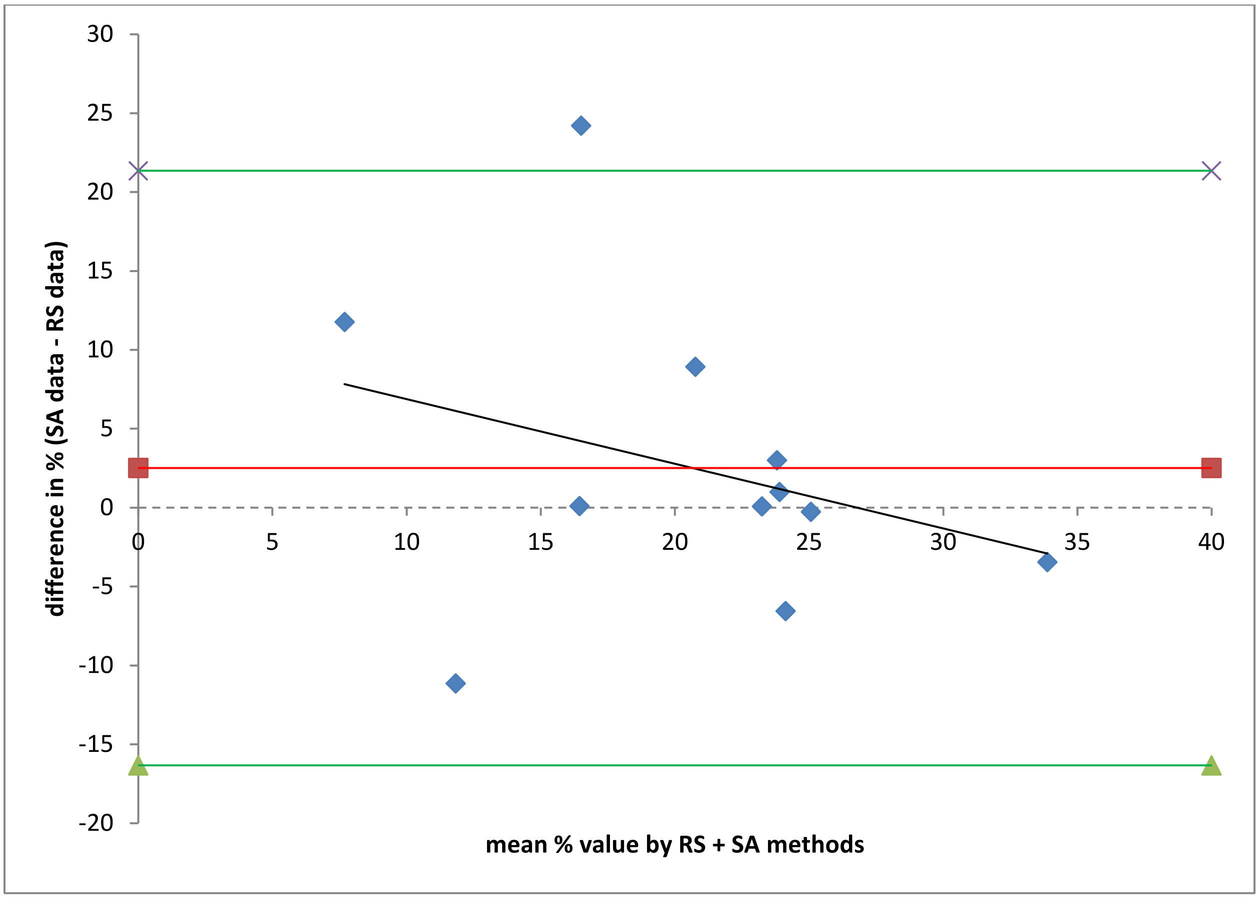


Figure 16 shows that the RS method under-estimated natural shade by 2.51% (lower limit: -16.71%, upper limit: 21.74%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.306, p=0.361).

Built shade:

Figure 17. Scatter plot: Schools at which ≤89% of classroom buildings were single-storey – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

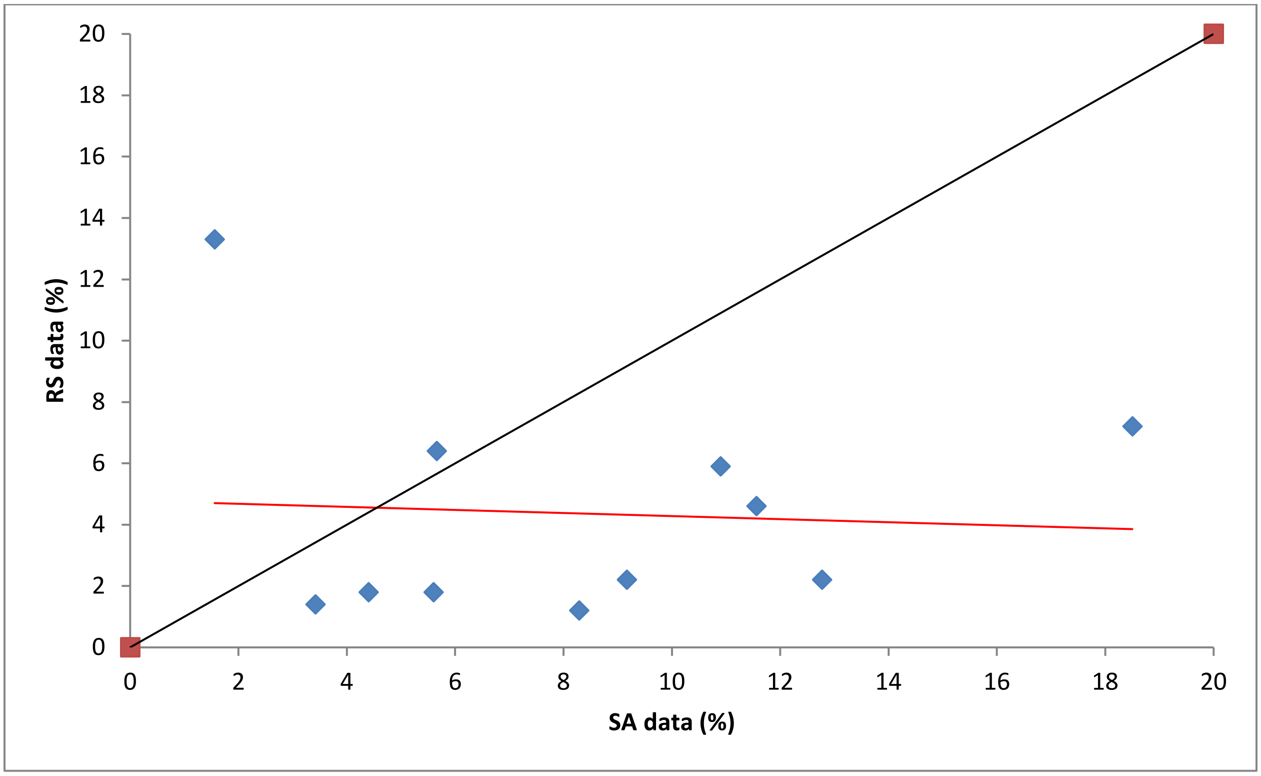


Figure 17 shows the RS method under-estimated built shade at most schools compared to the SA method. For RS and SA data, negligible correlation was found (r=0.067, p=0.846).

Figure 18. Bland-Altman plot: Schools at which ≤89% of classroom buildings were single-storey – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

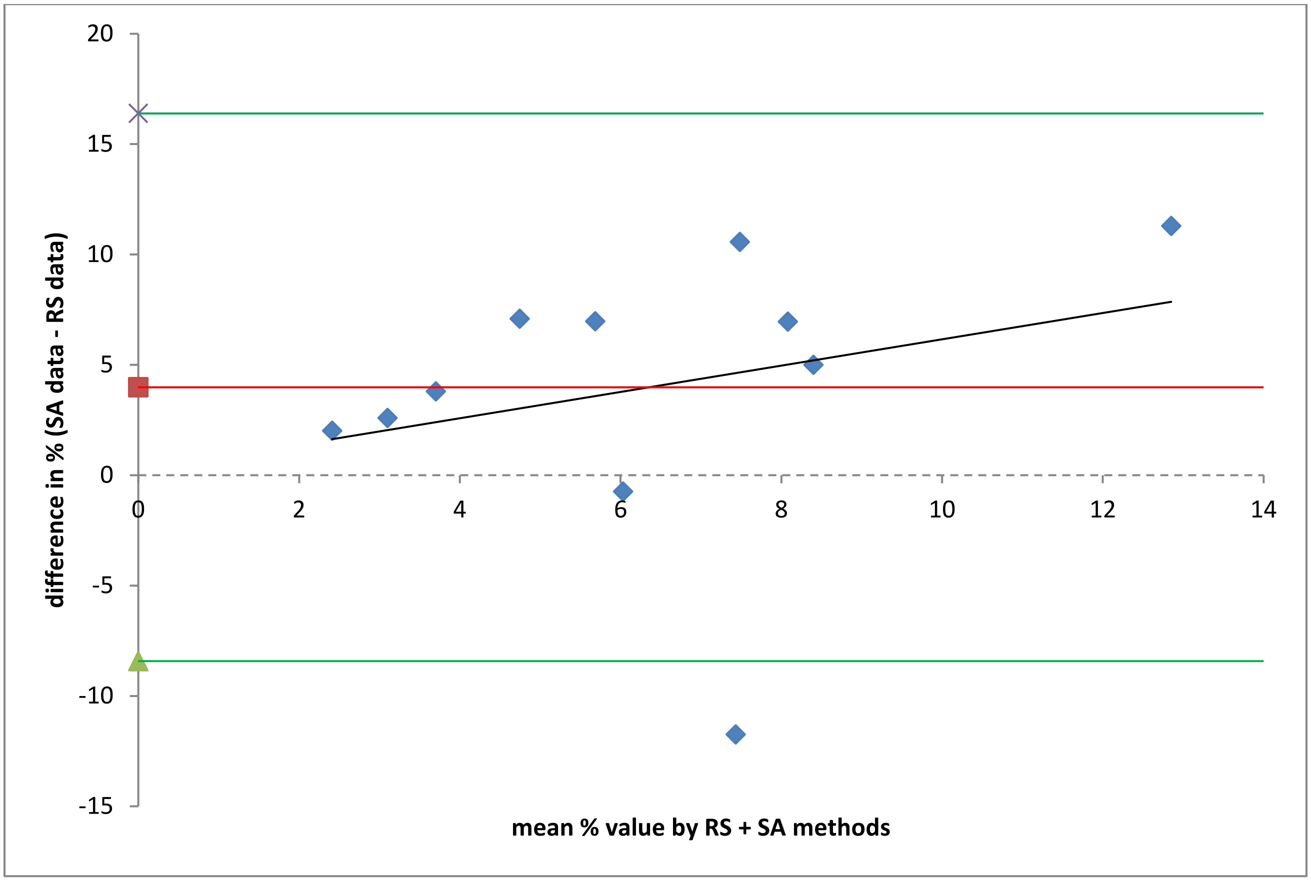


Figure 18 shows the RS method under-estimated built shade by 3.98% (lower limit: -8.68%, upper limit: 16.65%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.208, p=0.405).

Schools at which ≥90% of classroom buildings were single-storey

<u>Combined shade:</u>

Figure 19. Scatter plot: Schools at which ≥90% of classroom buildings were single-storey – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

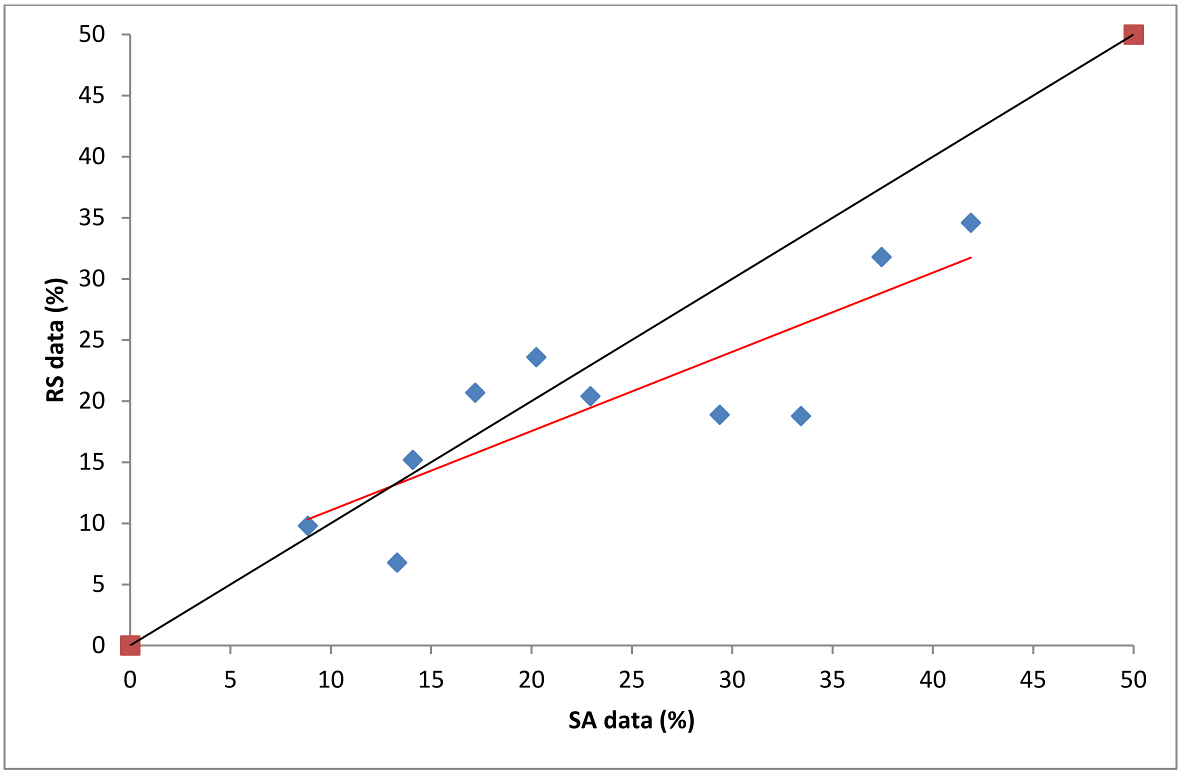


Figure 19 shows the RS method under-estimated combined shade at most schools compared to the SA method. For RS and SA data, high correlation was found (r=0.843, p=0.001).

Figure 20. Bland-Altman plot: Schools at which ≥90% of classroom buildings were single-storey – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

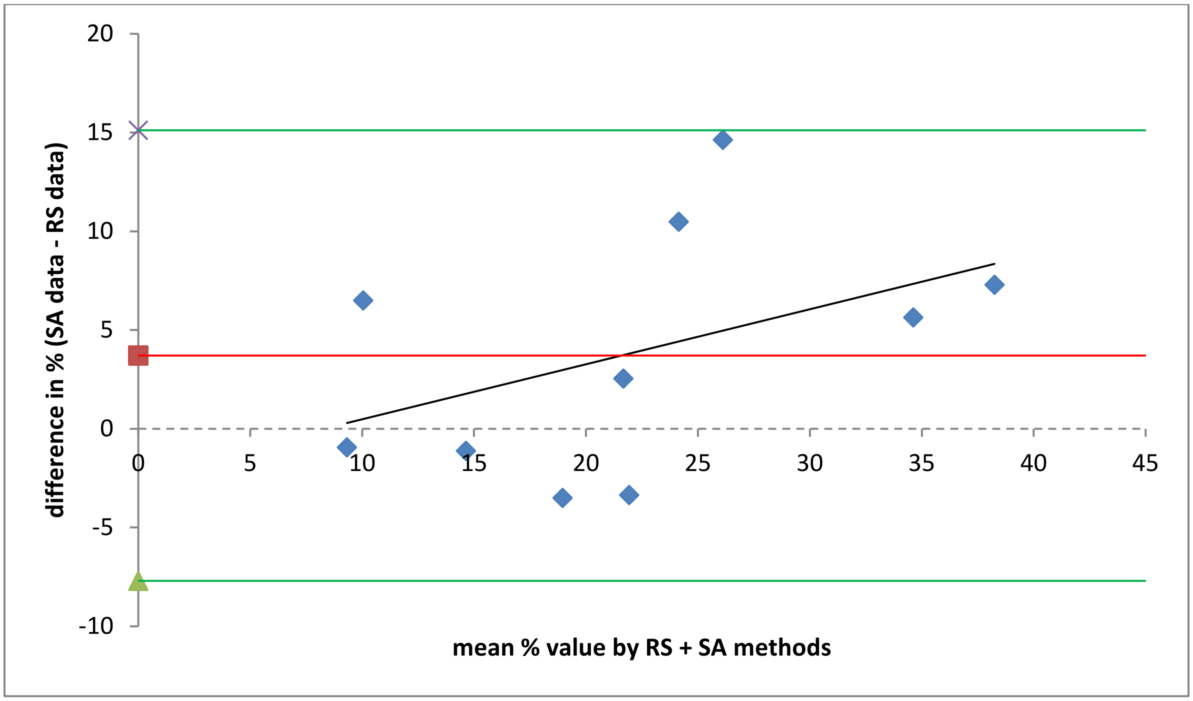


Figure 20 shows the RS method under-estimated combined shade by 3.71% (lower limit: -7.93%, upper limit: 15.35%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.435, p=0.181).

Natural shade:

Figure 21. Scatter plot: Schools at which ≥90% of classroom buildings were single-storey – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

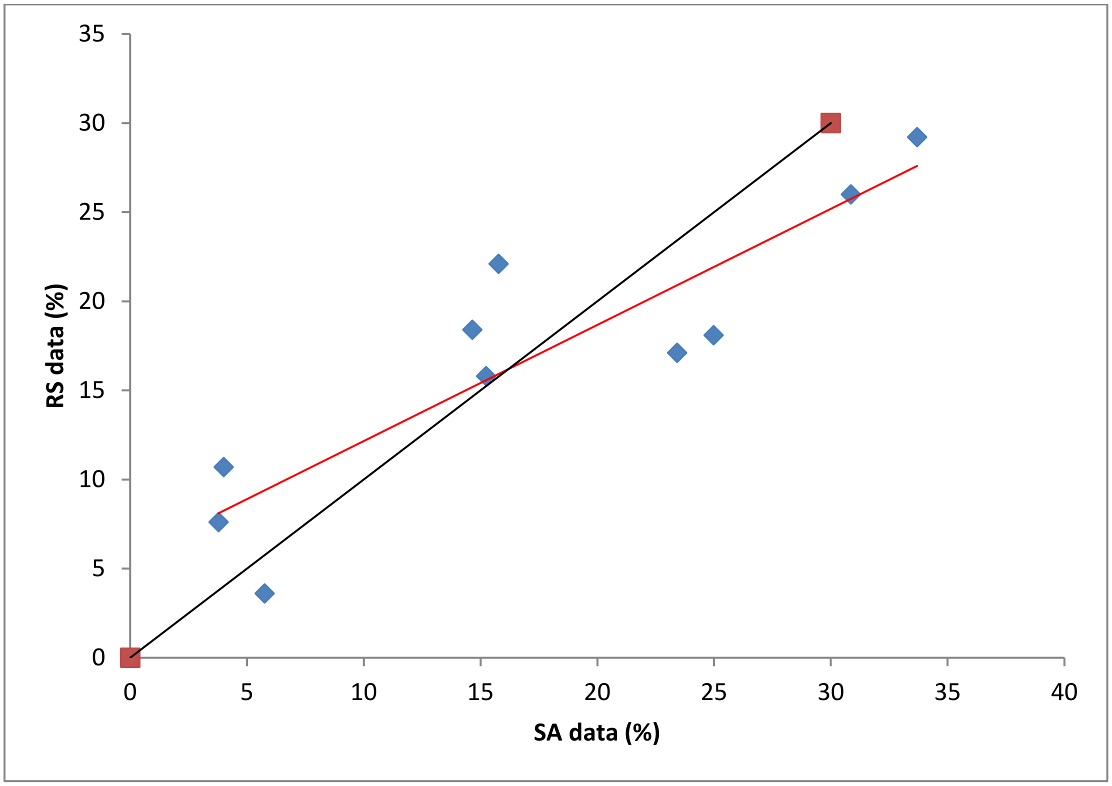


Figure 21 shows the RS over- or under-estimated natural shade data compared to the SA method for half the schools respectively. For RS and SA data, high correlation was found ($r=0.888$, $p<0.001$).

Figure 22. Bland-Altman plot: Schools at which ≥90% of classroom buildings were single-storey – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

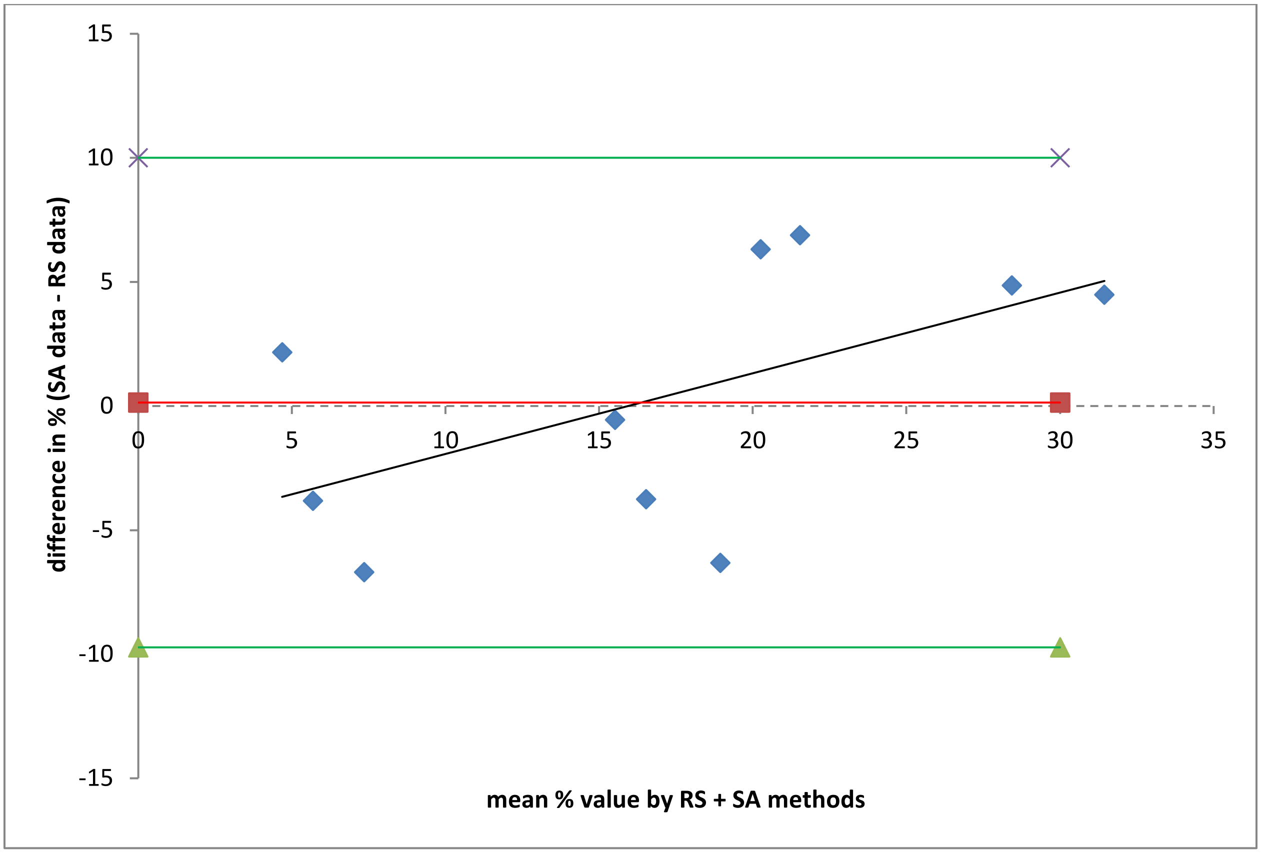


Figure 22 shows the RS method under-estimated natural shade by 0.14% (lower limit: -9.93%, upper limit: 10.21%) compared to the SA method. For mean and difference values, a non-significant correlation was found ($r=0.571$, $p=0.066$).

Built shade:

Figure 23. Scatter plot: Schools at which ≥90% of classroom buildings were single-storey – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

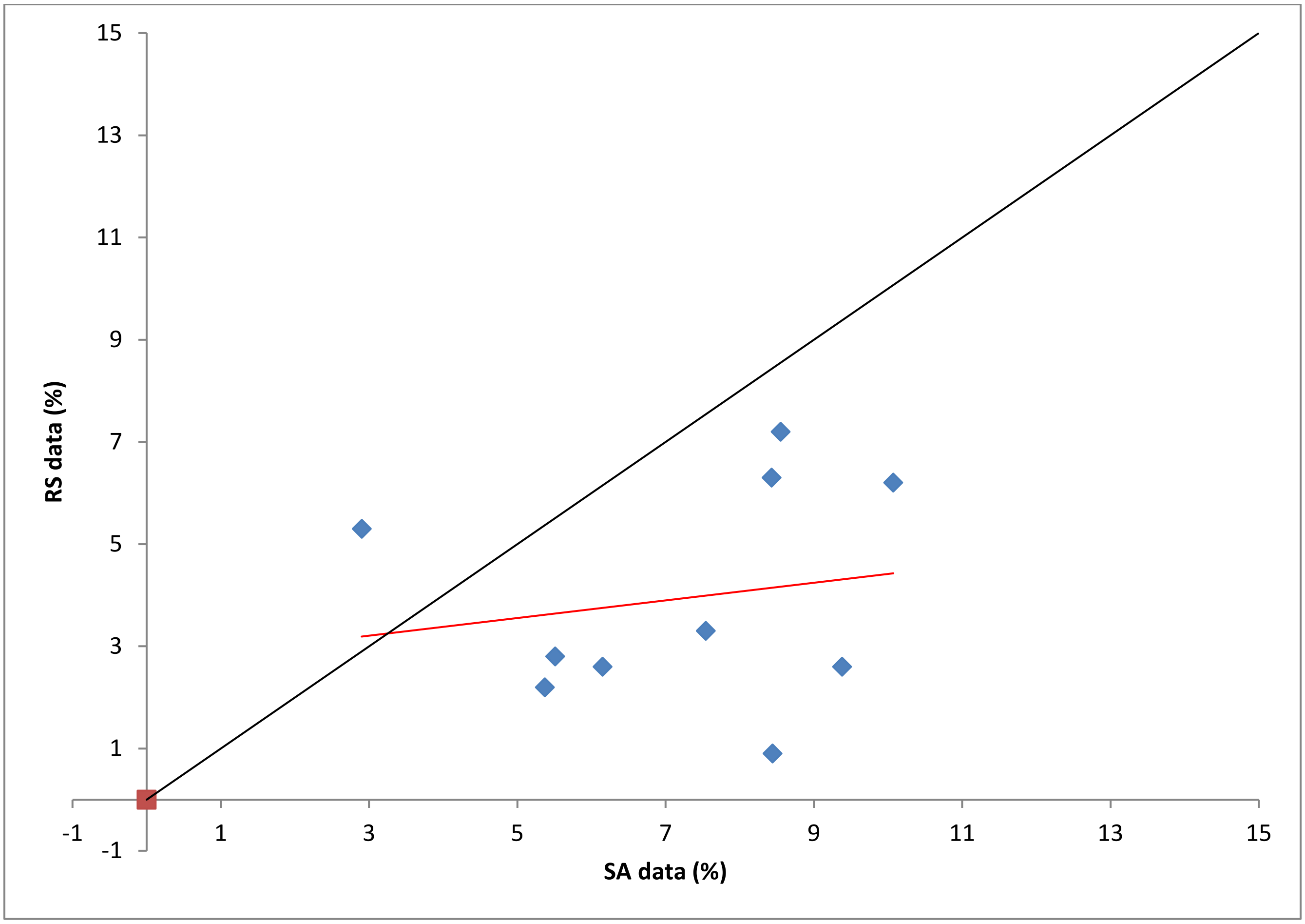


Figure 23 shows the RS method under-estimated built shade at most schools compared to the SA method. For RS and SA data, negligible correlation was found (r=0.230, p=0.496).

Figure 24. Bland-Altman plot: Schools at which ≥90% of classroom buildings were single-storey – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

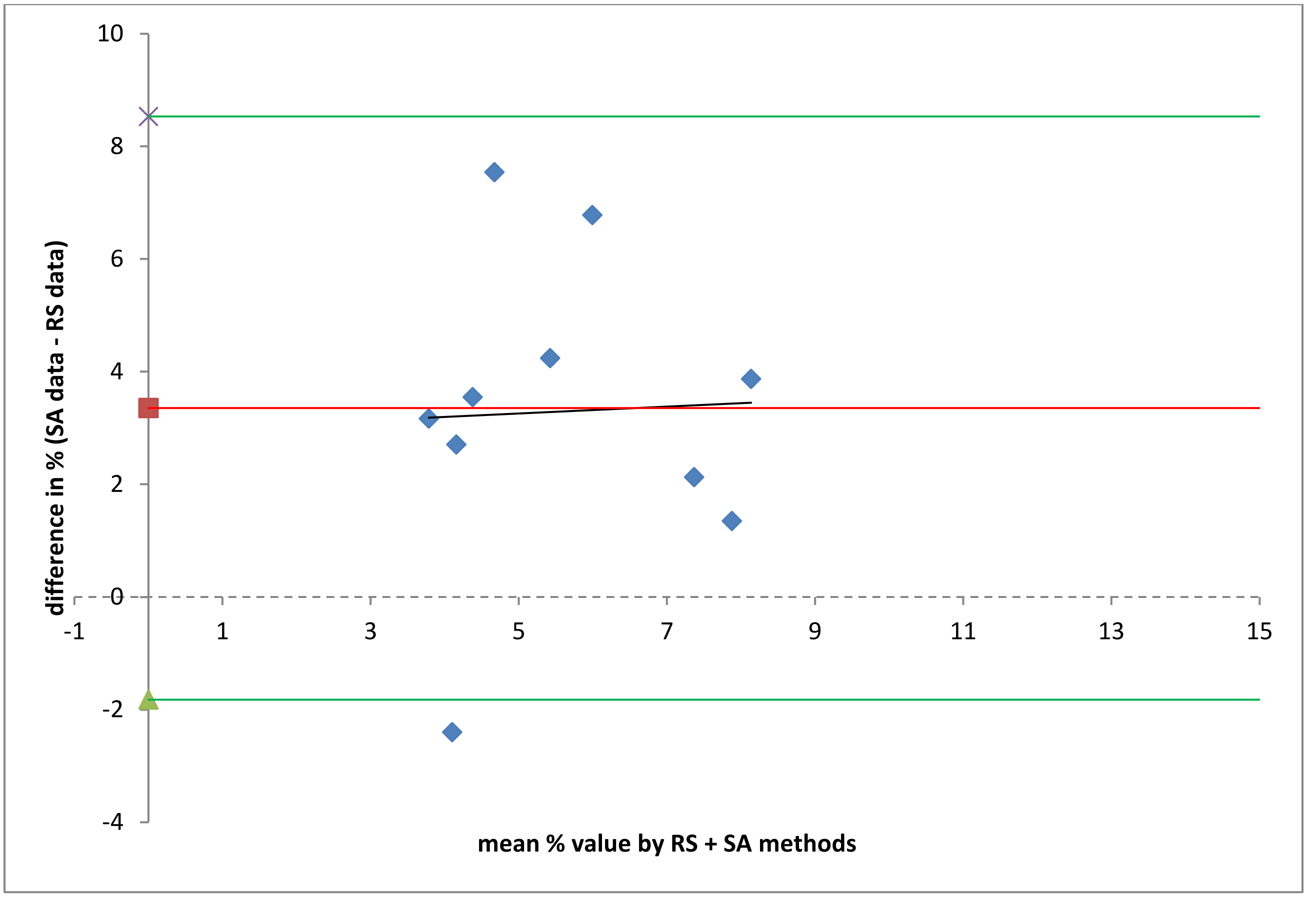


Figure 24 shows the RS method under-estimated built shade by 3.35% (lower limit: -1.93%, upper limit: 8.64%) compared to the SA method. For mean values and difference values, Pearson's r value was close to zero and the p value was not significant (r=0.010, p=0.978).

Schools grouped according to 'the size of their total usable area'

Schools at which the usable land area was less than the median value for all schools

Combined shade:

Figure 25. Scatter plot: Schools at which the land area was ≤ median size – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

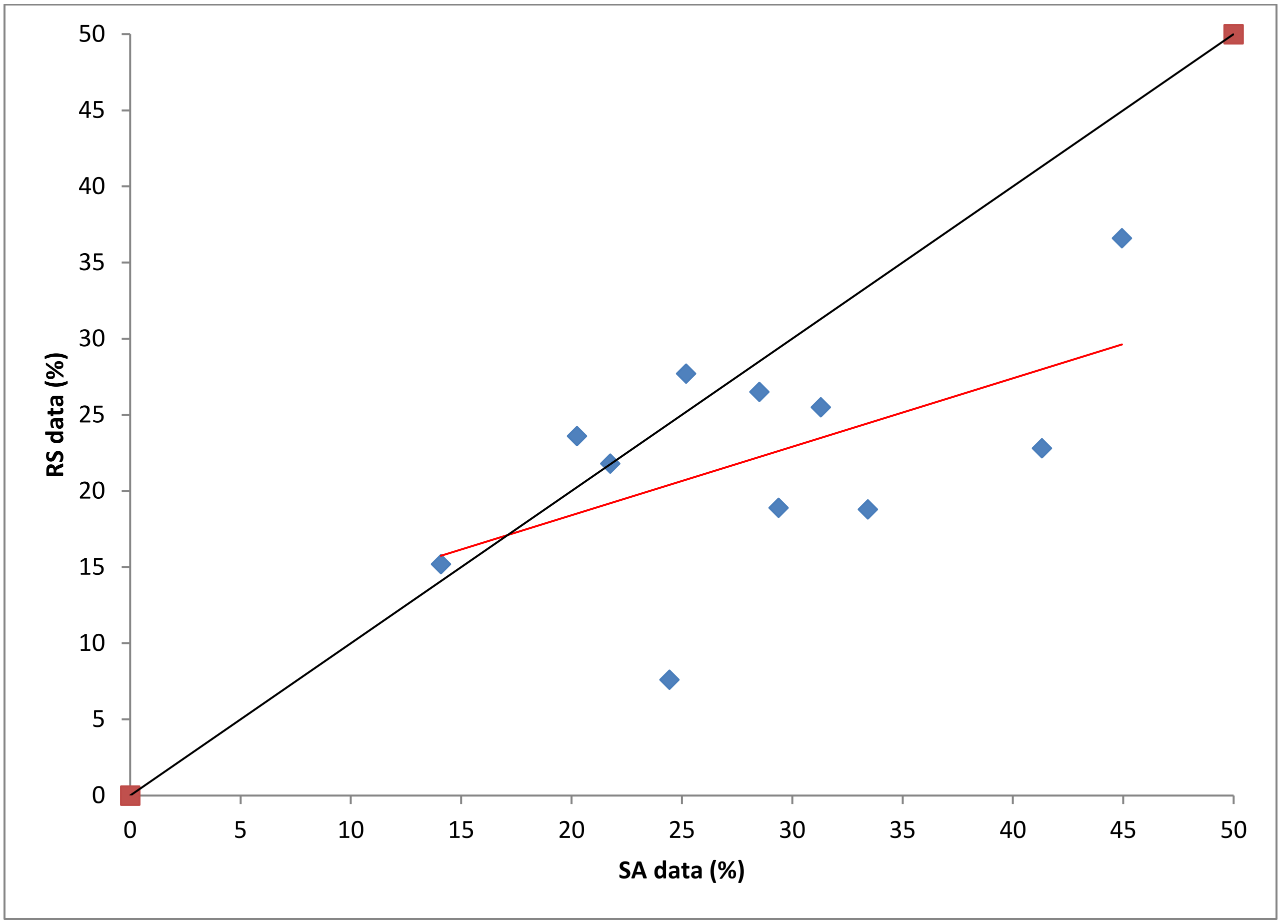


Figure 25 shows the RS method under-estimated combined shade at most schools compared to the SA method. For RS and SA data, a non-significant correlation was found (r=0.546, p=0.082).

Figure 26. Bland-Altman plot: Schools at which the land area was ≤ median size – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

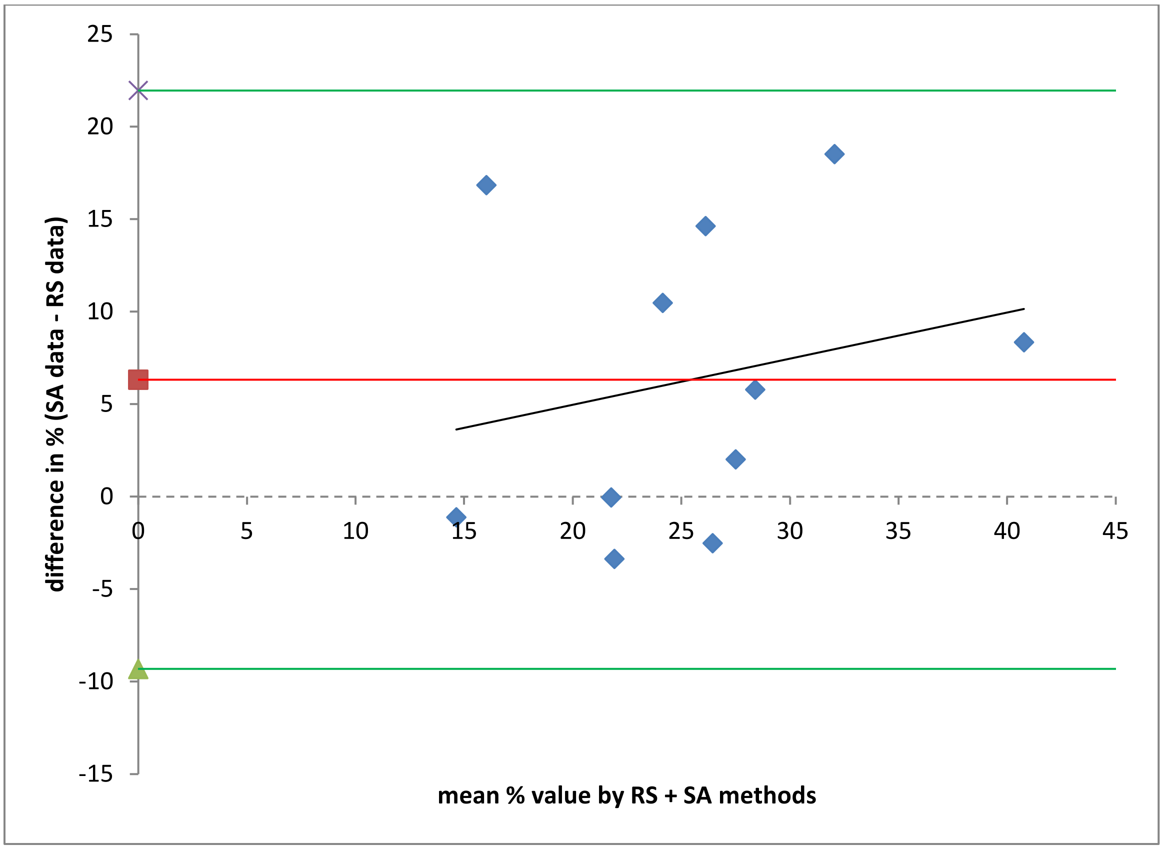


Figure 26 shows the RS method under-estimated combined shade by 6.32% (lower limit: -9.63%, upper limit: 22.28%) compared to the SA method. For mean and difference values, a non-significant correlation was found (r=0.227, p=0.502).

Natural shade:

Figure 27. Scatter plot: Schools at which the land area was ≤ median size – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

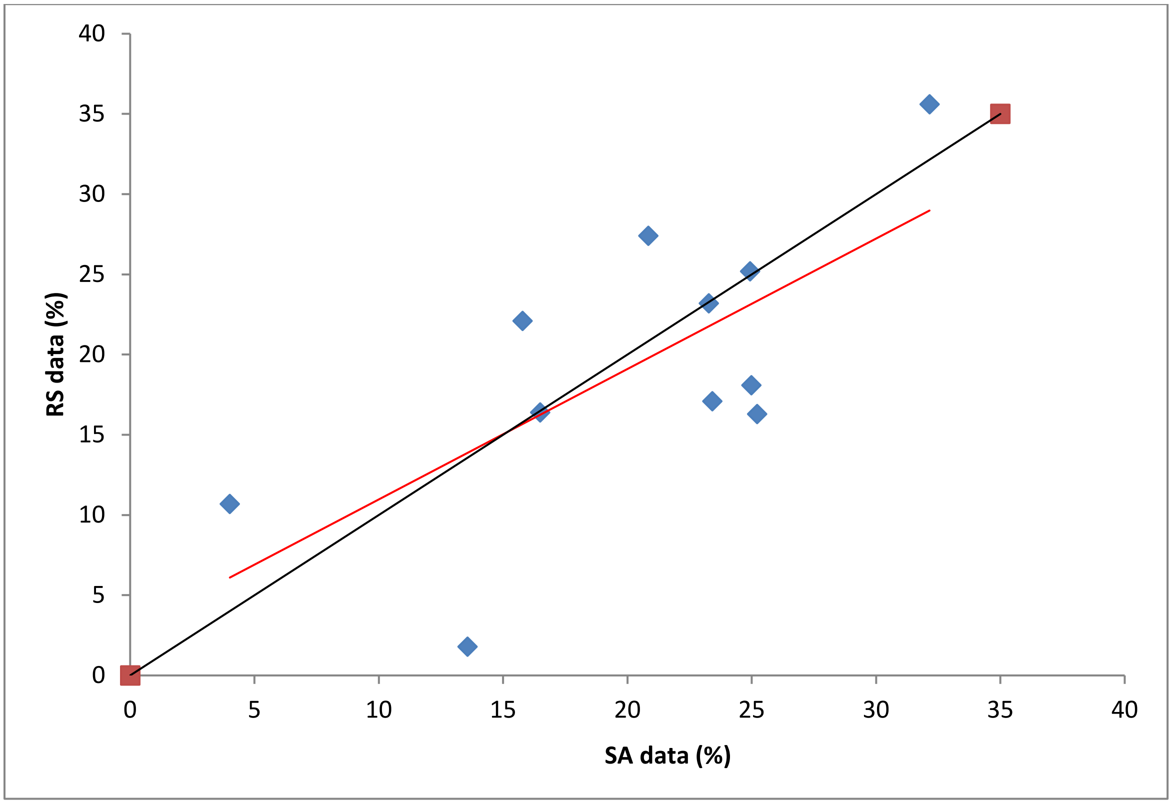


Figure 27 shows the RS under- or over-estimated natural shade compared to the SA method for half the schools respectively. For RS and SA data, high correlation was found (r=0.691, p=0.019).

Figure 28. Bland-Altman plot: Schools at which the land area was ≤ median size – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

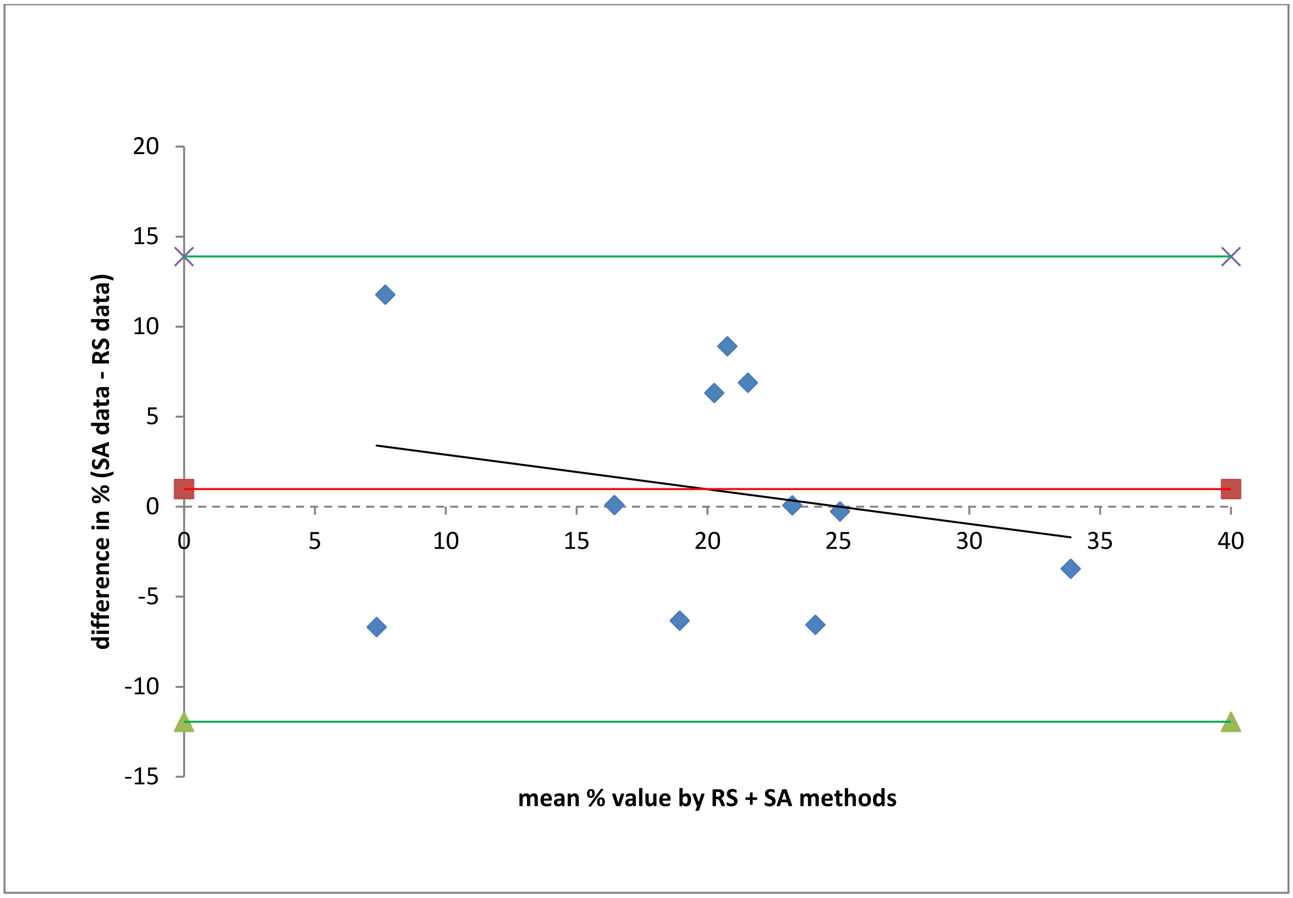


Figure 28 shows the RS method under-estimated natural shade by 0.98% (lower limit: -12.21, upper limit: 14.16%) compared to the SA method. For mean and difference values, a non-significant correlation was found (r=0.221, p=0.514).

Built shade:

Figure 29. Scatter plot: Schools at which the land area was ≤ median size – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

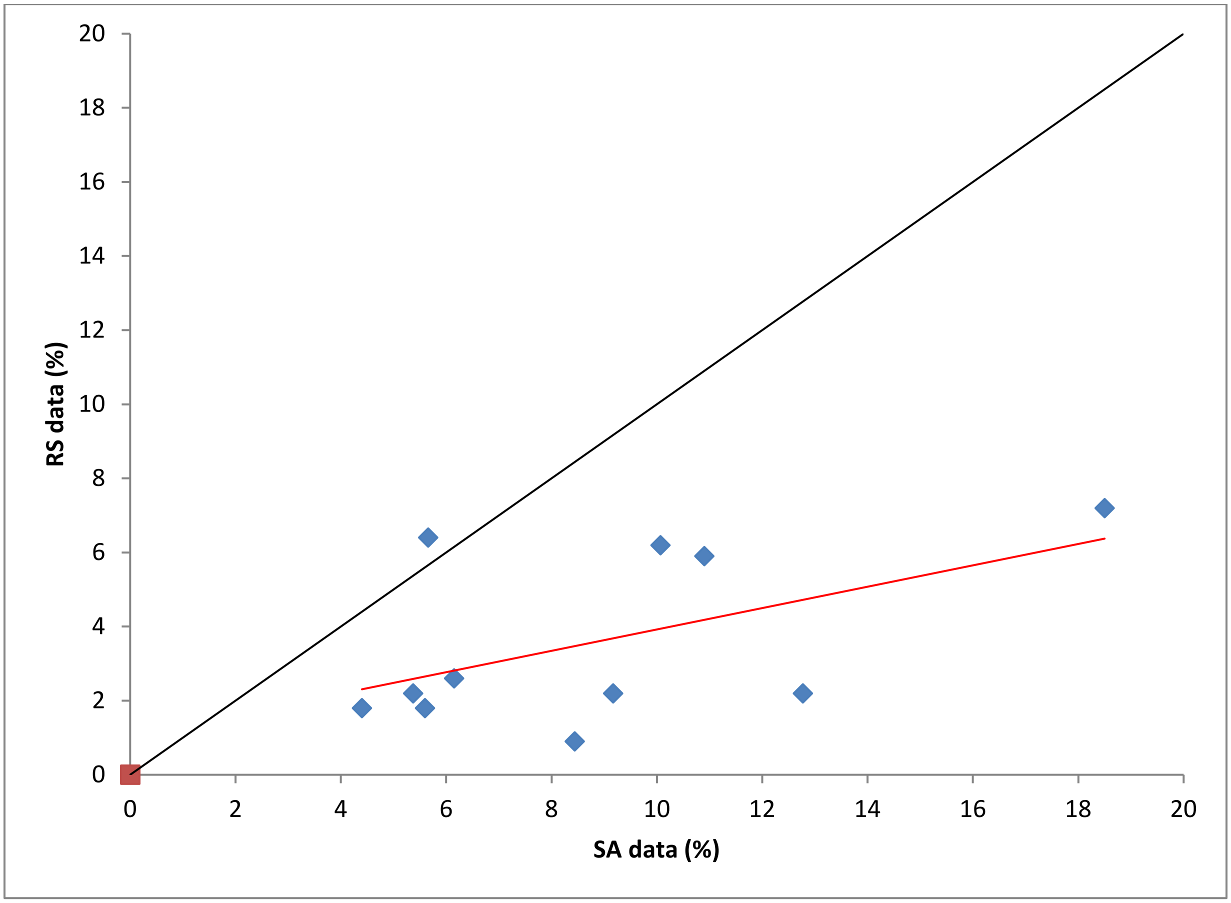


Figure 29 shows the RS method under-estimated built shade at most schools compared to the SA method. For RS and SA data, a non-significant correlation was found (r=0.521, p=0.101).

Figure 30. Bland-Altman plot: Schools at which the land area was ≤ median size – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

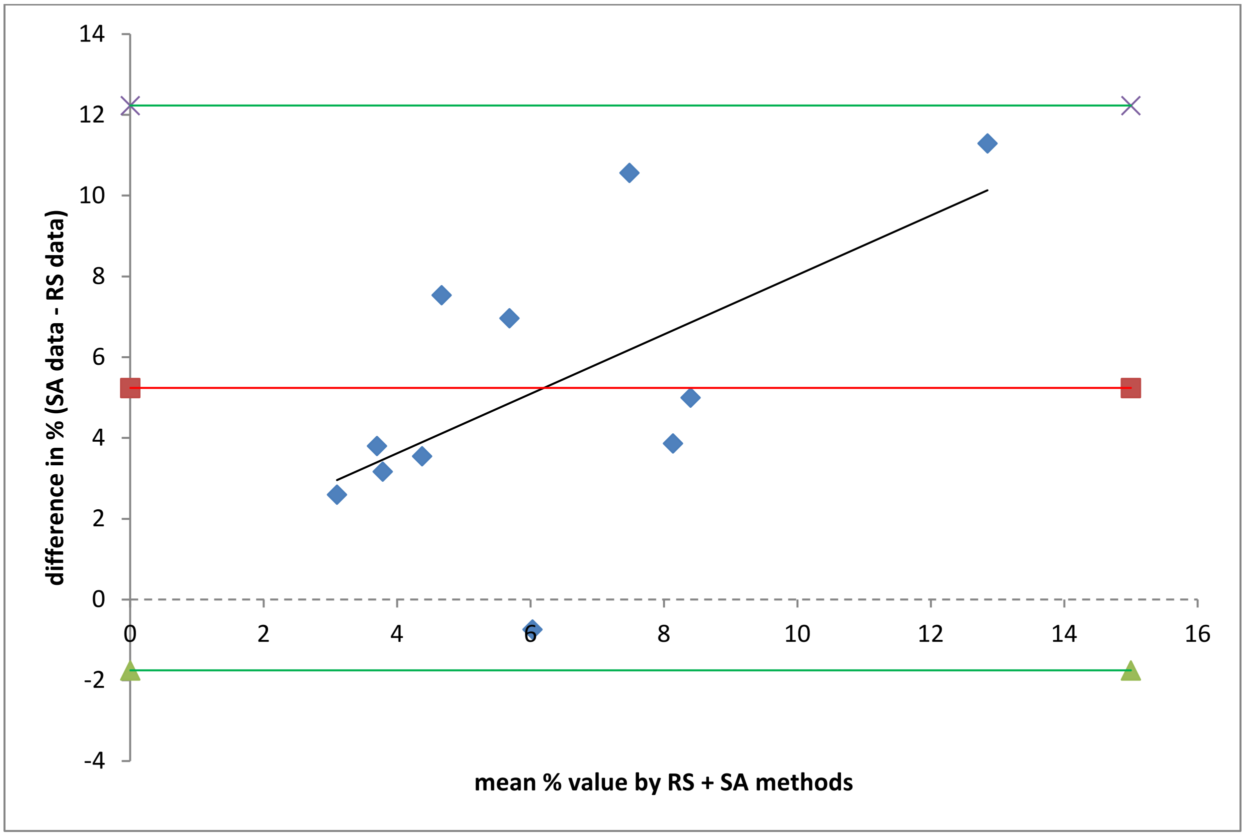


Figure 30 shows the RS method under-estimated built shade by 5.24% (lower limit: -1.88, upper limit: 12.38) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.591, p=0.055).

Schools at which the usable land area was more than the median value for all schools

Combined shade:

Figure 31. Scatter plot: Schools at which the land area was > median size – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

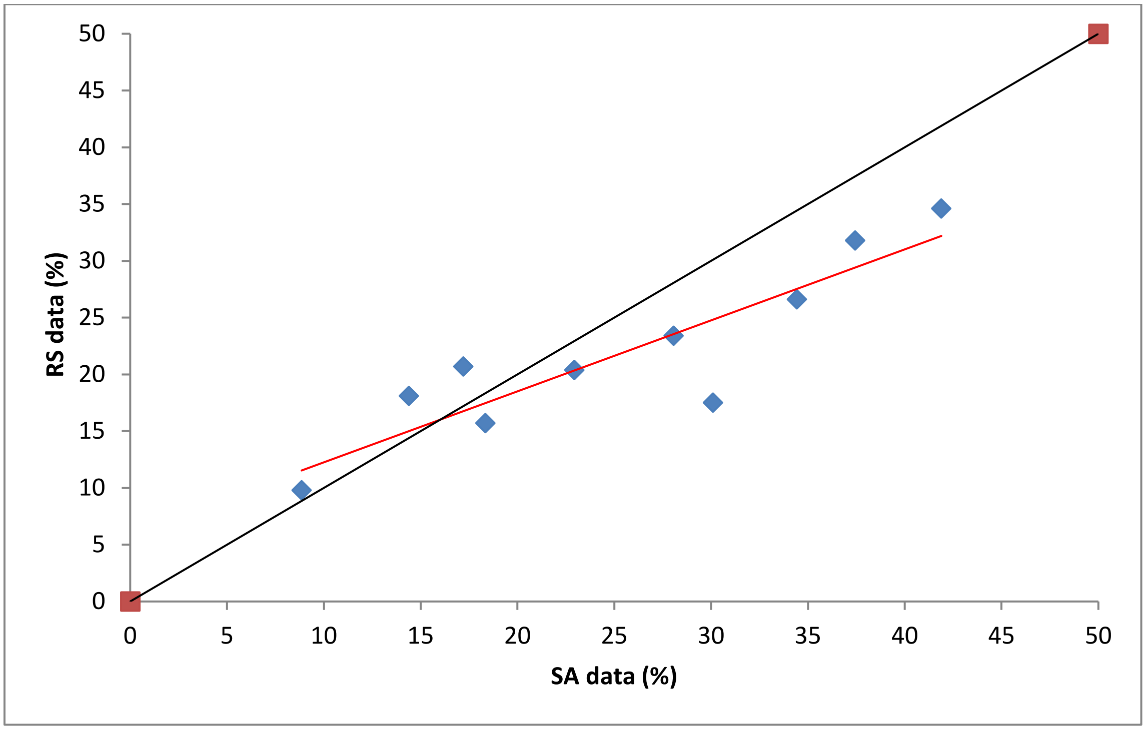


Figure 31 shows the RS method under-estimated combined shade at most schools compared to the SA method. For RS and SA data, high correlation was found (r=0.894, p<0.001).

Figure 32. Bland-Altman plot: Schools at which the land area was > median size – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

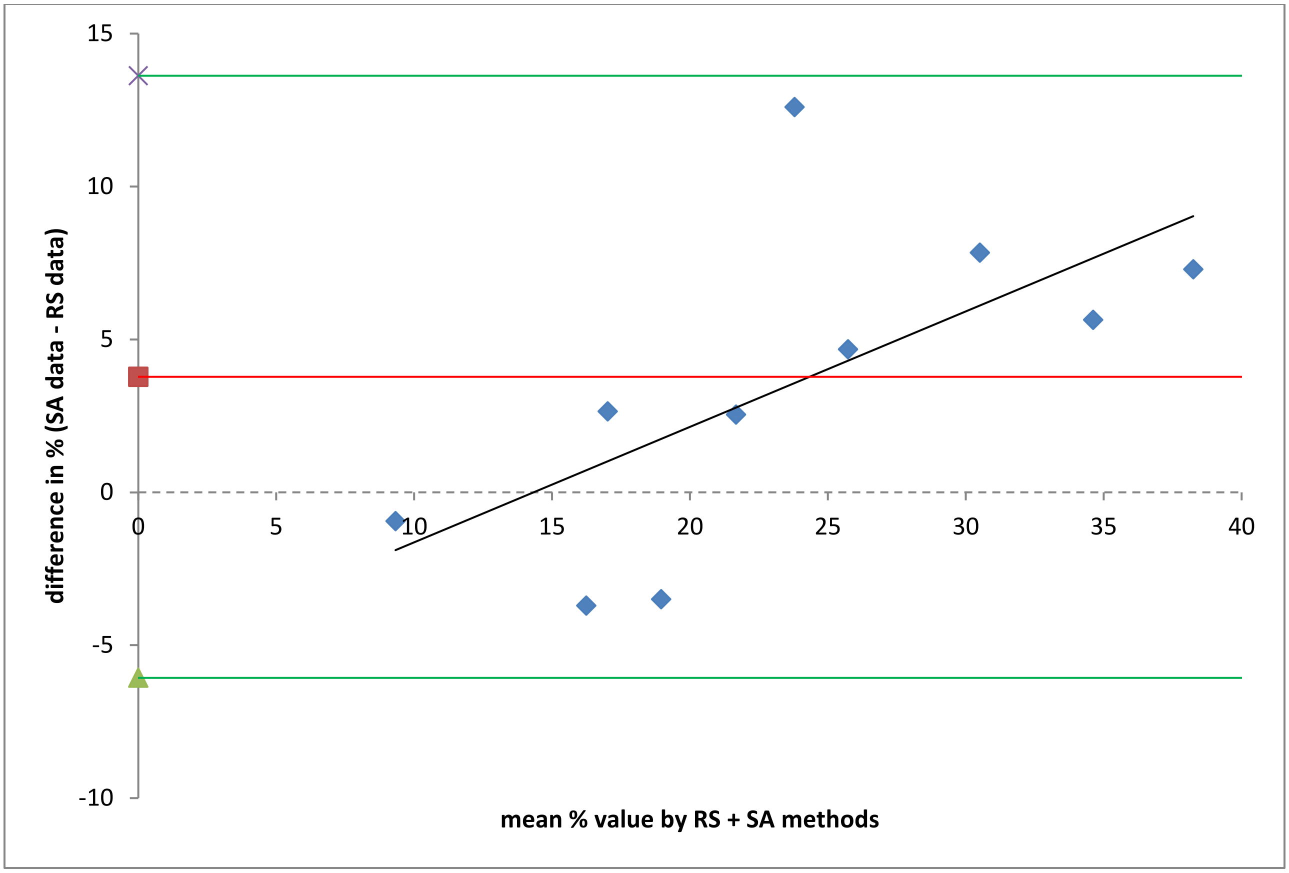


Figure 32 shows the RS method under-estimated combined shade by 3.78% (lower limit: -6.27, upper limit: 13.82%) compared to the SA method. For mean and difference values, a non-significant correlation was found (r=0.494, p=0.123).

Natural shade:

Figure 33. Scatter plot: Schools at which the land area was > median size – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

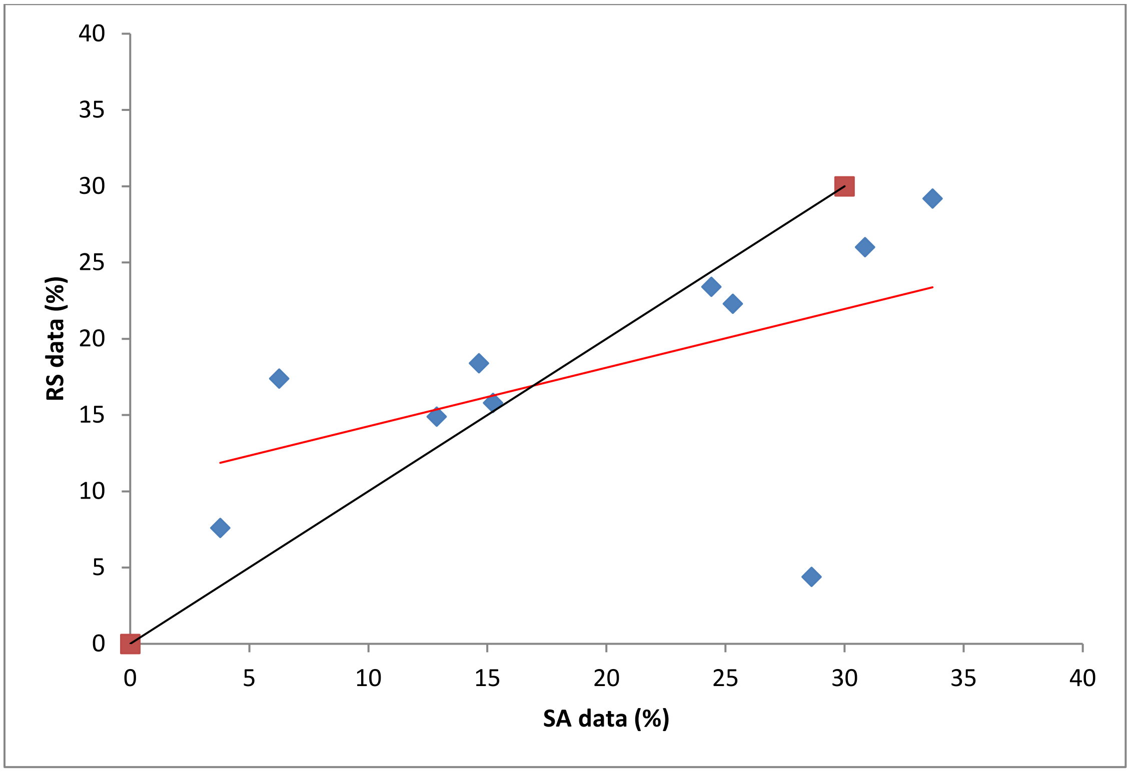


Figure 33 shows the RS method under- or over-reported natural shade compared to the SA method for half the schools respectively. For RS and SA data, a non-significant correlation was found (r=0.606, p=0.048).

Figure 34. Bland-Altman plot: Schools at which the land area was > median size – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

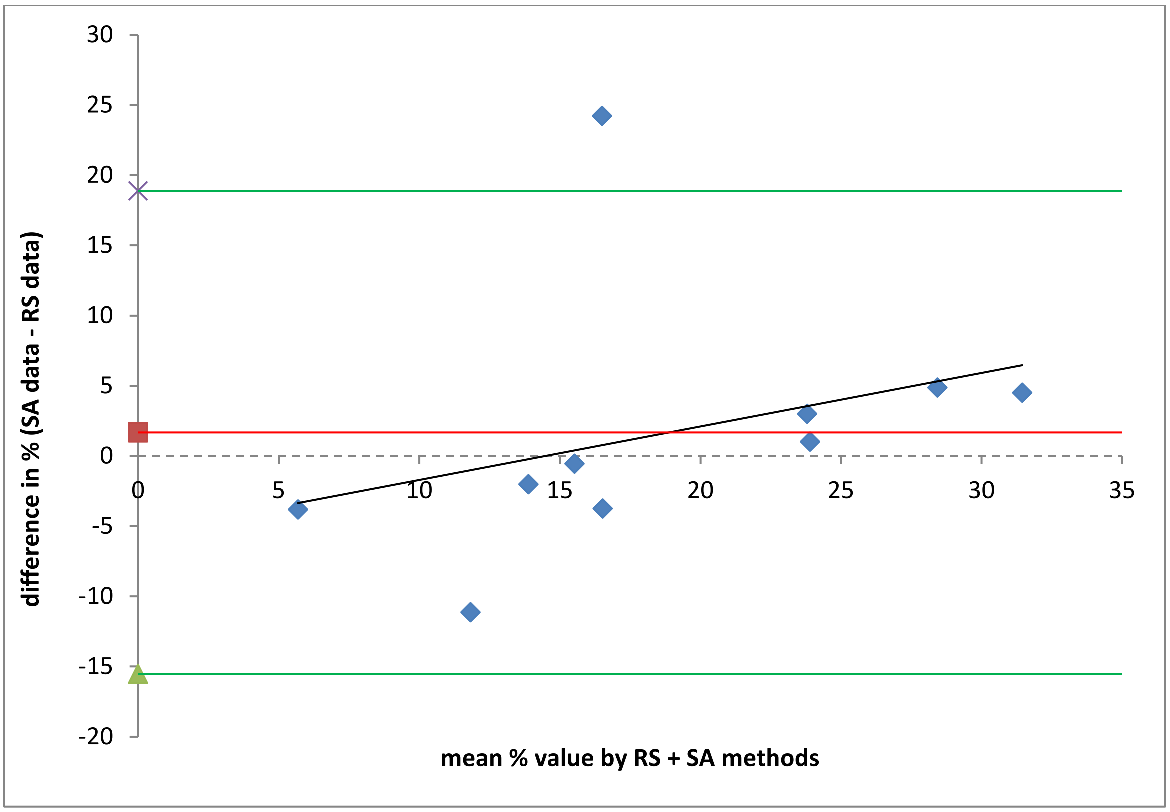


Figure 34 shows the RS method under-estimated natural shade by 1.67% (lower limit: -15.89%, upper limit: 19.24%) compared to the SA method. For mean and difference values, negligible correlation was found (r=0.277, p=0.410).

Built shade:

Figure 35. Scatter plot: Schools at which the land area was > median size – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

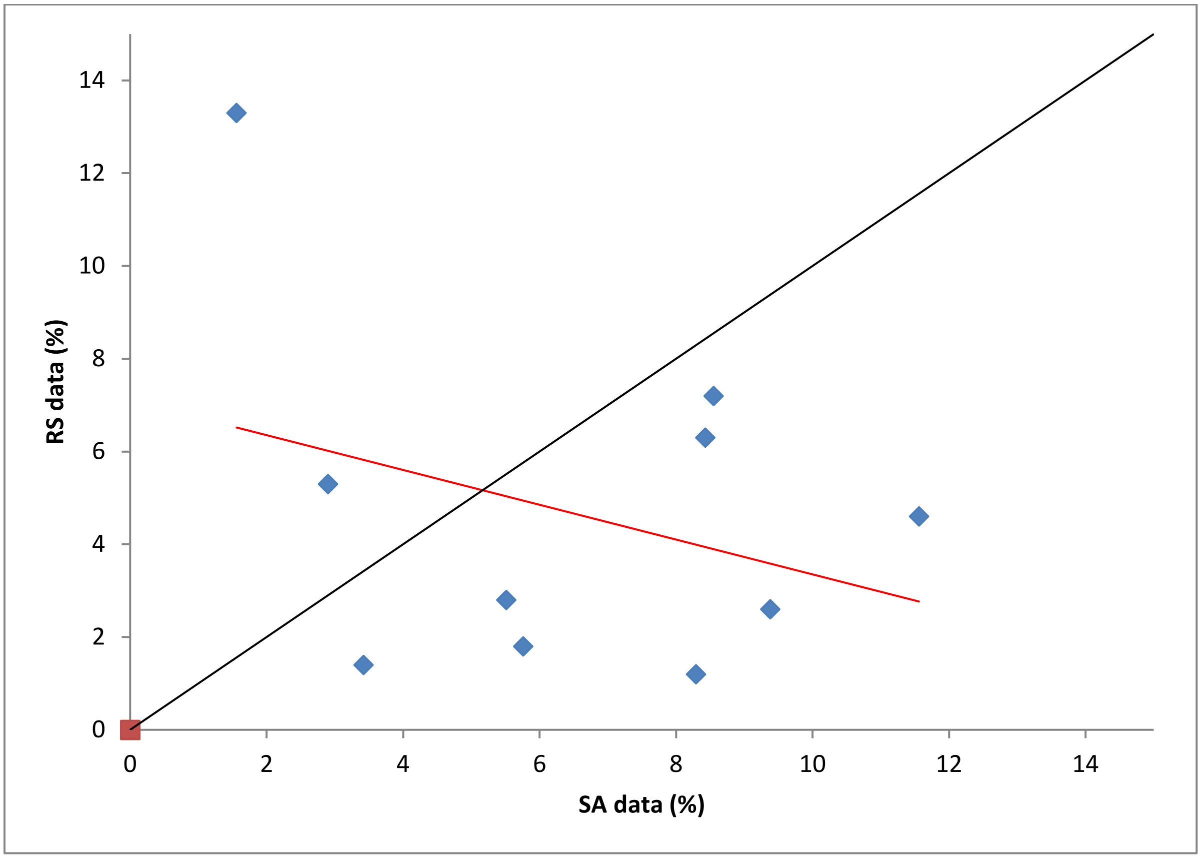


Figure 35 shows the RS method under-estimated built shade at most schools compared to the SA method. For RS and SA data, a non-significant correlation was found (r=0.335, p=0.314).

Figure 36. Bland-Altman plot: Schools at which the land area was > median size – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

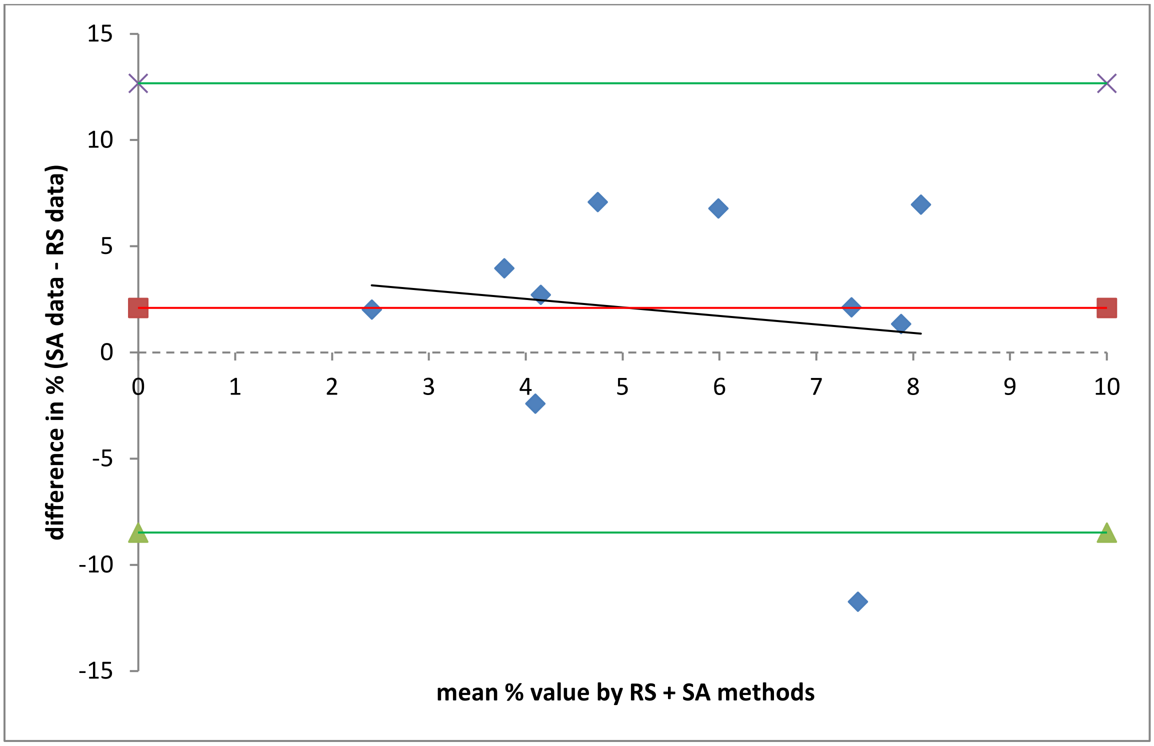


Figure 36 shows the RS method under-estimated built shade by 2.10% (lower limit: -8.70, upper limit: 12.89%) compared to the SA method. For mean and difference values, negligible correlation was found (r=0.146, p=0.669).

Schools grouped according to their amount of green-space

Schools at which the green-space amounted to approximately ≤74%

Combined shade:

Figure 37. Scatter plot: Schools at which green-space amount to ≤74% of the total area – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

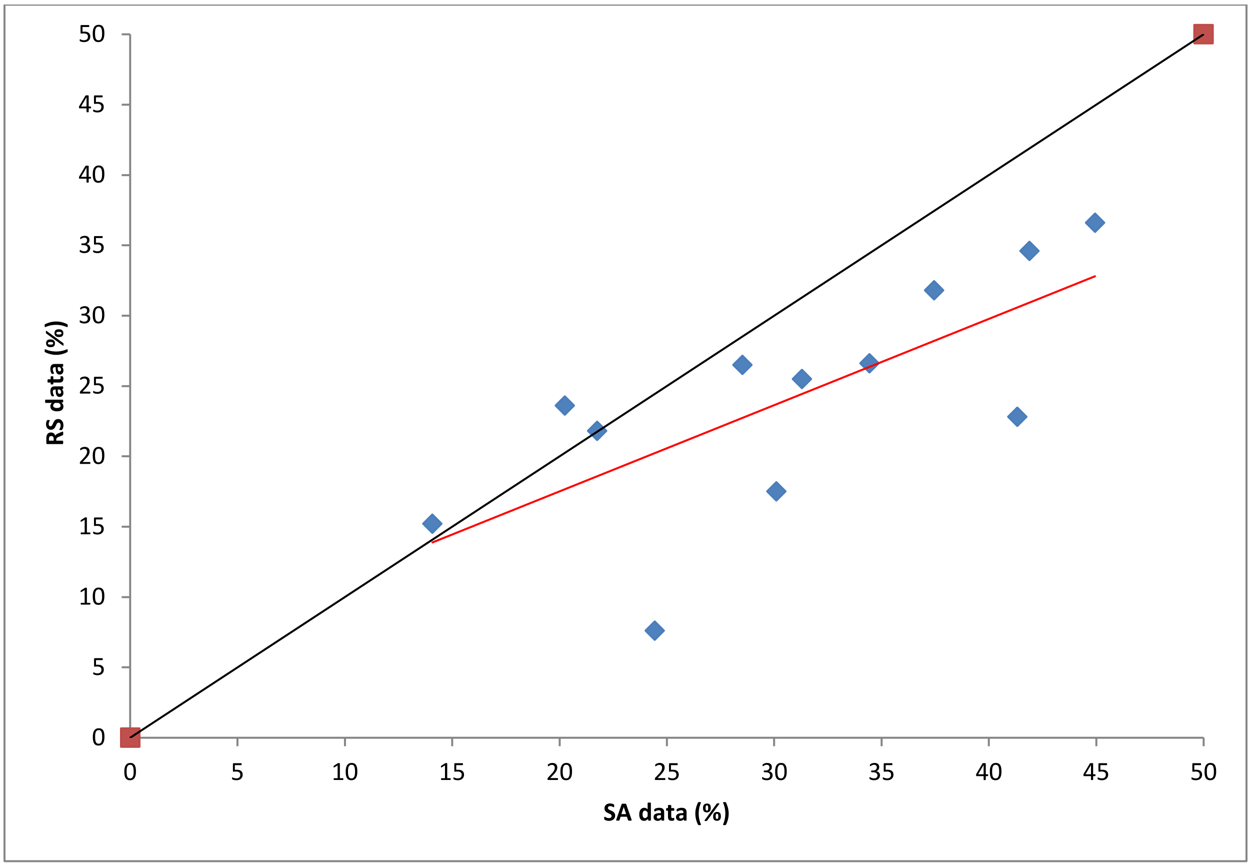


Figure 37 shows the RS method under-estimated combined shade at most schools compared to the SA method. For SA and RS data, high correlation was found ($r=0.788$, $p<0.001$).

Figure 38. Bland-Altman plot: Schools at which green-space amount to ≤74% of the total area – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

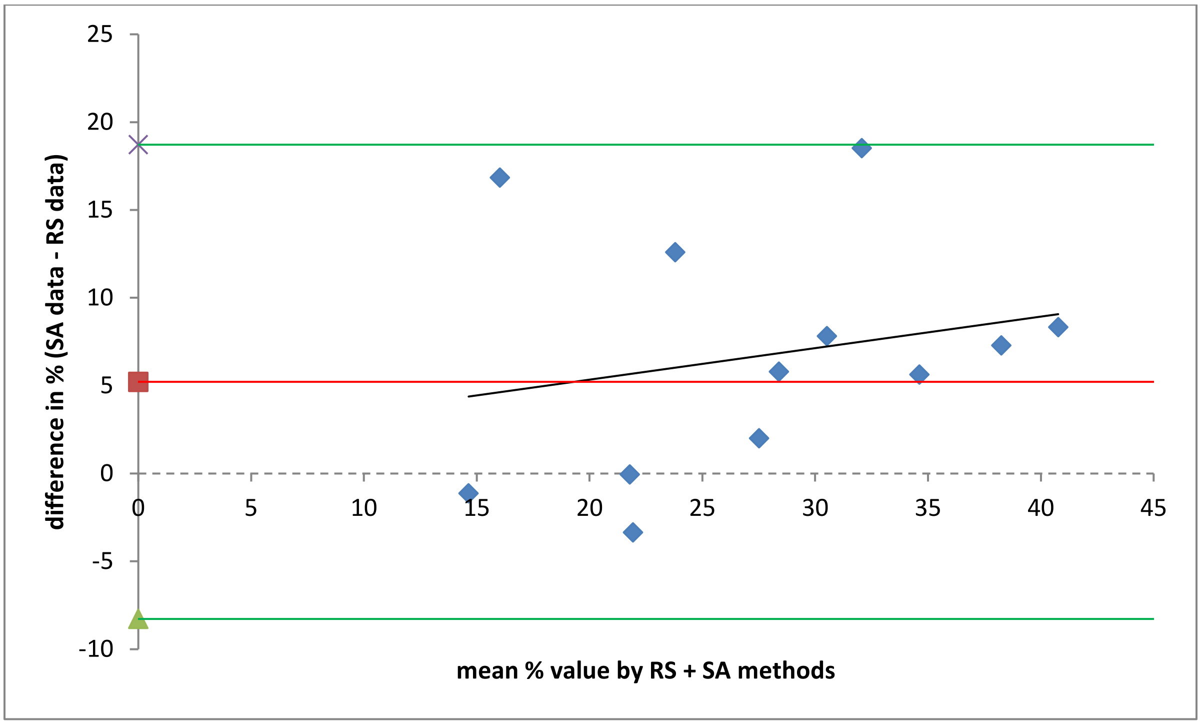


Figure 38 shows the RS method under-estimated combined shade by 5.22% (lower limit: -8.55%, upper limit: 18.99%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.418, p=0.121)

Natural shade:

Figure 39. Scatter plot: Schools at which green-space amount to ≤74% of the total area – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

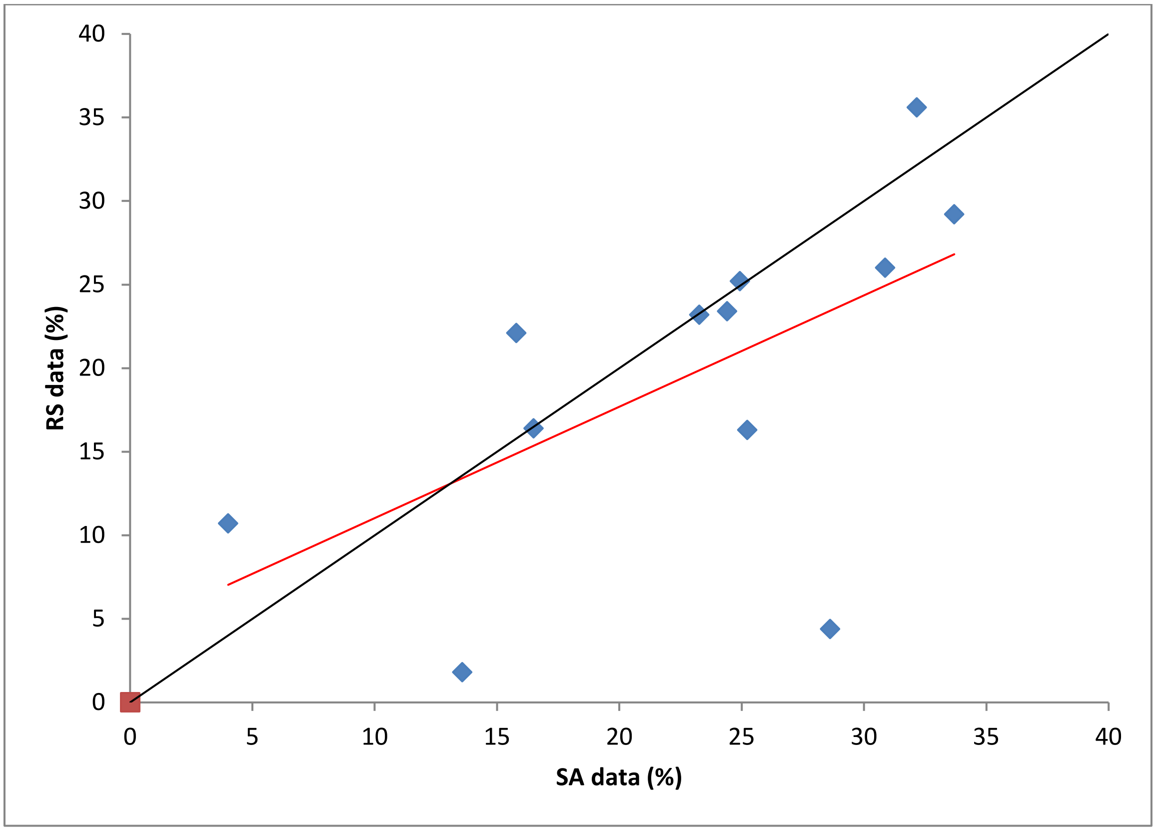


Figure 39 shows the RS method under-estimated natural shade at most schools compared to the SA method. For RS and SA data, high correlation was found (r=0.608, p=0.016).

Figure 40. Bland-Altman plot: Schools at which green-space amount to ≤74% of the total area – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

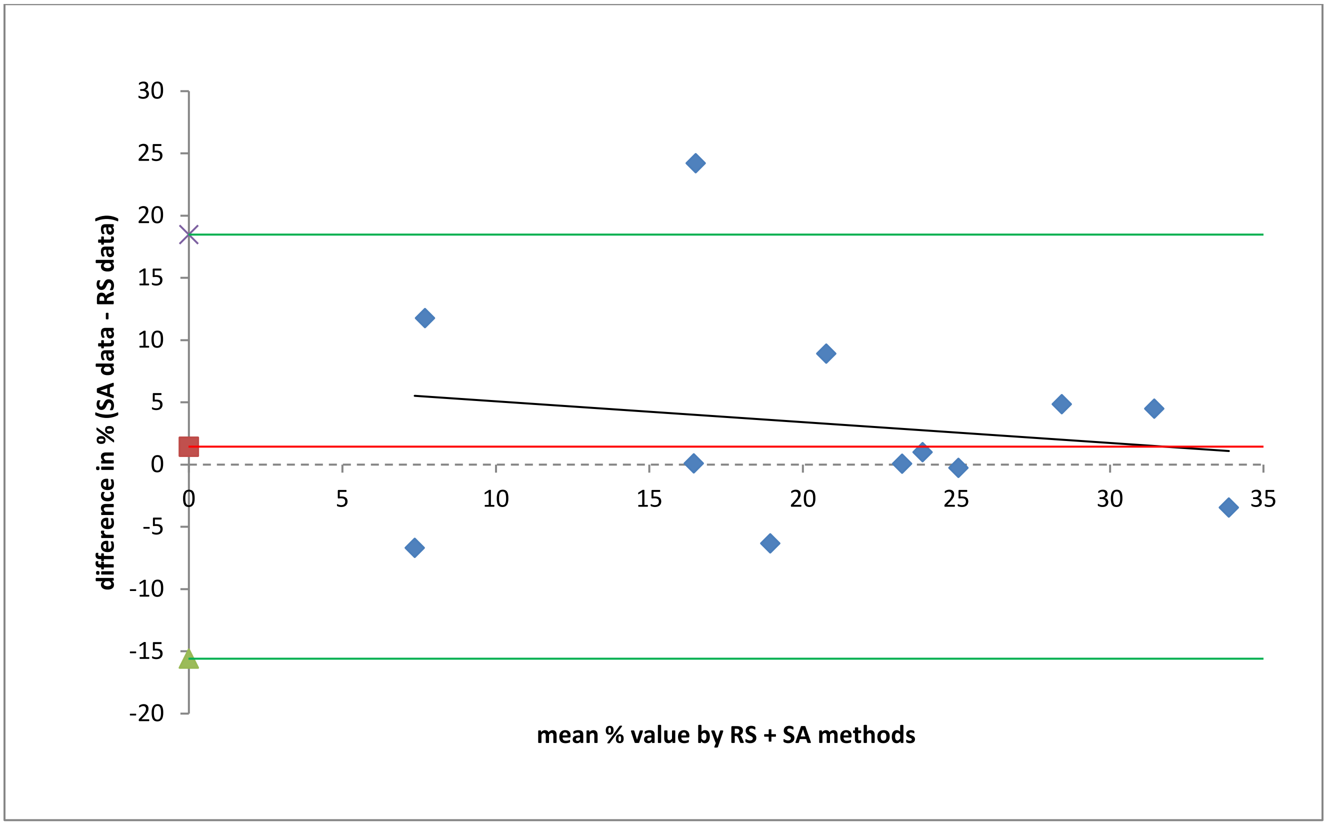


Figure 40 shows the RS method under-estimated natural shade by 1.45% (lower limit: -15.94%, upper limit: 18.83%) compared to the SA method. For mean values and difference values, r was close to zero ($r=0.089$, $p=0.753$).

Built shade:

Figure 41. Scatter plot: Schools at which green-space amount to ≤74% of the total area – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

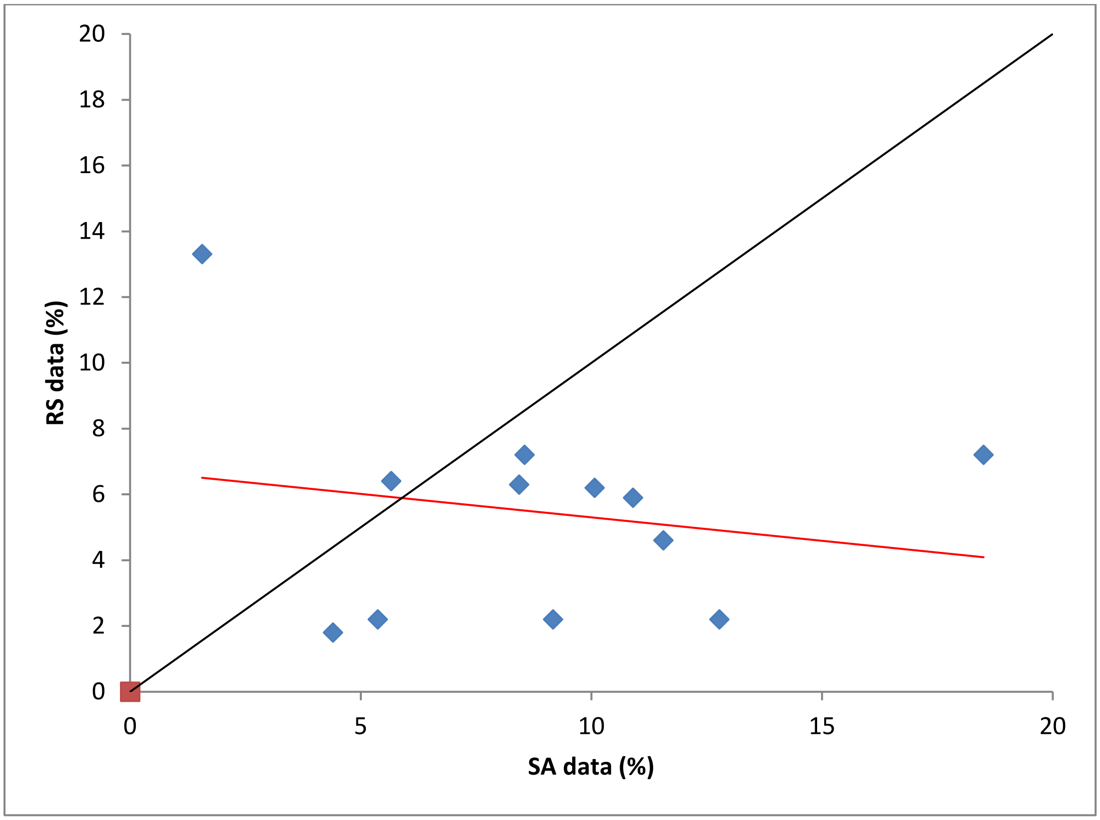


Figure 41 shows the RS method under-estimated built shade at all schools compared to the SA method, except two. For RS and SA data, a non-significant correlation was found (r=0.069, p=0.808).

Figure 42. Bland-Altman plot: Schools at which green-space amount to ≤74% of the total area – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

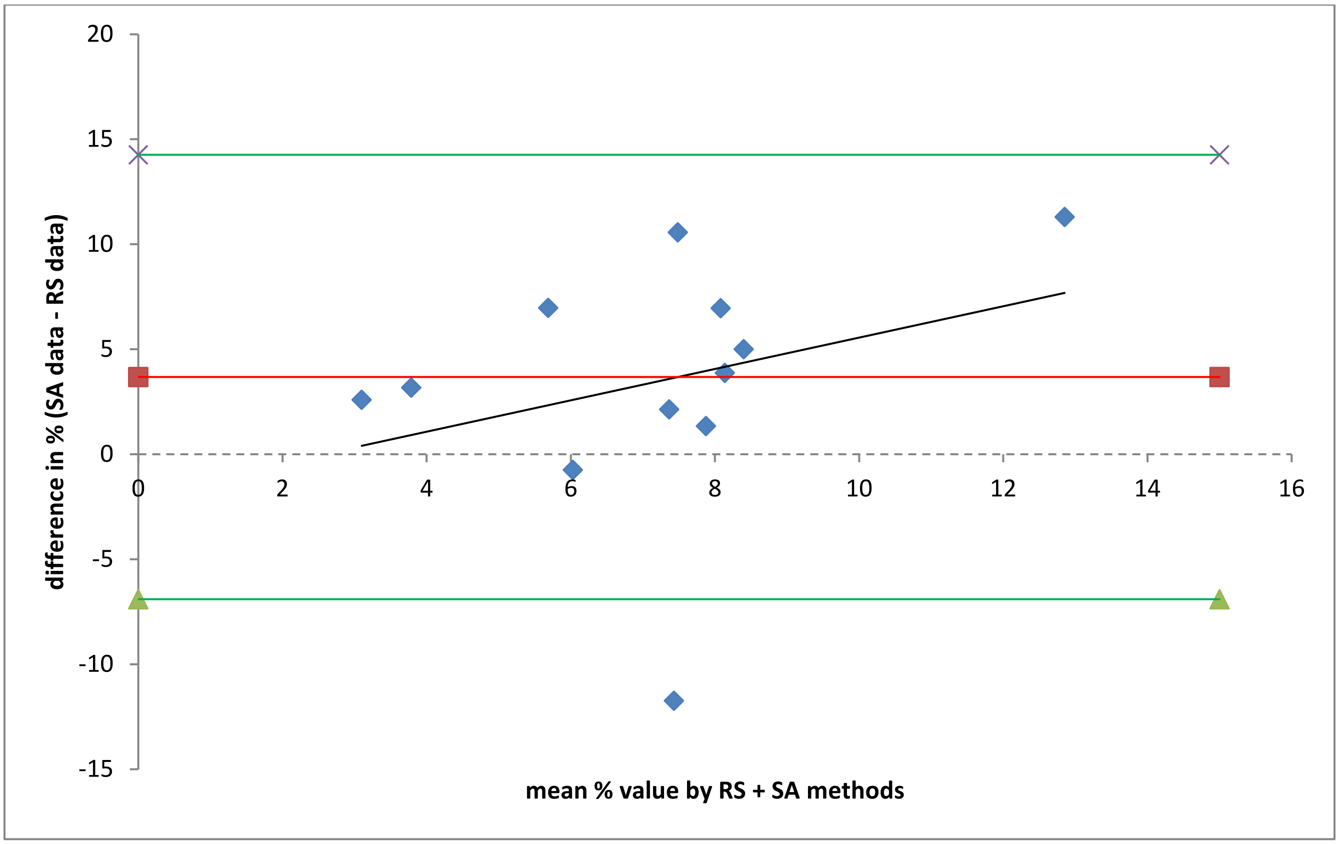


Figure 42 shows the RS method under-estimated built shade by 3.68% (lower limit: -7.12%, upper limit: 14.48%) compared to the SA method. For mean values and difference values, a non-significant correlation was found ($r=0.232$, $p=0.405$).

Schools at which the green-space amounted to approximately ≥75%

Combined shade:

Figure 43. Scatter plot: Schools at which green-space amount to ≥75% of the total area – combined shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

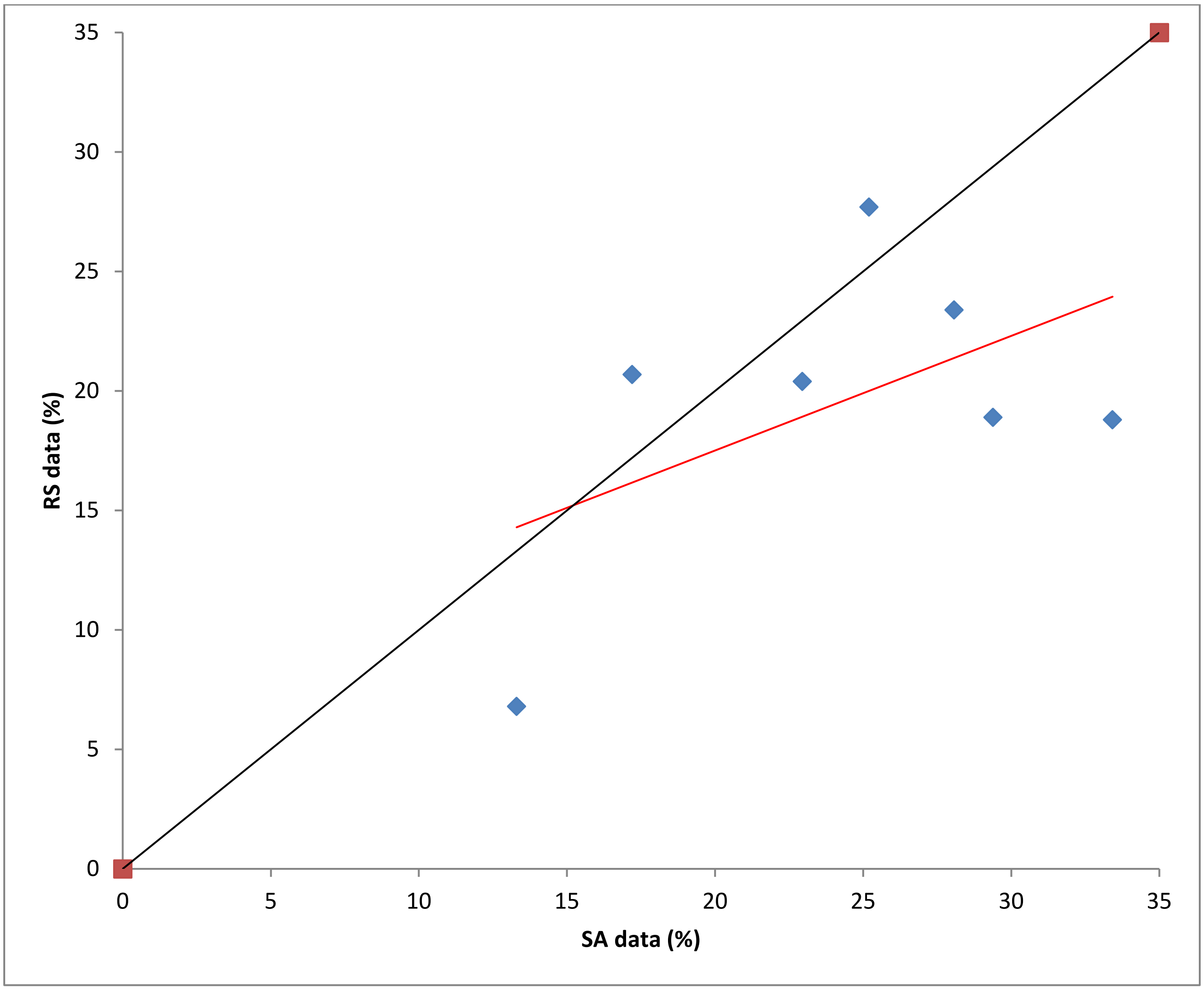


Figure 43 shows the RS method under-estimated combined shade for most schools compared to the SA method. For RS and SA data, a non-significant correlation was found (r=0.526, p=0.225).

Figure 44. Bland-Altman plot: Schools at which green-space amount to ≥75% of the total area – combined shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

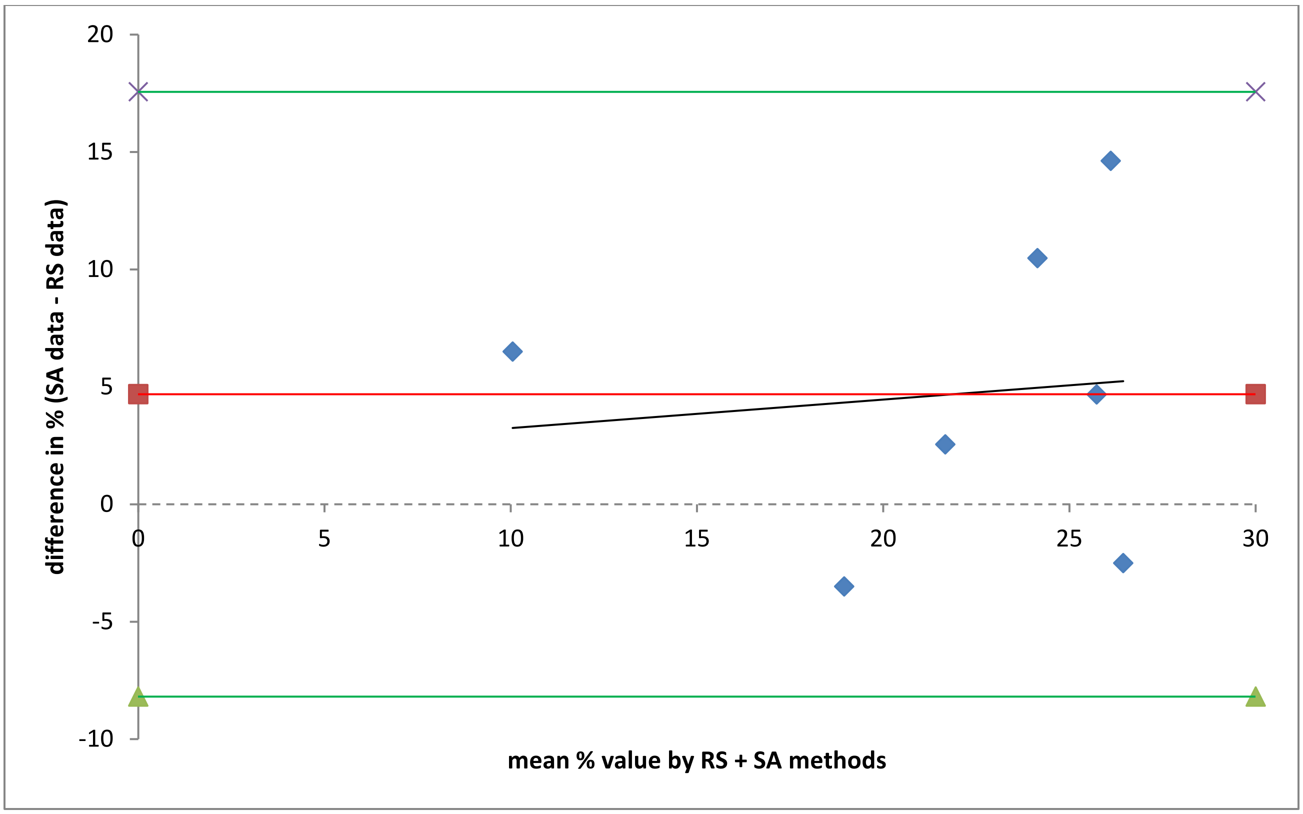


Figure 44 shows the RS method under-estimated combined shade by 4.69% (lower limit: -8.45%, upper limit: 17.83%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.109, p=0.817).

Natural shade:

Figure 45. Scatter plot: Schools at which green-space amount to ≥75% of the total area – natural shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

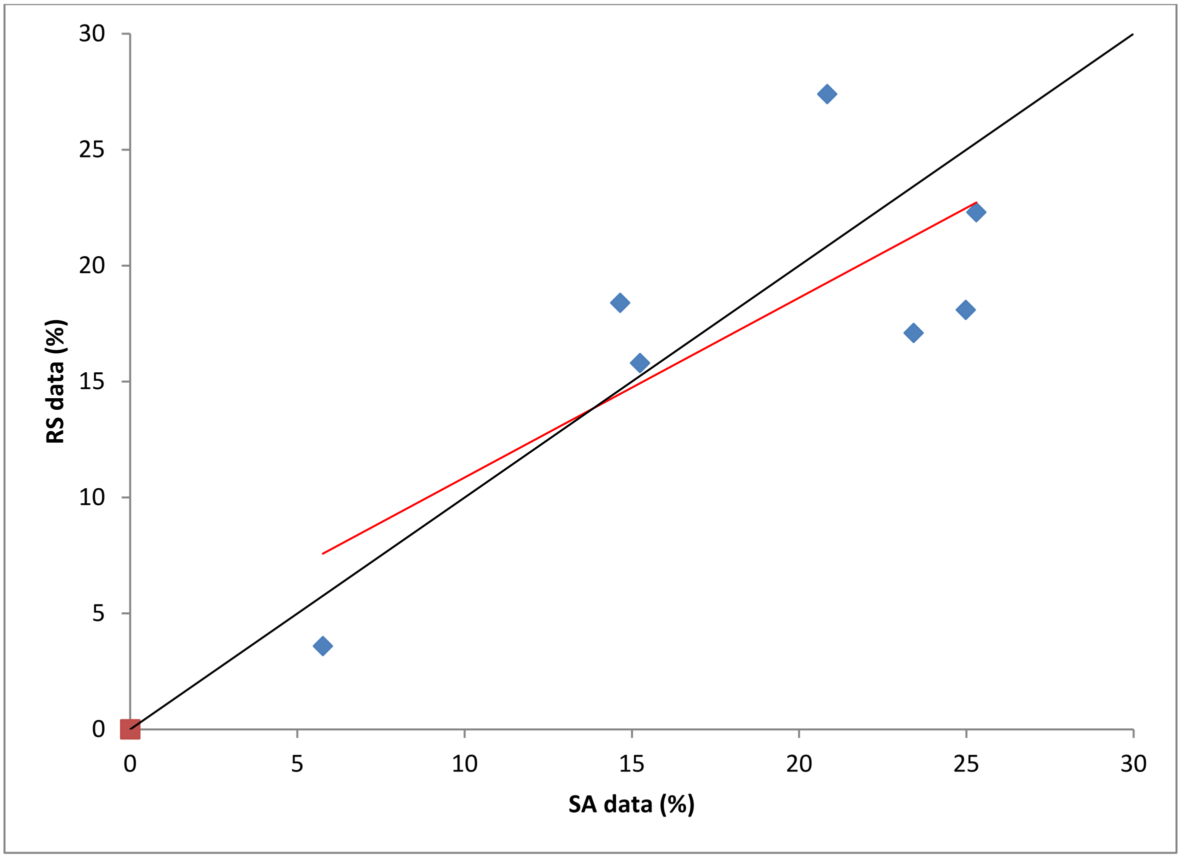


Figure 45 shows the RS method under-estimated natural shade for half the schools compared to the SA method. For RS and SA data, high correlation was found (r=0.759, p=0.048).

Figure 46. Bland-Altman plot: Schools at which green-space amount to ≥75% of the total area – natural shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

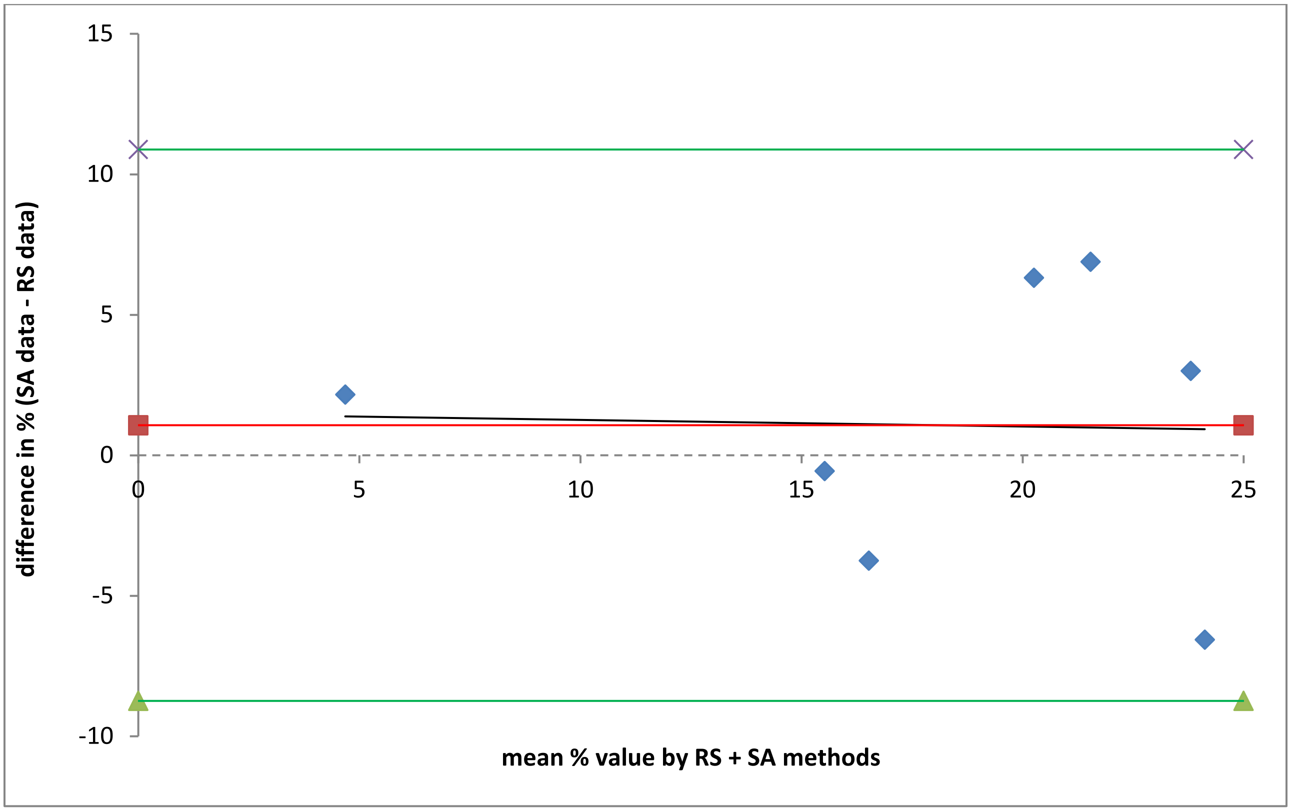


Figure 46 shows the RS method under-estimated natural shade by 1.07% (lower limit: -8.94, upper limit: 11.08%) compared to the SA method. For mean values and difference values, r was close to zero (r=0.032, p=0.946).

Built shade:

Figure 47. Scatter plot: Schools at which green-space amount to ≥75% of the total area – built shade at 11am, 1st December. WebShade® shade-audit (SA) data and remote shade-estimation (RS) data. Line of equality (black line) and regression line (red line) presented for visual reference.

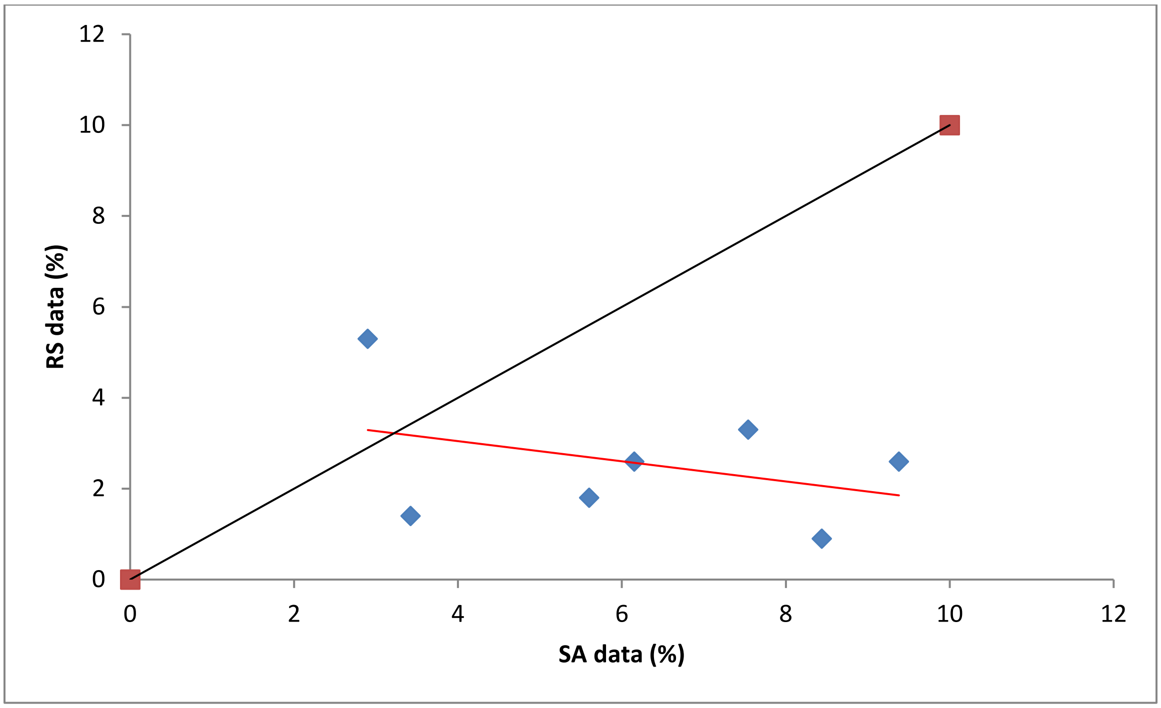


Figure 47 shows the RS method under-estimated built shade at all schools, except for one, compared to the SA method. For SA and RS data, a non-significant correlation was found ($r=0.372$, $p=0.411$).

Figure 48. Bland-Altman plot: Schools at which green-space amount to ≥75% of the total area – built shade at 11am, 1st December. Difference values (that is, difference between the WebShade® shade-audit (SA) data and the remote shade-estimation (RS) data) plotted against mean values (that is, the mean value of SA and RS data). Reference lines are represented by black (regression line), red (mean of differences), green (lower and upper limits) and dotted lines (zero difference line).

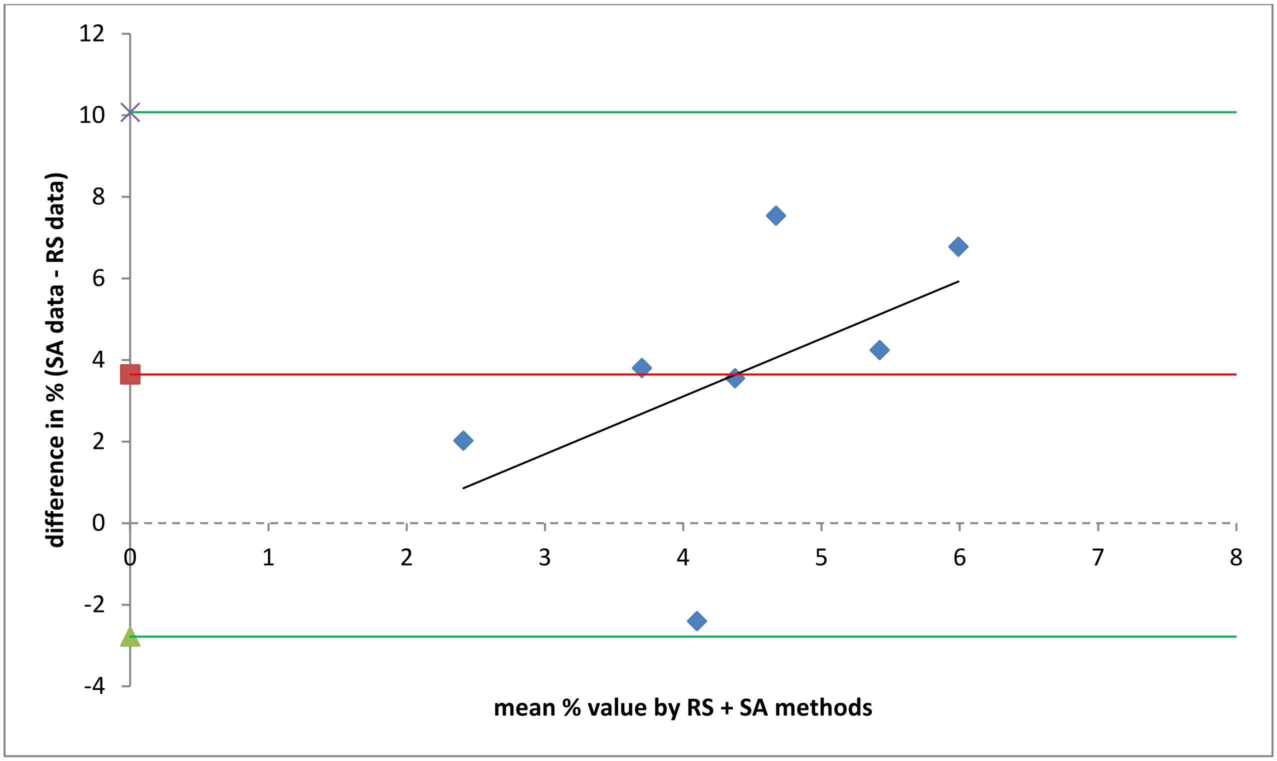


Figure 48 shows the RS method under-estimated built shade by 3.65% (lower limit: -2.92%, upper limit: 10.21%) compared to the SA method. For mean values and difference values, a non-significant correlation was found (r=0.504, p=0.249).

Figures of scatter plots and Bland-Altman plots are not shown for remaining comparisons (i.e. 11am for 1st of March, June and September respectively and 1:30pm for 1st December, March, June and September respectively). In total, 432 plots were created and it seemed impractical to provide all plots since each figure usually required a separate page to be adequately viewed.

Reference list

1. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;8(1):307-10.

2. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999;8:135-60.

Appendix 5.3. Additional shade-related data from study 3.

Table 1. The percent of usable school grounds shaded by ‘combined’, ‘natural’ and ‘built’ shade at 11am for the 1st of March: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			**Natural shade (%)**			**Built shade (%)**		
School ID	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**
A	8.96	10.40	-1.44	3.74	7.90	-4.16	5.79	3.30	2.49
B	18.29	15.60	2.69	12.63	14.80	-2.17	5.98	2.20	3.78
C	22.98	21.50	1.48	14.73	18.80	-4.07	9.44	3.40	6.04
D	41.67	35.90	5.77	33.39	30.20	3.19	8.52	7.10	1.42
E	45.21	36.90	8.31	32.66	35.40	-2.74	12.83	2.70	10.13
F	14.97	19.10	-4.13	6.30	18.00	-11.70	8.77	1.90	6.87
G	31.63	26.70	4.93	23.30	23.20	0.10	9.63	3.30	6.33
H	13.72	7.50	6.22	5.94	3.70	2.24	7.79	3.60	4.19
I	20.51	24.40	-3.89	15.96	22.90	-6.94	5.55	2.50	3.05
J	25.14	28.10	-2.96	20.79	27.80	-7.01	5.88	2.20	3.68
K	33.20	19.00	14.20	24.38	18.10	6.28	8.78	1.10	7.68
L	14.84	16.10	-1.26	3.90	10.50	-6.60	10.94	7.00	3.94
M	37.06	32.10	4.96	30.24	26.30	3.94	8.86	7.60	1.26
N	29.33	18.70	10.63	23.45	17.00	6.45	6.13	2.70	3.43
O	34.69	27.20	7.49	24.71	24.00	0.71	11.71	5.20	6.51
P	17.35	21.70	-4.35	15.45	16.50	-1.05	3.18	5.70	-2.52
Q	30.13	18.10	12.03	28.50	4.70	23.80	1.73	13.70	-11.97
R	29.88	28.40	1.48	26.76	26.90	-0.14	4.69	2.10	2.59
S	41.58	23.60	17.98	25.97	16.80	9.17	18.81	7.50	11.31
T	24.49	10.10	14.39	13.36	1.70	11.66	11.17	8.60	2.57
U	22.13	23.00	-0.87	16.81	16.70	0.11	6.06	7.40	-1.34
V	28.38	23.70	4.68	25.76	22.70	3.06	3.48	1.50	1.98
Mean (SD)			4.47 (6.52)			1.10 (7.58)			3.34 (4.74)

For 11am on the 1st of March it was found that for combined shade, the differences between the SA and RS data ranged from -4.35% to 17.98%. For natural shade, the differences between the SA and RS data ranged from -11.70% to 23.80%. For built shade, the differences between the SA and RS data ranged from -11.97% to 11.31.

Table 2. The percent of usable school grounds shaded by 'combined', 'natural' and 'built' shade at 11am for the 1st of June: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			**Natural shade (%)**			**Built shade (%)**		
School ID	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**
A	10.16	12.90	-2.74	3.78	9.60	-5.82	7.27	5.30	1.97
B	18.69	16.70	1.99	12.80	16.40	-3.60	6.71	3.50	3.21
C	23.34	25.00	-1.66	14.71	21.00	-6.29	10.39	5.70	4.69
D	41.54	39.60	1.94	33.37	32.20	1.17	8.70	10.10	-1.40
E	44.81	39.40	5.41	33.31	37.30	-3.99	13.06	4.80	8.26
F	17.75	22.20	-4.45	6.94	20.10	-13.16	11.19	4.00	7.19
G	32.14	29.10	3.04	23.48	24.50	-1.02	11.85	6.70	5.15
H	15.31	9.50	5.81	6.80	4.30	2.50	8.52	4.90	3.62
I	21.53	26.80	-5.27	16.89	26.00	-9.11	6.28	3.80	2.48
J	27.73	31.30	-3.57	22.42	30.80	-8.38	7.49	3.90	3.59
K	33.49	20.80	12.69	24.44	19.40	5.04	9.80	1.70	8.10
L	16.88	16.50	0.38	2.89	8.30	-5.41	13.76	9.70	4.06
M	39.21	35.60	3.61	31.47	29.40	2.07	10.33	9.60	0.73
N	27.61	20.10	7.51	21.85	18.10	3.75	6.53	3.90	2.63
O	34.85	29.70	5.15	24.40	26.00	-1.60	13.43	8.40	5.03
P	14.34	24.20	-9.86	10.74	19.00	-8.26	4.16	6.70	-2.54
Q	30.88	20.50	10.38	28.81	5.40	23.41	2.13	15.70	-13.57
R	35.44	31.70	3.74	33.55	30.00	3.55	5.80	3.00	2.80
S	40.30	27.30	13.00	26.28	19.10	7.18	19.96	9.50	10.46
T	24.64	11.30	13.34	13.93	1.90	12.03	10.85	9.90	0.95
U	22.37	25.10	-2.73	16.83	16.60	0.23	7.54	10.20	-2.66
V	29.64	26.20	3.44	27.14	25.00	2.14	3.69	1.90	1.79
Mean (SD)			2.78 (6.23)			-0.16 (7.99)			2.57 (4.91)

For 11am on the 1st of June it was found that for combined shade, the differences between the SA and RS data ranged from -9.86% to 13.34%. For natural shade, the differences between the SA and RS data ranged from -13.16% to 23.41%. For built shade, the differences between the SA and RS data ranged from -13.57% to 10.46%.

Table 3. The percent of usable school grounds shaded by 'combined', 'natural' and 'built' shade at 11am for the 1st of September: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			**Natural shade (%)**			**Built shade (%)**		
School ID	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**
A	9.35	11.50	-2.15	3.65	8.50	-4.85	6.43	4.20	2.23
B	18.38	15.90	2.48	12.56	15.20	-2.64	6.30	2.80	3.50
C	23.10	23.00	0.10	14.62	19.50	-4.88	9.91	4.50	5.41
D	41.44	37.40	4.04	33.19	30.70	2.49	8.55	8.50	0.05
E	45.41	37.90	7.51	32.90	36.00	-3.10	12.96	3.70	9.26
F	16.12	20.20	-4.08	6.57	18.60	-12.03	9.74	2.90	6.84
G	31.76	28.10	3.66	23.20	23.70	-0.50	10.59	4.70	5.89
H	14.16	8.20	5.96	6.16	3.90	2.26	8.00	4.10	3.90
I	20.79	25.40	-4.61	16.20	24.10	-7.90	5.83	3.10	2.73
J	26.08	29.20	-3.12	21.28	28.70	-7.42	6.55	3.00	3.55
K	32.78	19.50	13.28	24.02	18.50	5.52	9.03	1.30	7.73
L	15.23	15.80	-0.57	3.29	8.90	-5.61	11.94	7.80	4.14
M	37.86	33.60	4.26	30.63	27.50	3.13	9.43	8.40	1.03
N	27.74	19.10	8.64	21.96	17.20	4.76	6.30	3.30	3.00
O	34.27	28.20	6.07	24.11	24.80	-0.69	12.35	6.60	5.75
P	13.47	22.70	-9.23	10.18	17.30	-7.12	3.59	6.10	-2.51
Q	30.46	18.90	11.56	28.59	5.00	23.59	1.90	14.30	-12.40
R	32.44	30.10	2.34	29.83	28.30	1.53	5.16	2.60	2.56
S	40.70	24.90	15.80	25.94	17.80	8.14	19.11	7.70	11.41
T	24.28	10.30	13.98	13.54	1.60	11.94	10.79	9.00	1.79
U	21.81	23.80	-1.99	16.42	16.30	0.12	6.62	8.80	-2.18
V	29.05	24.40	4.65	26.47	23.20	3.27	3.58	1.60	1.98
Mean (SD)			3.58 (6.55)			0.46 (7.74)			2.99 (4.79)

For 11am on the 1st of September it was found that for combined shade, the differences between the SA and RS data ranged from -9.23% to 15.80%. For natural shade, the differences between the SA and RS data ranged from -12.03% to 23.59%. For built shade, the differences between the SA and RS data ranged from -12.40% to 11.41%.

Table 4. The percent of usable school grounds shaded by 'combined', 'natural' and 'built' shade at 1:30pm for the 1st of December: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

School ID	Combined shade (%) SA	RS	difference (SA-RS)	Natural shade (%) SA	RS	difference (SA-RS)	Built shade (%) SA	RS	difference (SA-RS)
A	8.89	9.70	-0.81	3.72	7.60	-3.88	5.63	3.00	2.63
B	19.04	17.00	2.04	13.51	16.50	-2.99	6.00	2.00	4.00
C	22.17	20.20	1.97	13.94	18.00	-4.06	9.49	3.00	6.49
D	41.88	34.30	7.58	33.66	28.00	5.66	8.61	6.90	1.71
E	43.23	37.80	5.43	30.87	37.30	-6.43	12.56	2.50	10.06
F	14.73	18.20	-3.47	6.35	17.30	-10.95	8.50	1.60	6.90
G	31.24	26.60	4.64	23.59	24.80	-1.21	9.59	2.40	7.19
H	13.38	7.30	6.08	5.87	3.80	2.07	7.50	3.60	3.90
I	19.43	22.90	-3.47	15.18	21.60	-6.42	5.44	2.40	3.04
J	25.57	28.50	-2.93	21.04	28.50	-7.46	5.80	1.90	3.90
K	33.68	19.80	13.88	26.03	18.90	7.13	8.69	1.10	7.59
L	13.85	13.40	0.45	2.59	7.50	-4.91	11.26	6.50	4.76
M	36.85	32.70	4.15	30.17	26.80	3.37	8.56	7.40	1.16
N	28.61	18.40	10.21	23.38	17.00	6.38	6.08	2.60	3.48
O	33.15	26.40	6.75	23.21	23.10	0.11	11.69	5.00	6.69
P	18.13	20.80	-2.67	15.26	15.60	-0.34	3.21	5.40	-2.19
Q	31.05	17.80	13.25	29.43	4.60	24.83	1.68	13.50	-11.82
R	29.15	27.00	2.15	25.20	25.30	-0.10	4.62	2.10	2.52
S	40.17	24.50	15.67	23.52	17.90	5.62	18.41	7.00	11.41
T	23.10	8.90	14.20	12.20	2.30	9.90	11.07	7.10	3.97
U	20.85	21.40	-0.55	15.34	15.30	0.04	5.75	6.90	-1.15
V	28.53	24.00	4.53	25.58	22.90	2.68	3.38	1.40	1.98
Mean (SD)			4.50 (6.00)			0.87 (7.56)			3.56 (4.73)

For 1:30pm on the 1st of December, it was found that for combined shade the differences between the SA and RS data ranged from-3.47% to 15.67%. For natural shade, the differences between the SA and RS data ranged from -10.95% to 24.83%. For built shade, the differences between the SA and RS data ranged from -11.82% to 11.41%.

Table 5. The percent of usable school grounds shaded by 'combined', 'natural' and 'built' shade at 1:30pm for the 1st of March: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			**Natural shade (%)**			**Built shade (%)**		
School ID	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**
A	8.66	9.70	-1.04	3.57	7.50	-3.93	5.54	3.00	2.54
B	18.64	16.30	2.34	13.19	16.00	-2.81	5.90	2.00	3.90
C	21.99	20.40	1.59	13.86	18.10	-4.24	9.39	3.10	6.29
D	41.36	34.60	6.76	32.97	28.20	4.77	8.56	7.00	1.59
E	43.69	37.50	6.19	31.29	36.80	-5.51	12.55	2.40	10.15
F	14.78	18.10	-3.32	6.35	17.30	-10.95	8.53	1.60	6.93
G	31.41	27.30	4.11	23.79	24.70	-0.91	9.57	2.70	6.87
H	13.20	7.20	6.00	5.84	3.70	2.14	7.37	3.50	3.87
I	19.63	23.10	-3.47	15.33	21.80	-6.47	5.49	2.60	2.89
J	25.41	28.60	-3.19	20.79	28.40	-7.61	5.87	2.20	3.67
K	33.74	19.50	14.24	25.62	18.70	6.92	8.76	1.00	7.76
L	13.24	12.70	0.54	2.34	6.70	-4.36	10.90	6.50	4.40
M	37.04	32.50	4.54	30.40	26.80	3.60	8.44	7.30	1.14
N	28.36	18.10	10.26	22.99	16.60	6.39	6.05	2.60	3.45
O	33.24	27.10	6.14	23.31	23.50	-0.19	11.71	5.40	6.31
P	17.74	20.80	-3.06	15.31	15.70	-0.39	2.96	5.30	-2.34
Q	30.85	17.40	13.45	29.16	4.50	24.66	1.65	13.30	-11.65
R	30.48	28.10	2.38	27.15	26.40	0.75	4.44	2.00	2.44
S	39.39	24.10	15.29	23.49	17.60	5.89	18.23	7.00	11.23
T	22.87	7.60	15.27	12.09	2.10	9.99	10.91	5.80	5.11
U	20.69	21.30	-0.61	15.37	15.20	0.17	5.65	6.70	-1.05
V	28.90	23.80	5.10	26.00	22.60	3.40	3.37	1.30	2.07
Mean (SD)			4.52 (6.11)			0.97 (7.48)			3.52 (4.69)

For 1:30pm on the 1st of March it was found that for combined shade, the differences between the SA and RS data ranged from-3.47% to 15.29%. For natural shade the differences between the SA and RS data ranged from -10.95% to 24.66%. For built shade, the differences between the SA and RS data ranged from -11.65% to 11.23%

Table 6. The percent of usable school grounds shaded by 'combined', 'natural' and 'built' shade at 1:30pm for the 1st of June: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

	Combined shade (%)			**Natural shade (%)**			**Built shade (%)**		
School ID	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**	**SA**	**RS**	**difference (SA-RS)**
A	9.98	12.70	-2.72	3.68	9.50	-5.82	7.23	5.40	1.83
B	19.34	18.10	1.24	13.45	17.80	-4.35	6.85	3.80	3.05
C	22.02	24.00	-1.98	13.54	20.30	-6.76	10.53	6.00	4.53
D	41.46	39.10	2.36	32.91	30.80	2.11	8.91	10.40	-1.49
E	43.45	40.50	2.95	32.08	39.30	-7.22	12.97	5.10	7.87
F	18.09	22.20	-4.11	7.21	20.00	-12.79	11.20	4.50	6.70
G	31.74	30.00	1.74	23.73	26.50	-2.77	12.16	6.40	5.76
H	15.19	9.30	5.89	6.84	4.40	2.44	8.33	5.10	3.23
I	20.46	25.60	-5.14	16.13	24.80	-8.67	6.37	3.90	2.47
J	27.76	32.00	-4.24	22.58	32.00	-9.42	7.66	3.90	3.76
K	34.42	22.10	12.32	26.09	20.80	5.29	11.30	1.90	9.40
L	14.14	15.90	-1.76	1.51	8.00	-6.49	12.37	8.80	3.57
M	38.68	35.60	3.08	31.22	30.00	1.22	9.83	9.30	0.53
N	25.66	19.20	6.46	20.26	17.80	2.46	6.41	3.70	2.71
O	33.74	30.40	3.34	23.22	26.10	-2.88	13.63	8.70	4.93
P	14.76	23.70	-8.94	11.05	18.30	-7.25	4.64	6.80	-2.16
Q	31.26	20.10	11.16	28.97	5.90	23.07	2.39	15.40	-13.01
R	36.90	32.50	4.40	34.48	30.30	4.18	5.95	3.30	2.65
S	38.47	26.80	11.67	23.66	19.20	4.46	20.00	10.70	9.30
T	23.02	16.50	6.52	11.16	2.60	8.56	12.25	15.10	-2.85
U	21.57	24.10	-2.53	15.11	15.20	-0.09	7.43	10.20	-2.77
V	30.73	27.10	3.63	28.21	25.70	2.51	3.51	1.70	1.81
Mean (SD)			2.06 (5.66)			-0.83 (7.78)			2.36 (4.89)

For 1:30pm on the 1st of June it was found that for combined shade, the differences between the SA and RS data ranged from -8.94% to 12.32%. For natural shade, the differences between the SA and RS data ranged from -12.79% to 23.07%. For built shade, the differences between the SA and RS data ranged from -13.01% to 9.30%.

Table 7. The percent of usable school grounds shaded by ‘combined’, ‘natural’ and ‘built’ shade at 1:30pm for the 1st of September: a comparison of shade-audit (SA) and remote shade-estimation (RS) values.

School ID	Combined shade (%) SA	RS	difference (SA-RS)	Natural shade (%) SA	RS	difference (SA-RS)	Built shade (%) SA	RS	difference (SA-RS)
A	9.21	11.00	-1.79	3.53	8.20	-4.67	6.38	4.10	2.28
B	18.97	17.10	1.87	13.24	16.70	-3.46	6.36	2.90	3.46
C	21.92	22.00	-0.08	13.60	18.80	-5.20	9.91	4.60	5.31
D	41.32	36.80	4.52	32.77	29.20	3.57	8.73	8.70	0.03
E	43.60	38.80	4.80	31.51	37.70	-6.19	12.70	3.80	8.90
F	16.19	19.90	-3.71	6.71	18.30	-11.59	9.65	3.00	6.65
G	31.53	28.90	2.63	23.57	25.40	-1.83	10.75	4.40	6.35
H	13.99	8.10	5.89	6.17	3.90	2.27	7.82	4.20	3.62
I	19.85	24.10	-4.25	15.53	22.90	-7.37	5.89	3.30	2.59
J	26.33	29.80	-3.47	21.43	29.60	-8.17	6.70	3.00	3.70
K	33.76	20.50	13.26	25.72	19.50	6.22	9.73	1.30	8.43
L	13.18	13.70	-0.52	1.75	6.80	-5.05	11.17	7.50	3.67
M	37.52	33.80	3.72	30.46	28.00	2.46	9.02	8.30	0.72
N	26.21	18.30	7.91	20.83	16.70	4.13	6.21	3.10	3.11
O	33.10	28.70	4.40	22.80	24.60	-1.80	12.61	7.00	5.61
P	13.66	22.20	-8.54	10.41	16.70	-6.29	3.80	6.10	-2.30
Q	31.10	18.50	12.60	29.01	5.20	23.81	2.05	14.00	-11.95
R	33.38	30.30	3.08	30.37	28.30	2.07	5.15	2.60	2.55
S	38.57	25.40	13.17	23.21	18.30	4.91	18.96	8.70	10.26
T	22.69	12.40	10.29	11.28	2.30	8.98	11.65	10.80	0.85
U	20.68	22.60	-1.92	14.84	14.90	-0.06	6.46	8.50	-2.04
V	29.85	25.10	4.75	27.08	23.80	3.28	3.44	1.50	1.94
Mean (SD)			3.11 (5.94)			0.00 (7.54)			2.90 (4.64)

For 1:30pm on the 1st of September it was found that for combined shade, the differences between the SA and RS data ranged from -8.54% to 13.26%. For natural shade, the differences between the SA and RS data ranged from -11.59% to 23.81%. For built shade, the differences between the SA and RS data ranged from -11.95% to 10.26%

Appendix 6. Additional hat-use at school-related data from study 4.

Notes:

- Overall refers to the average hat-wearing proportion using a combination of all available before, after and during school hours data for each school.
- Before hours (hrs) refers to hat-wearing proportions immediately before school commencement as students entered school property.
- After hrs refers to hat-wearing proportions at school dismissal time as students exited school property.
- During hrs refers to hat-wearing proportions during school hours, e.g. recess periods.
- Any hat refers to all hat styles including cap, visors, bucket, broad-brim and legionnaire styles.
- GSH – refers to ‘gold standard hat’ i.e. Bucket, broad-brim and legionnaire style hats only.
- School characteristics as described in chapter 6.2 (and school descriptive table has been copied below as a reference).
- SSS = SunSmart school.
- Gov = Government.
- Government owned schools = Queensland Government publicly owned schools
- Non-government owned schools = independently or privately funded schools
- * in place of the 75th quartile value in [IQR] represents an incomputable value.

Table 1. School descriptive table (for reference regarding the number of schools in each strata). Index of community socio-educational advantage = ICSEA.

Characteristic		All eligible schools (n=36) N (%)	SunSmart Schools (n=23) N (%)	Non-SunSmart Schools (n=13) N (%)
Ownership	Government	23 (63.9)	13 (56.5)	10 (76.9)
	Non-Government	13 (13.1)	10 (43.5)	3 (23.1)
School size	Small (≤399 students)	12 (33.3)	7 (30.4)	5 (38.5)
	Medium (400-799 students)	15 (41.7)	9 (39.1)	6 (46.2)
	Large (≥800 students)	9 (25.0)	7 (30.4)	2 (15.4)
ICSEA group	≤ mean (≤1000)	31 (86.1)	18 (78.3)	13 (100)
	> mean (≥1001)	5 (13.9)	5 (21.7)	0 (0)
Sun-protection policy score	≤ median (≤3)	21 (58.3)	11 (47.8)	10 (76.9)
	> median (≥4)	15 (41.7)	12 (52.2)	3 (23.1)

Most schools were government owned (63.9%) and had an ICSEA score that was below 1000 (86.1%) (Table 1).

STUDENT DATA

Table 2: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at 36 Townsville primary schools (considered together as one group): overall, before, after and during school hours.

	Summer				**Winter**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
All schools (any hat)	59.2 [49.8, 77.2]; 13.6 to 100	29.8 [16.6, 55.4]; 7.9 to 95.9	15 [9.4, 31.8]; 4.3 to 94.4	96.4 [91.5, 100]; 30 to 100	55.1 [48.2, 59.6]; 22.1 to 83.4	21.8 [15.5, 51.2]; 0 to 80	20.2 [12.7, 31]; 0 to 66.9	90.5 [85.3, 95.8]; 46.2 to 100
All schools (GSH)	58.5 [40.5, 75.7]; 9.3 to 100	28.6 [15.3, 55.4]; 0 to 95.9	11.1 [6.1, 31.8]; 0 to 94.4	95.7 [88, 100]; 20 to 100	53.7 [47.2, 58.8]; 6.5 to 83.4	19.1 [11.2, 51.1]; 0 to 80	16.3 [9.9, 30.4]; 0 to 66.9	90 [81.5, 95.8]; 10.3 to 100
	Autumn				**Spring**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
All schools (any hat)	46.6 [40.8, 63.2]; 16 to 88.5	19.8 [10.1, 33.9]; 0 to 79	24.2 [14, 39.3]; 6.3 to 76.5	92.9 [86.8, 97.5]; 49.3 to 100	55.6 [49.6, 62.1]; 25.2 to 100	21.4 [12.7, 25]; 9.4 to 70	19.4 [11.4, 40]; 5 to 88.2	95.6 [85.6, 100]; 30 to 100
All schools (GSH)	45.6 [37.4, 60]; 16 to 88.5	16.6 [9.1, 29.7]; 0 to 77.6	17.8 [14, 35.3]; 6.3 to 76.5	92.3 [86.2, 97.4]; 30.2 to 100	53.8 [47.1, 58.9]; 12.5 to 95.7	19.1 [9.5, 25]; 0 to 70.1	18.5 [11.3, 30]; 0 to 88.2	94.1 [85, 97.7]; 25 to 100

The median student hat-wearing rate before school hours when all schools were considered together as one group, was < 30% in summer, < 22% in winter, < 20% in autumn and < 22% in spring, and after hours hat-wearing proportions were usually lower than these. The median hat-wearing proportion during school hours ranged from 90.0% (winter) to 96.4% (summer) (Table 2).

Table 3: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by SunSmart school (SSS) status.

	Summer				Winter			
	overall	before hrs	after hrs	during hrs	overall	before hrs	after hrs	during hrs
SSS (any hat)	63.6 [54.1, 85]; 13.6 to 98	33.1 [17.7, 64]; 7.9 to 95.9	20.7 [10.5, 42.4]; 4.3 to 87.2	96.9 [92.3, 100]; 30 to 100	55.1 [48.2, 59.4]; 22.1 to 83.4	19.8 [14.3, 51.2]; 0 to 80	19.8 [12.5, 28.9]; 0 to 47.6	90.5 [86.8, 95.8]; 54.2 to 100
non-SSS (any hat)	53 [37.7, 65.2]; 18 to 100	22.9 [15.3, 43.1]; 13 to 60.3	13.4 [8.3, 19.3]; 5.3 to 94.4	94.2 [80, 96.8]; 36.4 to 100	54.3 [48.4, 62.6]; 39.8 to 73.6	26 [19, 48.3]; 9.1 to 54	28.5 [13.1, 59.3]; 8.3 to 66.9	91.5 [70.6, 96]; 46.2 to 97.7
P value	0.099	0.393	0.475	0.084	1.000	0.571	0.302	0.668
SSS (GSH)	46.1 [39.9, 63.8]; 16 to 88.5	20.3 [10, 34.2]; 9.1 to 79	20.7 [13.5, 32.2]; 6.3 to 52.9	92.1 [86.8, 95.7]; 49.3 to 100	56.3 [50.6, 62.7]; 25.2 to 100	20.7 [12.3, 25.6]; 9.5 to 36.1	22.6 [11.4, 59.1]; 9.1 to 88.2	96.3 [92, 100]; 69.2 to 100
non-SSS (GSH)	48.4 [42, 62.8]; 30.2 to 72.5	19.5 [12.3, 32.5]; 0 to 56.9	39.4 [16.8, 71.1]; 12.5 to 76.5	96.6 [87.2, 100]; 74.8 to 100	52 [40.9, 60.2]; 30.6 to 64.3	21.4 [14.2, 46.6]; 9.4 to 70	19.1 [10, 28.5]; 5 to 55.3	86.3 [51.7, 97.5]; 30 to 100
P value	0.053	0.365	0.230	0.005	0.461	0.792	0.677	0.115
	Autumn				**Spring**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
SSS (any hat)	62 [53.2, 83.2]; 13.6 to 98	30.3 [16.6, 61]; 7.9 to 95.9	16.1 [7.9, 42.4]; 4.3 to 87.2	96.9 [92.3, 100]; 30 to 100	54.3 [48.2, 58.8]; 22.1 to 83.4	17.5 [12.2, 51.2]; 0 to 80	19.8 [12.5, 27.7]; 0 to 47.6	90.5 [86.8, 95.8]; 54.2 to 100
non-SSS (any hat)	50.7 [17, 64.3]; 9.3 to 100	22 [13, 45]; 0 to 60.3	8.3 [0, 15]; 0 to 94.4	80 [44.1, 95]; 20 to 100	52.7 [20.9, 59.7]; 6.5 to 73.3	19.7 [9.6, 47.1]; 1 to 53.3	10.8 [3.8, 58.8]; 2.6 to 66.9	84.4 [35.6, 95.6]; 10.3 to 97.7
P value	0.721	0.779	0.109	0.107	0.151	0.953	0.548	0.074
SSS (GSH)	45.4 [35.4, 60.4]; 16 to 88.5	16.9 [9.8, 29.8]; 6.6 to 77.6	16.9 [13.5, 28.8]; 6.3 to 52.9	92.1 [86.8, 95.7]; 49.3 to 100	56.3 [50.6, 62.1]; 25.2 to 95.7	20.7 [11.3, 25.6]; 9.5 to 36.1	22.6 [11.4, 59.1]; 7.6 to 88.2	95.8 [92, 100]; 69.2 to 100
non-SSS (GSH)	45.9 [38.4, 61.5]; 16.6 to 72.5	15.4 [7.7, 31.4]; 0 to 56.9	39.4 [16.8, 71.1]; 12.5 to 76.5	95.6 [81.2, 99.4]; 30.2 to 100	49.2 [33.6, 52.6]; 12.5 to 62.3	8.6 [0.8, 44.6]; 0 to 70.1	16 [5.5, 25.9]; 0 to 55.3	84.9 [42, 93.8]; 25 to 97.9
P value	0.922	0.531	0.051	0.379	0.008	0.206	0.213	0.002

SunSmart status was not a predictor of significantly higher hat-wearing proportions among the Townsville primary school student population across the seasons. With the exception of 'during school hours in summer' (non-SSS students were more likely to wear a GSH compared to SSS students) and 'during school hours in spring' (SSS students were more likely to wear their GSH compared to non-SSS), hat-wearing rates were similar (Table 3)

Table 4: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school ownership.

	Summer				**Winter**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
Gov (any hat)	54.4 [39.7, 64.6]; 13.6 to 100	19.6 [14.9, 33.6]; 7.9 to 80.9	13.4 [8.9, 21.7]; 5.3 to 87.2	95.4 [92.3, 100]; 30 to 100	53.8 [44.5, 58.7]; 22.1 to 73.6	19.8 [13.8, 24.6]; 0 to 54	21.4 [14.2, 30]; 8.3 to 56.7	90.3 [85.3, 94.9]; 50 to 97.7
non-Gov (any hat)	73 [59.9, 84.5]; 52.1 to 98	56.3 [34.8, 67.6]; 17 to 95.9	34.5 [11.6, 80.3]; 4.3 to 94.4	96.9 [88, 100]; 36.4 to 100	57.9 [51.4, 70.6]; 48.2 to 83.4	53.4 [37.8, 78.9]; 14.1 to 80	20.2 [11.4, 47.6]; 0 to 66.9	94.6 [83.5, 97]; 46.2 to 100
P value	0.010	0.008	0.234	0.659	0.073	0.020	0.799	0.381
Gov (GSH)	53.6 [19.3, 64.6]; 9.3 to 100	17.2 [13.3, 30.6]; 0 to 80.9	8.7 [6, 14.6]; 0 to 87.2	94.7 [82.8, 99.3]; 20 to 100	53 [39.8, 58.1]; 6.5 to 73.3	15.1 [9.6, 21.1]; 0 to 53.3	15.6 [10.7, 29]; 2.6 to 56.1	89.6 [77.1, 93.3]; 10.3 to 97.7
non-Gvo (GSH)	51.6 [40.2, 69.3]; 32.3 to 88.5	15.4 [9.5, 43]; 8.8 to 56.9	13.8 [12.2, 29.5]; 6.3 to 69.3	94 [80.8, 100]; 49.3 to 100	60.5 [50.2, 82.9]; 36.1 to 94.5	31.7 [16.3, 61.5]; 12.7 to 70	57.2 [23.4, 79.6]; 17.8 to 88.2	94.4 [83.3, 98.7]; 30 to 100
P value	0.344	0.835	0.067	0.474	0.107	0.078	0.002	0.537
	Autumn				**Spring**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
Gov (any hat)	46.1 [42.1, 60.2]; 16 to 72.5	20.1 [17, 30.5]; 0 to 79	31.5 [18.3, 40.8]; 12.5 to 76.5	92.2 [86.8, 96.6]; 50 to 100	54.6 [47.1, 58.6]; 25.2 to 100	20 [11.1, 23.3]; 9.4 to 25	15.3 [10.2, 23.6]; 5 to 28.6	96 [86.8, 100]; 45.8 to 100
non-Gov (any hat)	67 [58.7, 81.7]; 52.1 to 98	56.3 [34.8, 67.6]; 17 to 95.9	34.5 [11.6, 80.3]; 4.3 to 94.4	96.9 [88, 100]; 36.4 to 100	57.9 [50.7, 70.6]; 48.2 to 83.4	53 [37.8, 78.9]; 14.1 to 80	20.2 [6.8, 47.6]; 0 to 66.9	94.6 [83.5, 97]; 46.2 to 100

P value	0.023	0.004	0.104	0.346	0.031	0.009	0.856	0.161
Gov (GSH)	45 [35.4, 57.4]; 16 to 72.5	17.1 [9.2, 28.8]; 0 to 77.6	25.4 [16.9, 39.4]; 12.5 to 76.5	92.1 [86, 95.7]; 30.2 to 100	52.7 [38.1, 56.3]; 12.5 to 95.7	13.1 [8.6, 21.4]; 0 to 25	12.4 [7.6, 22.6]; 0 to 28.3	93.8 [85.2, 96.6]; 25 to 100
non-Gvo (GSH)	51.6 [38.8, 69.3]; 25.1 to 88.5	15.4 [8.1, 42.8]; 6.6 to 56.9	13.8 [12.2, 29.5]; 6.3 to 69.3	94 [80.8, 100]; 49.3 to 100	58.3 [50.2, 82.9]; 36.1 to 94.5	31.7 [15.4, 61.6]; 11.4 to 70.1	57.2 [20.9, 76.8]; 17.8 to 88.2	94.4 [83.3, 98.7]; 30 to 100
P value	0.179	0.945	0.097	0.296	0.053	0.040	0.001	0.913

Non-government school students were more likely to wear any type of hat overall and before school hours in summer and autumn, and before school hours in winter and spring. GSH use was also higher at non-government schools before and after school hours in spring and after school hours in winter (Table 4).

Table 5: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by Index of community socio-educational advantage (ICSEA) group.

	Summer				**Winter**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
≤ average (any hat)	57.6 [46.2, 71.6]; 13.6 to 100	22.9 [15.3, 47]; 7.9 to 80.9	15 [10.3, 29.2]; 5.3 to 94.4	95.8 [89.5, 100]; 30 to 100	53.7 [47.7, 59]; 22.1 to 74.7	21.1 [15.9, 38.7]; 0 to 54	20 [12.5, 34.5]; 0 to 66.9	90.4 [82.1, 95.1]; 46.2 to 97.7
above average (any hat)	83.2 [57.9, 91.5]; 52.1 to 98	70 [34.9, 0]; 34.9 to 95.9	35.3 [4.3, 0]; 4.3 to 66.3	100 [96.2, 100]; 92.3 to 100	59.4 [55.9, 75.7]; 54.8 to 83.4	78.6 [14.1, 0]; 14.1 to 80	23.1 [12.5, 0]; 12.5 to 26	95.7 [87.7, 98.6]; 86.8 to 100
P value	0.128	0.040	0.824	0.068	0.069	0.258	0.814	0.202
≤ average (GSH)	55.8 [36.3, 67]; 9.3 to 100	18.4 [15.3, 47]; 0 to 80.9	11.1 [6.2, 29.2]; 0 to 94.4	95 [80, 97.4]; 20 to 100	52.9 [44.3, 58.7]; 6.5 to 74.7	18.3 [10.4, 37.6]; 0 to 53.3	15.6 [7.9, 34.5]; 0 to 66.9	89.8 [72.2, 95]; 10.3 to 97.7
above average (GSH)	83.2 [57.3, 91.5]; 52.1 to 98	70 [32.6, 0]; 32.6 to 95.9	35.3 [4.3, 0]; 4.3 to 66.3	100 [96.2, 100]; 92.3 to 100	58.5 [55.9, 75.7]; 54.8 to 83.4	78.6 [14.1, 0]; 14.1 to 80	21.2 [12.5, 0]; 12.5 to 26	95.7 [87.7, 98.6]; 86.8 to 100
P value	0.594	0.080	0.200	0.594	0.061	0.933	0.035	0.888
	Autumn				**Spring**			
	overall	**before**	**after**	**during**	**overall**	**before**	**after**	**during**

		hrs	hrs	hrs		hrs	hrs	hrs
≤ average (any hat)	46.6 [40.4, 61.4]; 16 to 74.5	20.6 [14.1, 34.5]; 0 to 79	25.4 [14.6, 40]; 6.3 to 76.5	93.3 [86.8, 98.8]; 49.3 to 100	54.8 [48.1, 60.1]; 25.2 to 100	21.4 [12.3, 25.6]; 9.4 to 70	18.8 [11.3, 28.3]; 5 to 76.8	96 [85.6, 100]; 30 to 100
above average (any hat)	51.6 [37.2, 79.7]; 32.3 to 88.5	9.9 [9.1, 0]; 9.1 to 16.9	12.2 [12.2, 12.2]; 12.2 to 12.2	92.5 [79.7, 95.6]; 70.9 to 97.1	74.9 [53.4, 92.4]; 50.6 to 94.5	20 [20, 20]; 20 to 20	69.8 [28.1, 86.3]; 17.8 to 88.2	92.5 [87, 98.8]; 83.3 to 100
P value	0.086	0.040	1.000	0.040	0.043	0.146	0.814	0.141
≤ average (GSH)	45.4 [37.3, 58.8]; 16 to 74.5	17.3 [9, 31.2]; 0 to 77.6	18.3 [14.6, 37.1]; 6.3 to 76.5	92.2 [86, 97.6]; 30.2 to 100	52.9 [42.1, 58.4]; 12.5 to 95.7	16.1 [9.3, 25.6]; 0 to 70.1	17.9 [9.1, 23.6]; 0 to 76.8	94.4 [84.9, 97.4]; 25 to 100
above average (GSH)	51.6 [37.1, 79.7]; 32.3 to 88.5	9.9 [9.1, 0]; 9.1 to 16.6	12.2 [12.2, 12.2]; 12.2 to 12.2	92.5 [79.7, 95.6]; 70.9 to 97.1	74.9 [53.4, 91.4]; 50.6 to 94.5	20 [20, 20]; 20 to 20	67.9 [28.1, 85.3]; 17.8 to 88.2	92.5 [87, 98.8]; 83.3 to 100
P value	0.371	0.389	0.200	0.756	0.037	0.933	0.035	0.777

ICSEA score was not a consistent predictor of student hat-wearing behaviour at schools. At times, schools with lower ICSEA scores were associated with higher hat-wearing proportions (e.g. before hours during autumn) while at other times, hat-use tended to be higher at schools with higher ICSEA scores (e.g. before school hours in summer) (Table 5).

Table 6: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by sun-protection policy score

	Summer				**Winter**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
≤ median (any hat)	56.2 [47.2, 69.4]; 19.3 to 86.1	31 [18.9, 56]; 13 to 80.9	13.4 [8.4, 25.8]; 5.3 to 66.3	95 [91.2, 100]; 30 to 100	55.3 [47.9, 62.3]; 39.8 to 74.7	22.7 [19, 47.7]; 15.2 to 78.6	24.5 [13.3, 32]; 0 to 66.9	92.1 [83.1, 96.2]; 50 to 97.1
above median (any hat)	62 [52.1, 92.3]; 13.6 to 100	24.6 [14.1, 55.2]; 7.9 to 95.9	19.1 [11.7, 74]; 4.3 to 94.4	97.4 [93, 100]; 36.4 to 100	53.8 [50, 59.6]; 22.1 to 83.4	16.3 [9.2, 51.8]; 0 to 80	19.8 [11.4, 38.2]; 8.3 to 56.7	90 [86.8, 95.8]; 46.2 to 100
P value	0.227	0.616	0.370	0.147	0.780	0.305	0.702	0.934

≤ median (GSH)	54.5 [29.7, 69.1]; 10 to 86.1	28.6 [16.3, 56]; 0 to 80.9	8.5 [3, 22.1]; 0 to 66.3	92.9 [80, 96.9]; 20 to 100	54.6 [45.2, 58.6]; 6.5 to 74.7	20.4 [15, 47.2]; 1 to 78.6	14.1 [6.3, 31.3]; 0 to 66.9	89.6 [78.2, 96.2]; 10.3 to 97.1
above median (GSH)	44.4 [32.7, 61.4]; 16 to 74.5	19.7 [10, 34.2]; 9.3 to 79	18.3 [12.5, 34.3]; 6.3 to 76.5	93.4 [73.9, 100]; 49.3 to 100	54.6 [49.6, 62.1]; 25.2 to 100	23.8 [9.5, 36.1]; 9.4 to 70	16.6 [10.8, 28.8]; 5 to 88.2	96.1 [84.9, 99]; 30 to 100
P value	0.279	0.879	0.261	1.000	0.730	0.694	0.343	0.986

	Autumn				**Spring**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
≤ median (any hat)	46.9 [44, 64.3]; 30.2 to 88.5	20.4 [13, 32.5]; 0 to 56.9	31.5 [16, 46.5]; 12.5 to 69.3	92.5 [88, 96.1]; 74.8 to 100	55.9 [49.2, 62.1]; 30.6 to 90.3	20.7 [15.8, 22.8]; 11.1 to 25	22.6 [14.6, 57.2]; 8.2 to 80.5	94.8 [86, 100]; 34.6 to 100
above median (any hat)	59.2 [52.1, 92.3]; 9.3 to 100	24.6 [14.1, 55.2]; 7.9 to 95.9	16.1 [7.5, 74]; 4.3 to 94.4	97.4 [93, 100]; 36.4 to 100	53.1 [49.6, 59]; 22.1 to 83.4	12.9 [9.3, 51.1]; 0 to 80	19.8 [9.9, 37.6]; 6.8 to 56.1	90 [86.8, 95.8]; 46.2 to 100
P value	0.347	0.973	0.200	0.054	0.856	0.384	0.651	0.499
≤ median (GSH)	45.9 [40.7, 61.8]; 16.6 to 88.5	16.6 [8.6, 32.1]; 0 to 56.9	29.5 [16, 45]; 12.5 to 69.3	92.2 [86.8, 95.6]; 30.2 to 100	53.3 [44.3, 59.4]; 12.5 to 88.3	16.1 [4, 21]; 0 to 25	18.8 [9.5, 57.2]; 0 to 76.8	91.6 [84.8, 97.6]; 25 to 100
above median (GSH)	41.2 [32.3, 60.4]; 16 to 74.5	16.3 [9.8, 27.5]; 6.6 to 77.6	16.8 [12.5, 25.4]; 6.3 to 76.5	93.4 [73.9, 100]; 49.3 to 100	54.6 [48.8, 58.6]; 25.2 to 95.7	23.8 [9.5, 36.1]; 8.6 to 70.1	15.6 [10.8, 25.2]; 5 to 88.2	95.8 [84.9, 97.9]; 30 to 100
P value	0.427	0.913	0.131	0.680	0.856	0.281	0.648	0.545

Student hat-wearing rates at schools with above and below median sun-protection policy scores were not significantly different (Table 6).

Table 7: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by student enrolment figure.

	Summer				**Winter**			
student #	**overall**	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
≤ 399 (any hat)	62 [46.1, 64.6]; 13.6 to 96.8	32.8 [14.9, 44.6]; 13.6 to 60.3	11.8 [7.6, 30.5]; 5.3 to 34.5	93.7 [85.2, 96.8]; 30 to 100	50.9 [43.6, 58.8]; 38.7 to 70.7	21.1 [5.3, 27.4]; 0 to 29.5	23.1 [19.8, 47.6]; 12.9 to 66.9	82.4 [57.6, 95.7]; 50 to 97.4
400-799 (any hat)	58.5 [52.1, 83.2]; 18 to 100	19.6 [17.7, 40.1]; 15.3 to 80.9	19.1 [11, 55.4]; 4.3 to 94.4	96.3 [91.8, 100]; 36.4 to 100	54.8 [50, 58.1]; 42 to 73.6	22.5 [14.1, 53.8]; 9.1 to 54	16.2 [11.6, 32]; 0 to 56.7	93.3 [89.6, 96.4]; 46.2 to 100
800+ (any hat)	75.7 [46.9, 88.7]; 34.8 to 98	54.6 [13, 70]; 7.9 to 95.9	13.4 [11.1, 0]; 11.1 to 87.2	97.4 [94.6, 100]; 80 to 100	63.3 [53, 72.5]; 22.1 to 83.4	31.7 [17.5, 65.8]; 9.7 to 80	18.7 [11.5, 0]; 11.5 to 26	90.5 [87.3, 95.3]; 86.4 to 96.4
P value	0.602	0.748	0.662	0.127	0.174	0.537	0.388	0.200
≤ 399 (GSH)	62 [26.1, 64.6]; 13.6 to 96.8	32.6 [22.2, 49.8]; 13.6 to 60.3	11.8 [6.2, 30.5]; 0 to 34.5	93.7 [73, 96.8]; 30 to 100	50.9 [39.8, 58.7]; 6.5 to 70.7	21.1 [5.3, 27.4]; 0 to 29.5	20.2 [12.9, 47.6]; 2.6 to 66.9	82.4 [54.2, 95.7]; 10.3 to 97.4
400-799 (GSH)	56.7 [40.5, 66]; 9.3 to 100	17.7 [16, 38.4]; 0 to 80.9	11.2 [6, 54.4]; 4.3 to 94.4	96.3 [89.4, 100]; 20 to 100	54.3 [49.6, 58.1]; 14.6 to 73.3	15.2 [11.1, 52.9]; 9.1 to 53.3	14.1 [7.2, 31.7]; 0 to 56.1	91.3 [85.3, 96.4]; 32.1 to 100
800+ (GSH)	75.7 [46.7, 88.7]; 17.8 to 98	40.9 [13, 67]; 7.9 to 95.9	11.1 [0, 0]; 0 to 87.2	96.9 [86.4, 100]; 46.7 to 100	53.7 [37.3, 72.5]; 7.6 to 83.4	18.3 [10.7, 65.8]; 1 to 80	18.7 [11.5, 0]; 11.5 to 26	88.6 [86.6, 95.3]; 14.3 to 96.4
P value	0.988	0.446	0.148	0.031	0.708	0.807	0.218	0.360
	Autumn				**Spring**			
	overall	**before hrs**	**after hrs**	**during hrs**	**overall**	**before hrs**	**after hrs**	**during hrs**
≤ 399 (any hat)	47.6 [40.8, 63.2]; 26.1 to 72.5	27.1 [9, 51.7]; 0 to 79	16.7 [12.5, 40]; 6.3 to 69.3	86.8 [75.2, 94.4]; 49.3 to 100	55.6 [48.4, 62.1]; 33.6 to 100	21.4 [12.7, 25]; 11.1 to 27.3	26.7 [20.3, 48.6]; 18.8 to 55.3	96.3 [69.2, 100]; 34.6 to 100
400-799 (any hat)	45.7 [39.9, 64.8]; 32.3 to 88.5	17.1 [9.9, 20.8]; 9.3 to 33.3	35.7 [26.4, 50.1]; 12.2 to 76.5	95.7 [91.7, 100]; 88.5 to 100	55.1 [50.1, 59.6]; 30.6 to 74.9	16.9 [10.7, 57.3]; 9.4 to 70	17.8 [10.7, 26.1]; 5 to 59.1	93.6 [85.4, 97.9]; 30 to 100

800+ (any hat)	46.1 [37.3, 65.6]; 16 to 74.5	25 [12.8, 35.4]; 9.1 to 48.9	18.3 [13.1, 27.3]; 12.5 to 31.5	93.3 [79.9, 98.8]; 70.9 to 100	58.3 [44.6, 87.9]; 25.2 to 94.5	22.3 [12.5, 32.9]; 9.5 to 36.1	48.1 [10.8, 82.4]; 9.1 to 88.2	96.8 [94.6, 100]; 86.8 to 100
P value	0.503	0.652	0.981	0.398	0.601	0.884	0.667	0.350
≤ 399 (GSH)	47.4 [40.4, 60]; 21 to 72.5	16.9 [8.6, 51.7]; 0 to 77.6	16.7 [12.5, 30]; 6.3 to 69.3	86.8 [75.2, 94.4]; 49.3 to 100	55.1 [48.4, 62.1]; 12.5 to 95.7	20 [11.1, 25]; 0 to 27.3	25.4 [19.7, 48.6]; 18.8 to 55.3	95.7 [69.2, 98.7]; 25 to 100
400-799 (GSH)	45 [37.3, 64.8]; 32.3 to 88.5	15.1 [8.8, 19.6]; 6.6 to 29	33.3 [19, 50.1]; 12.2 to 76.5	95.7 [91.7, 100]; 88.5 to 100	53.1 [38.1, 58.6]; 29.7 to 74.9	16.1 [9.7, 57.3]; 8.6 to 70.1	13.5 [7.3, 23.1]; 0 to 59.1	90.6 [83.3, 96.6]; 30 to 100
800+ (GSH)	45.1 [22, 61.2]; 16 to 74.5	21.3 [9.4, 35]; 2.9 to 48.9	17.3 [13.1, 23.4]; 12.5 to 28.6	92.2 [72.4, 95.8]; 30.2 to 100	54.6 [39.8, 87]; 25.2 to 94.5	15.4 [3.6, 32.4]; 1.6 to 36.1	47.6 [10.8, 79.7]; 9.1 to 88.2	95.6 [88.7, 99.4]; 85.2 to 100
P value	0.736	0.610	0.179	0.022	0.788	0.965	0.121	0.479

Student hat-wearing rates at schools were not significantly influenced by student enrolment figure. However, students attending large sized schools were more likely to wear a GSH during school hours in summer and those from medium sized schools were more likely to wear a GSH during school hours in autumn (Table 7).

Table 8: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school ownership within SunSmart school (SSS) status

		Non-government			**Government**		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations (any hat)	**Overall**	54.8 [40.4, 0]; 40.4 to 62.7	61.5 [50.3, 72.8]; 44.9 to 89.6	0.287	50.2 [43.8, 53.4]; 40.9 to 64.2	51.6 [42.4, 57.6]; 21.4 to 60.4	0.563
	Before	46.6 [8.8, 0]; 8.8 to 58	27.3 [14.2, 53.1]; 9.8 to 88	01.00	20.4 [15.4, 30.4]; 10.5 to 39.6	22.5 [16.3, 28.4]; 9.8 to 51.4	0.872
	After	63.6 [12.5, 0]; 12.5 to 94.4	29.4 [17.1, 49.6]; 11.4 to 88.2	0.482	20.3 [13.5, 33.2]; 9.9 to 37.1	23.1 [14.8, 32.8]; 10.7 to 39.8	0.738

	During	63.5 [53.1, 0]; 53.1 to 100	94.6 [89.3, 96]; 81.9 to 99.1	0.469	91.3 [83.9, 97]; 69 to 98.7	92.7 [87.4, 93.8]; 66.3 to 97.7	0.832
All observations (GSH)	**Overall**	54.7 [39.9, 0]; 39.9 to 62.7	61.4 [47.8, 72.5]; 44.9 to 89.6	0.287	42.9 [25.3, 53.4]; 20.6 to 64	51.2 [41.4, 56.6]; 21.4 to 59.9	0.186
	Before	46.4 [7.2, 0]; 7.2 to 58	27.3 [14.2, 53.1]; 6.6 to 88	01.00	16.5 [9.5, 24.3]; 6 to 39.6	21 [16.3, 25]; 8.3 to 50.7	0.418
	After	63.6 [12.5, 0]; 12.5 to 94.4	29.4 [17.1, 48.6]; 11.4 to 88.2	0.482	16 [1.9, 29.6]; 0 to 37.1	19.7 [14.2, 29.1]; 10.7 to 37.9	0.284
	During	63.5 [53.1, 0]; 53.1 to 100	94.6 [89.3, 96]; 81.9 to 99.1	0.469	84.5 [50.8, 94]; 40.9 to 98.5	92.7 [87.4, 93.8]; 66.3 to 97.7	0.186
Warmer months (any hat)	**Overall**	55.6 [8.8, 0]; 8.8 to 59.5	61.3 [52.5, 81.2]; 48.6 to 95.9	0.287	41.6 [38.6, 56]; 27.1 to 98.1	54.9 [42.5, 58.4]; 24.8 to 72.8	0.343
	Before	58.5 [8.8, 0]; 8.8 to 60.3	34 [18.8, 64.3]; 11.1 to 95.9	1.000	21.8 [17.5, 23.3]; 11.3 to 39.3	20.2 [14.5, 28.2]; 10.8 to 80.9	1.000
	After	80.5 [66.6, 0]; 66.6 to 94.4	39.9 [25.1, 76.1]; 11 to 88.2	0.178	13.5 [8.7, 19.4]; 5.3 to 21.7	18.8 [12.2, 29.7]; 8.5 to 39.8	0.230
	During	41.5 [33.2, 0]; 33.2 to 49.7	96.8 [92.8, 98.8]; 86.5 to 100	0.030	92.7 [79.9, 97.2]; 66.4 to 100	96.8 [93.7, 98.5]; 49.6 to 100	0.232
Warmer months (GSH)	**Overall**	55.6 [7.2, 0]; 7.2 to 59.5	61.3 [52.5, 80.9]; 45.8 to 95.9	0.287	36.1 [22.8, 52.5]; 19.3 to 98.1	54.4 [38.9, 58.1]; 24.8 to 72.8	0.077
	Before	58.5 [7.2, 0]; 7.2 to 60.3	34 [18.7, 64.3]; 7.4 to 95.9	01.00	12.6 [3.5, 20.6]; 0 to 39.3	19.1 [14.5, 24.8]; 10.8 to 80.9	0.115
	After	80.5 [66.6, 0]; 66.6 to 94.4	39.9 [23.9, 73.1]; 11 to 88.2	0.178	7.4 [0, 18.5]; 0 to 21.7	13.7 [9.3, 24.3]; 7.6 to 37.9	0.088

	During	55.6 [7.2, 0]; 7.2 to 59.5	61.3 [52.5, 80.9]; 45.8 to 95.9	0.287	36.1 [22.8, 52.5]; 19.3 to 98.1	54.4 [38.9, 58.1]; 24.8 to 72.8	0.077
Cooler months (any hat)	**Overall**	56.3 [53.8, 0]; 53.8 to 64.9	62.8 [47.5, 67.7]; 40.5 to 79.2	0.937	54.8 [47.8, 57.6]; 43.4 to 75.5	58.5 [42.6, 61.8]; 18.7 to 70.7	0.976
	Before	45.7 [34.6, 0]; 34.6 to 56.9	47.3 [11.3, 55.4]; 8.6 to 80	0.889	20.7 [14.8, 35.8]; 9.3 to 43.2	21.1 [14.9, 26]; 8.4 to 31.5	0.549
	After	37.2 [12.5, 0]; 12.5 to 61.9	12.5 [11.4, 26]; 0 to 26.9	0.333	29 [18.3, 37.1]; 14.7 to 51.7	23.3 [14.7, 32.6]; 10.9 to 46	0.299
	During	77.3 [73.1, 0]; 73.1 to 100	93.8 [77.5, 97.5]; 70.5 to 98.6	0.811	93.9 [82.8, 97]; 71.5 to 98.9	89.9 [82, 92.2]; 68.6 to 96.7	0.148
Cooler months (GSH)	**Overall**	56.3 [53.6, 0]; 53.6 to 64.9	62.8 [46.7, 67.6]; 37.7 to 79.2	0.937	53.1 [29.9, 56.1]; 15.2 to 60.4	57.9 [40.9, 61.1]; 18.7 to 68.3	0.284
	Before	45.5 [34.2, 0]; 34.2 to 56.9	47.3 [5.7, 55.4]; 4.8 to 80	0.667	16.5 [10.1, 35.4]; 1 to 41.5	19.8 [10, 25.7]; 6.5 to 27.6	1.000
	After	37.2 [12.5, 0]; 12.5 to 61.9	12.5 [6.8, 26]; 0 to 26.9	0.333	18.3 [2.6, 37.1]; 2.1 to 51.3	22 [14.7, 29.6]; 10.9 to 46	0.837
	During	77.3 [73.1, 0]; 73.1 to 100	93.8 [77.5, 97.5]; 70.5 to 98.6	0.811	88.6 [58.7, 96.6]; 22.2 to 98.9	89.9 [82, 92.2]; 68.6 to 96.7	0.927

When schools were grouped according to school ownership and hat-wearing rates were compared according to SunSmart status, these rates were not significantly different. The only exception was that student hat-wearing rates (any hat) at non-government owned SSSs were higher during school hours in winter compared to the same rates from non-government non-SSSs (Table 8).

Table 9: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school Index of community socio-educational advantage (ICSEA) score within SunSmart school (SSS) status

		≤ average ICSEA score			**> average ICSEA score**		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations (any hat)	**Overall**	51 [43.1, 55.1]; 40.4 to 64.2	53.5 [47.7, 59]; 21.4 to 68.6	0.373	n/a	72.5 [49.4, 81.5]; 44.9 to 89.6	
	Before	20.5 [13.8, 35.5]; 8.8 to 58	24.2 [16.6, 29.5]; 9.8 to 51.4	1.000	n/a	40.6 [14, 80.7]; 11.3 to 88	
	After	21.7 [13.5, 35.2]; 9.9 to 94.4	23.4 [15.4, 32.8]; 10.7 to 45.3	1.000	n/a	46 [17.3, 70.7]; 11.4 to 88.2	
	During	89.2 [76.2, 97.5]; 53.1 to 100	92.3 [85.5, 95.1]; 66.3 to 99.1	0.737	n/a	94.1 [91.9, 95.4]; 90.6 to 95.7	
All observations (GSH)	**Overall**	45.9 [32.6, 55]; 20.6 to 64	53.3 [44.8, 57.9]; 21.4 to 68.6	0.135	n/a	72.2 [49.1, 81.5]; 44.9 to 89.6	
	Before	19 [8.9, 34.5]; 6 to 58	20.5 [16.6, 27.8]; 6.6 to 50.7	0.592	n/a	40.3 [13.8, 80.7]; 11.3 to 88	
	After	18.4 [5.3, 34.9]; 0 to 94.4	19.7 [16.1, 29.5]; 10.7 to 45.3	0.536	n/a	46 [16.3, 69.8]; 11.4 to 88.2	
	During	84.1 [53.1, 94.7]; 40.9 to 100	92.3 [85.5, 95.1]; 66.3 to 99.1	0.097	n/a	94.1 [91.9, 95.4]; 90.6 to 95.7	
Warmer months (any hat)	**Overall**	42.8 [38.1, 57.5]; 8.8 to 98.1	55.2 [51.1, 60.9]; 24.8 to 72.8	0.146	n/a	79 [50.4, 91.7]; 49.5 to 95.9	

	Before	22.2 [17.4, 39.3]; 8.8 to 60.3	24.3 [15.3, 34.5]; 10.8 to 80.9	0.963	n/a	70 [20.8, 0]; 20.8 to 95.9
	After	14.6 [11.1, 44.1]; 5.3 to 94.4	24.3 [13.3, 32.2]; 8.5 to 45.3	0.439	n/a	71.6 [23.9, 86.3]; 11 to 88.2
	During	87.8 [67.2, 96.8]; 33.2 to 100	96.8 [93.8, 98.5]; 49.6 to 100	0.039	n/a	95.3 [92, 99.2]; 91.7 to 100
Warmer months (GSH)	**Overall**	37.4 [22.6, 55.2]; 7.2 to 98.1	54.5 [45.6, 60.9]; 24.8 to 72.8	0.042	n/a	79 [50.1, 91.3]; 48.9 to 95.9
	Before	14.3 [7.2, 39.3]; 0 to 60.3	22.4 [15.3, 34]; 7.4 to 80.9	0.225	n/a	70 [19.9, 0]; 19.9 to 95.9
	After	13.5 [2.9, 44.1]; 0 to 94.4	22.6 [12, 30.5]; 7.6 to 45.3	0.277	n/a	69.7 [23.9, 85.3]; 11 to 88.2
	During	37.4 [22.6, 55.2]; 7.2 to 98.1	54.5 [45.6, 60.9]; 24.8 to 72.8	0.042	n/a	79 [50.1, 91.3]; 48.9 to 95.9
Cooler months (any hat)	**Overall**	56 [50.5, 58.7]; 43.4 to 75.5	56.1 [45.2, 63.7]; 18.7 to 72.5	0.953	n/a	62.5 [50, 72.6]; 40.5 to 79.2
	Before	26.8 [16.9, 38.5]; 9.3 to 56.9	22 [14.1, 34.5]; 8.4 to 50.2	0.590	n/a	40.8 [15, 73.9]; 11.3 to 80
	After	29 [16.5, 44.4]; 12.5 to 61.9	19.1 [12.9, 31.5]; 0 to 46	0.155	n/a	17.8 [12.3, 25.3]; 12.2 to 26
	During	92.6 [75.2, 97.2]; 71.5 to 100	90 [79, 94.8]; 68.6 to 98.2	0.373	n/a	92.8 [85.1, 96.3]; 78.9 to 98.6
Cooler months (GSH)	**Overall**	53.7 [39.1, 56.2]; 15.2 to 64.9	54.8 [43.3, 63.7]; 18.7 to 72.3	0.441	n/a	62.5 [49.7, 72.6]; 40.5 to 79.2

Before	19.8 [10.7, 38.4]; 1 to 56.9	17.4 [6.9, 27]; 4.8 to 49.8	0.590	n/a	40.8 [15, 73.9]; 11.3 to 80	
After	18.3 [7.6, 44.2]; 2.1 to 61.9	18.4 [12.9, 28.6]; 0 to 46	0.815	n/a	16.8 [12.3, 24.8]; 12.2 to 26	
During	86.2 [68.2, 96.7]; 22.2 to 100	90 [79, 94.8]; 68.6 to 98.2	0.679	n/a	92.8 [85.1, 96.3]; 78.9 to 98.6	

Comparisons between SSS and non-SSSs with above average ICSEA scores could not be made since there were zero non-SSSs schools with an above average ICSEA score. Hat-wearing proportions at SSSs in the below average ICSEA group were higher during school hours in the warmer months (any hat and GSH) and students at these schools were also more likely to wear a GSH overall during the warmer months (Table 9).

Table 10: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school sun-protection policy score within SunSmart school (SSS) status

		≤ median policy score			> median policy score		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations (any hat)	**Overall**	50.2 [43.6, 53.4]; 40.4 to 62.7	57.6 [51.6, 65.3]; 40.1 to 73.5	0.061	54.8 [41.8, 0]; 41.8 to 64.2	53.1 [45.8, 58.1]; 21.4 to 89.6	1.000
	Before	21.3 [15.4, 33.4]; 8.8 to 58	22.5 [17, 33.5]; 16.1 to 59.1	0.853	19.5 [10.5, 0]; 10.5 to 46.6	27.1 [11.3, 47.2]; 9.8 to 88	0.769
	After	18 [13.2, 30.5]; 9.9 to 63.6	31.5 [15.8, 45.3]; 10.7 to 53.3	0.197	33.4 [33.1, 0]; 33.1 to 94.4	21 [14.6, 29.4]; 11.4 to 88.2	0.060
	During	91.3 [80.3, 97]; 63.5 to 100	93.3 [91.2, 95.3]; 66.3 to 99.1	0.809	83.4 [53.1, 0]; 53.1 to 98.5	91.2 [85.4, 94.9]; 79.1 to 97.7	0.633

All observations (GSH)	**Overall**	42.9 [25.3, 53.4]; 20.6 to 62.7	57.6 [51.1, 65.3]; 40.1 to 73.5	0.016	54.7 [39.9, 0]; 39.9 to 64	51.9 [45, 56.6]; 21.4 to 89.6	1.000
	Before	16.5 [7.6, 31.9]; 6 to 58	21.7 [17, 32.5]; 16.1 to 59.1	0.315	19.5 [10.1, 0]; 10.1 to 46.4	20.5 [9.8, 47.2]; 6.6 to 88	1.000
	After	13 [1.9, 25.5]; 0 to 63.6	28.6 [15.8, 45.3]; 10.7 to 51.3	0.085	32.8 [28.6, 0]; 28.6 to 94.4	18.6 [16.4, 29.4]; 11.4 to 88.2	0.088
	During	84.5 [50.8, 94]; 40.9 to 100	93.3 [91.2, 95.3]; 66.3 to 99.1	0.085	83.4 [53.1, 0]; 53.1 to 98.5	91.2 [85.4, 94.9]; 77.6 to 97.7	0.633
Warmer months (any hat)	**Overall**	41.6 [38.6, 56]; 8.8 to 59.8	56.2 [49.5, 72.8]; 28.4 to 87.6	0.072	55.6 [27.1, 0]; 27.1 to 98.1	54.3 [51.5, 64.2]; 24.8 to 95.9	0.840
	Before	22.2 [17.6, 31.4]; 8.8 to 60.3	20.2 [17, 48]; 11.1 to 80.9	1.000	34.9 [11.3, 0]; 11.3 to 58.5	27.5 [13, 48.1]; 10.8 to 95.9	0.909
	After	13.5 [8.7, 21.7]; 5.3 to 66.6	23.7 [12.6, 54]; 8.5 to 80.5	0.210	54.5 [14.6, 0]; 14.6 to 94.4	29.5 [13.2, 37.1]; 11 to 88.2	0.582
	During	89.8 [74.9, 96.7]; 49.7 to 100	95.3 [93.4, 100]; 49.6 to 100	0.331	69.5 [33.2, 0]; 33.2 to 98.1	97.9 [94.1, 98.4]; 86.5 to 100	0.136
Warmer months (GSH)	**Overall**	36.1 [21.4, 52.5]; 7.2 to 59.5	56.2 [48.9, 72.8]; 28.4 to 86.7	0.013	55.6 [23.7, 0]; 23.7 to 98.1	54.1 [47.2, 63.6]; 24.8 to 95.9	0.840
	Before	14.3 [4.7, 30.3]; 0 to 60.3	19.1 [17, 48]; 11.1 to 80.9	0.156	34.7 [11, 0]; 11 to 58.5	24.5 [12.9, 48]; 7.4 to 95.9	0.909
	After	13.5 [0, 21.7]; 0 to 66.6	23.7 [9, 54]; 7.6 to 76.6	0.142	50.1 [5.8, 0]; 5.8 to 94.4	22.6 [13.2, 36.2]; 11 to 88.2	1.000
	During	36.1 [21.4, 52.5]; 7.2 to 59.5	56.2 [48.9, 72.8]; 28.4 to 86.7	0.013	55.6 [23.7, 0]; 23.7 to 98.1	54.1 [47.2, 63.6]; 24.8 to 95.9	0.840

Cooler months (any hat)	**Overall**	56.1 [47.8, 62]; 43.4 to 75.5	62.5 [59.4, 65.4]; 39.5 to 72.5	0.152	53.8 [52.9, 0]; 52.9 to 56.4	48.8 [41.3, 62]; 18.7 to 79.2	0.536
	Before	31.7 [17.6, 41.5]; 10.5 to 56.9	25.8 [21.1, 50.2]; 16.6 to 55.4	0.918	19.5 [9.3, 0]; 9.3 to 34.6	18.6 [9.9, 41.4]; 8.4 to 80	1.000
	After	28.4 [14.7, 37.1]; 12.5 to 61.9	24.5 [12.8, 34.8]; 0 to 46	0.740	42.5 [33.4, 0]; 33.4 to 51.7	18.4 [11.8, 25.2]; 10.9 to 27.2	0.036
	During	93 [76.1, 97]; 71.5 to 100	91.3 [88.5, 94.1]; 83.1 to 98.2	0.918	92.6 [73.1, 0]; 73.1 to 98.9	85.4 [72.5, 96.2]; 68.6 to 98.6	0.536
Cooler months (GSH)	**Overall**	54.3 [29.9, 57.3]; 15.2 to 64.9	62.5 [57.9, 65.4]; 36.6 to 72.3	0.016	53.6 [52.6, 0]; 52.6 to 56.2	48.1 [38.4, 61.9]; 18.7 to 79.2	0.448
	Before	20 [11, 40.6]; 1 to 56.9	25.2 [19.8, 49.8]; 15.1 to 55.4	0.470	19.5 [8.8, 0]; 8.8 to 34.2	11.3 [6.1, 37.5]; 4.8 to 80	0.600
	After	13.2 [2.6, 37.1]; 2.1 to 61.9	23.6 [12.8, 30.8]; 0 to 46	0.601	42 [32.8, 0]; 32.8 to 51.3	18.3 [11.6, 24.7]; 6.8 to 26.9	0.036
	During	81.8 [58.7, 96.6]; 22.2 to 100	91.3 [88.5, 94.1]; 83.1 to 98.2	0.223	92.6 [73.1, 0]; 73.1 to 98.9	85.4 [72.5, 96.2]; 68.6 to 98.6	0.536

Students at SSSs with less developed sun-protection policies were more likely to wear their GSH overall and during school hours in the warmer months. Students from non-SSSs with better developed sun-protection policies were more likely to wear any type of hat after school hours in the cooler months (Table 10).

Table 11: Median [inter-quartile range]; range of student hat-wearing (any hat and gold-standard hat (GSH)) proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by student enrolment figure within SunSmart school (SSS) status

		≤ 399 students			400-799 students			800+ students		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations (any hat)	**Overall**	52.7 [42.5, 59.1]; 40.4 to 62.7	53.9 [40.1, 56.3]; 38.1 to 60.2	0.876	50.3 [45.8, 57.1]; 41.8 to 64.2	51.6 [47.6, 59]; 44.7 to 73.5	0.529	45.9 [40.9, 0]; 40.9 to 51	65.3 [51.6, 72.5]; 21.4 to 89.6	0.222
	Before	30.1 [9.7, 48.8]; 8.8 to 58	22.2 [16.1, 27.3]; 13.3 to 51.4	0.876	20 [15.4, 35.2]; 10.5 to 46.6	19.6 [11.3, 29.5]; 9.8 to 29.6	0.628	21.2 [20.3, 0]; 20.3 to 22.1	45.4 [22.8, 59.1]; 9.8 to 88	0.222
	After	17.1 [13, 42.6]; 12.5 to 63.6	21 [14.6, 29.4]; 10.7 to 34.6	0.755	33.2 [23.7, 51.4]; 9.9 to 94.4	23.4 [15.4, 31]; 11.4 to 46	0.224	16.1 [13.4, 0]; 13.4 to 18.9	42.5 [26.6, 62]; 11.9 to 88.2	0.286
	During	84.1 [66.2, 96.7]; 63.5 to 100	85.3 [79.1, 93.3]; 66.3 to 95.1	1.000	92.5 [75.8, 97]; 53.1 to 98.5	93.4 [91.5, 94.7]; 90.4 to 99.1	0.776	91.8 [84.8, 0]; 84.8 to 98.7	95.3 [90.6, 97.1]; 89.4 to 97.7	1.000
All observations (GSH)	**Overall**	52.7 [33, 59.1]; 26 to 62.7	53.3 [40.1, 55.7]; 35.1 to 59	0.755	48 [35.7, 57]; 23.2 to 64	51.1 [45.5, 58.7]; 42.7 to 73.5	0.388	29.9 [20.6, 0]; 20.6 to 39.2	65.3 [51.2, 72.2]; 21.4 to 89.6	0.111
	Before	22.6 [8.9, 48.8]; 7.2 to 58	19.1 [16.1, 27.3]; 8.3 to 50.7	0.876	16.7 [9.5, 33.6]; 7.7 to 46.4	17.7 [11.3, 25.8]; 6.6 to 28.3	0.945	12.5 [6, 0]; 6 to 19	45.2 [20.5, 59.1]; 9.8 to 88	0.111
	After	13.5 [6.9, 42.6]; 1.3 to 63.6	19.7 [16.4, 29.4]; 10.7 to 29.6	0.639	30.7 [7, 51.4]; 2.1 to 94.4	18.6 [13.6, 30.5]; 10.9 to 46	0.689	9.2 [0, 0]; 0 to 18.4	41.6 [24.4, 60.5]; 11.9 to 88.2	0.143
	During	84.1 [52.2, 96.7]; 40.9 to 100	85.3 [77.6, 93.3]; 66.3 to 95.1	0.876	86.3 [53.1, 96.6]; 53 to 98.5	93.4 [91.5, 94.7]; 90.4 to 99.1	0.224	64.5 [44.1, 0]; 44.1 to 84.8	95.3 [90.6, 97.1]; 89.4 to 97.7	0.056

Warmer months (any hat)	**Overall**	51.7 [24.3, 57.1]; 8.8 to 59.5	56.8 [49.5, 62.1]; 28.4 to 64.9	0.268	49.2 [36.1, 69.3]; 27.1 to 98.1	52.9 [50, 64.2]; 35.5 to 79	0.864	38.8 [37.2, 0]; 37.2 to 40.4	60.5 [53.4, 87.6]; 24.8 to 95.9	0.222
	Before	30.4 [12, 55.1]; 8.8 to 60.3	20.8 [13.6, 27.3]; 11.1 to 51.4	0.648	22.8 [14.6, 41]; 11.3 to 58.5	22.1 [15.5, 41]; 11.1 to 80.9	0.931	19.8 [17.4, 0]; 17.4 to 22.2	40.6 [18.3, 70]; 10.8 to 95.9	0.333
	After	17.6 [7.3, 55.3]; 5.3 to 66.6	27.1 [12.6, 33.2]; 8.5 to 34.5	0.686	14.6 [8.7, 0]; 8.7 to 94.4	22.6 [11.9, 30.4]; 10.2 to 62.7	0.864	16.4 [13.4, 0]; 13.4 to 19.4	45.3 [26.6, 84.4]; 13.4 to 88.2	0.190
	During	78.1 [53.9, 94.2]; 49.7 to 95.7	97.8 [92.4, 100]; 49.6 to 100	0.164	91.1 [60.4, 97.2]; 33.2 to 98.1	95.3 [92.5, 96.8]; 86.5 to 100	0.607	91.7 [83.4, 0]; 83.4 to 100	98.2 [95.7, 98.7]; 94.1 to 100	0.889
Warmer months (GSH)	**Overall**	51.7 [13.2, 57.1]; 7.2 to 59.5	54.7 [48.9, 62.1]; 28.4 to 64.2	0.268	39.4 [23.3, 66.2]; 22.2 to 98.1	52.9 [45.4, 63.9]; 32.8 to 79	0.328	28.9 [23, 0]; 23 to 34.8	60.5 [51.6, 86.7]; 24.8 to 95.9	0.111
	Before	23.2 [1.8, 55.1]; 0 to 60.3	19.9 [13.6, 27.3]; 11.1 to 50.7	0.927	14.3 [6.6, 39.9]; 2.2 to 58.5	20 [14.6, 38.2]; 7.4 to 80.9	0.429	13 [7.3, 0]; 7.3 to 18.7	40.6 [18.3, 70]; 10.8 to 95.9	0.222
	After	17.6 [3.4, 55.3]; 0 to 66.6	25.9 [12, 33.2]; 8.5 to 34.5	0.686	7.4 [5.8, 0]; 5.8 to 94.4	14 [10.3, 24.1]; 7.6 to 62.7	0.482	9.3 [0, 0]; 0 to 18.5	45.3 [25.6, 82.4]; 13.4 to 88.2	0.190
	During	51.7 [13.2, 57.1]; 7.2 to 59.5	54.7 [48.9, 62.1]; 28.4 to 64.2	0.268	39.4 [23.3, 66.2]; 22.2 to 98.1	52.9 [45.4, 63.9]; 32.8 to 79	0.328	28.9 [23, 0]; 23 to 34.8	60.5 [51.6, 86.7]; 24.8 to 95.9	0.111
Cooler months (any hat)	**Overall**	56.1 [50.9, 60.6]; 48.2 to 64.9	48.7 [43.8, 59.7]; 31.9 to 60.4	0.530	54.9 [50.5, 57.6]; 43.4 to 61.1	58.5 [44.7, 65.4]; 39.5 to 66	0.607	61.2 [46.9, 0]; 46.9 to 75.5	63.1 [48.6, 72.5]; 18.7 to 79.2	1.000
	Before	37.1 [16.5, 52.6]; 10.5 to 56.9	23.6 [15.2, 33.2]; 13.2 to 35.5	0.486	19.3 [14.5, 36.7]; 9.3 to 43.2	16.6 [9.9, 27.2]; 8.6 to 31.5	0.537	26.8 [21.8, 0]; 21.8 to 31.7	47.3 [18.6, 55.4]; 8.4 to 80	0.667

	After	29 [12.5, 0]; 12.5 to 61.9	19.1 [14.6, 26.9]; 12.9 to 40	0.667	33.4 [21.5, 44.4]; 14.7 to 51.7	14.9 [11.8, 30.1]; 0 to 46	0.083	18.3 [18.3, 18.3]; 18.3 to 18.3	26 [10.9, 0]; 10.9 to 31.5	1.000
	During	77.3 [72, 98.4]; 71.5 to 100	73.3 [70.5, 90.2]; 68.6 to 94.1	0.432	93.9 [86.4, 97.1]; 73.1 to 98.9	92.7 [89.2, 97.7]; 84.6 to 98.6	0.955	91.8 [86.2, 0]; 86.2 to 97.5	91.3 [80.9, 94.9]; 78.9 to 96.7	0.667
Cooler months (GSH)	**Overall**	56.1 [42.9, 60.6]; 32 to 64.9	48.7 [37.7, 58.9]; 28.5 to 59.7	0.755	54.3 [45.4, 57.2]; 23.7 to 60.4	58.2 [44, 65.4]; 36.6 to 66	0.529	30.6 [15.2, 0]; 15.2 to 46.1	63.1 [47.8, 72.3]; 18.7 to 79.2	0.111
	Before	36.8 [16.4, 52.6]; 10.5 to 56.9	13.8 [5.2, 24.9]; 4.8 to 26.2	0.114	16.5 [10.7, 36]; 8.8 to 41.5	15.1 [8.5, 23.7]; 5.7 to 27.6	0.662	10.5 [1, 0]; 1 to 20	47.3 [11.6, 55.4]; 8.4 to 80	0.222
	After	12.5 [2.6, 0]; 2.6 to 61.9	18.4 [14.6, 26.9]; 12.9 to 30	0.517	32.8 [7.7, 44.2]; 2.1 to 51.3	14.9 [9.5, 29.8]; 0 to 46	0.438	18.3 [18.3, 18.3]; 18.3 to 18.3	26 [10.9, 0]; 10.9 to 28.6	1.000
	During	77.3 [57.9, 98.4]; 43.3 to 100	73.3 [70.5, 90.2]; 68.6 to 94.1	0.639	91.8 [70.8, 97.1]; 63.9 to 98.9	92.7 [89.2, 97.7]; 84.6 to 98.6	0.607	54.2 [22.2, 0]; 22.2 to 86.2	91.3 [80.9, 94.9]; 78.9 to 96.7	0.222

No significant differences between hat-wearing rates were found when schools were grouped according to student enrolment figure and SunSmart status was compared within these groups (Table 11).

ADULT DATA

Table 12: Median [inter-quartile range]; range of adult hat-wearing proportions (%) from all 36 Townsville primary schools considered together: seasonal variation.

All observations				**Warm months**			
Overall	**Before**	**After**	**During**	**Overall**	**Before**	**After**	**During**
47.9 [38.1, 58.1]; 10.6 to 100	6.1 [1, 10.8]; 0 to 26.7	19.3 [11.7, 34.2]; 0 to 54.6	85.4 [58.5, 100]; 0 to 100	50 [27.5, 66.7]; 0 to 100	5.6 [0, 10.6]; 0 to 26.7	28.6 [18.9, 47.2]; 0 to 100	83.3 [50, 100]; 0 to 100
Cool months				**Summer**			
Overall	**Before**	**After**	**During**	**Overall**	**Before**	**After**	**During**
41.9 [29.2, 62.9]; 6.2 to 100	6.2 [0, 13]; 0 to 23.5	12.1 [7.2, 27]; 0 to 50	100 [71.9, 100]; 0 to 100	50 [27.1, 63.1]; 0 to 100	5.9 [0, 13.8]; 0 to 26.7	25 [15.9, 40.8]; 0 to 100	100 [50, 100]; 0 to 100
Autumn				**Winter**			
Overall	**Before**	**After**	**During**	**Overall**	**Before**	**After**	**During**
50 [14.5, 55.6]; 0 to 100	5.4 [1, 11.7]; 0 to 25	12 [7.6, 35.6]; 0 to 50	100 [85.7, 100]; 0 to 100	35.2 [8.6, 52.1]; 0 to 100	2.4 [0, 9]; 0 to 21.7	7.1 [1.8, 16.8]; 0 to 66.7	100 [50, 100]; 0 to 100
Spring							
Overall	**Before**	**After**	**During**				
58.1 [20.3, 100]; 0 to 100	7.4 [0.9, 13.9]; 0 to 20	35.3 [28.6, 50]; 0 to 100	100 [60, 100]; 0 to 100				

Median adult hat-wearing proportions were very low before school hours (approximately 6%). The highest median hat-wearing proportion for after school hours among the adult group was 35.3% in spring. During school hours, the median hat-wearing proportions were much higher, than before/after hours, although the minimum value for during school hours was often zero (Table 12).

Table 13 Median [inter-quartile range]; range of adult hat-wearing proportions (%) from Townsville primary schools: stratified by SunSmart school (SSS) status and school ownership.

		SunSmart status			School ownership		
Season	**Time**	**Yes**	**No**	**p value**	**Gov**	**Non-gov**	**p value**
warmer months	**overall**	57.3 [33.7, 67.9]; 0 to 100	46.1 [22.2, 61.5]; 11.1 to 75.3	0.344	50 [33.7, 62.5]; 0 to 100	66.7 [21.4, 72.9]; 11.8 to 75.3	0.327
	before	5.2 [0, 10.3]; 0 to 20	5.6 [0.8, 16.6]; 0 to 26.7	0.742	4.1 [0, 6.6]; 0 to 19.1	9.6 [1.4, 17.9]; 0 to 26.7	0.153
	after	28.6 [18.9, 47.2]; 15.1 to 50	28.3 [6.3, 82.9]; 0 to 100	0.940	26.8 [18.8, 40.7]; 0 to 50	31.5 [18.1, 75]; 15.1 to 100	0.524
	during	100 [50, 100]; 0 to 100	66.7 [37.5, 95.8]; 0 to 100	0.157	100 [50, 100]; 0 to 100	75 [40, 100]; 0 to 100	0.326
cooler months	**overall**	41.4 [25.5, 64.3]; 8.3 to 92.9	45 [30.5, 62.4]; 6.2 to 100	0.745	41.5 [32, 58.7]; 8.3 to 100	44 [19.4, 67.7]; 6.2 to 100	0.871
	before	2.8 [0, 9.8]; 0 to 16.1	12.5 [4.2, 17.1]; 0 to 23.5	0.033	9.5 [0, 16.1]; 0 to 23.5	2.8 [0.4, 9.6]; 0 to 13	0.265
	after	11.6 [1.3, 27.4]; 0 to 50	17.4 [11.7, 30.4]; 9.1 to 35.3	0.383	12.1 [5.3, 24.7]; 0 to 35.3	24.5 [6.3, 47.5]; 5.3 to 50	0.549
	during	100 [73.4, 100]; 0 to 100	100 [50, 100]; 43.3 to 100	0.866	100 [78.1, 100]; 16.7 to 100	100 [68.8, 100]; 0 to 100	0.866
Summer	**overall**	50 [37.5, 62]; 0 to 100	42.6 [22.8, 72.1]; 0 to 100	0.863	50 [29.2, 73.2]; 0 to 100	50 [15.8, 60.6]; 4 to 100	0.481
	before	3 [0, 7.6]; 0 to 14.3	13.3 [1.3, 21.5]; 0 to 26.7	0.222	5.9 [0, 13.8]; 0 to 16.3	4 [0, 22]; 0 to 26.7	1.00

	after	23.1 [16.3, 62.5]; 15.1 to 100	25 [0, *]; 0 to 31.5	0.714	25 [12.5, 62.5]; 0 to 100	21.1 [15.1, *]; 15.1 to 31.5	0.714
	during	100 [50, 100]; 0 to 100	87.5 [43.8, 100]; 0 to 100	0.796	100 [50, 100]; 0 to 100	75 [25, 100]; 0 to 100	0.408
Autumn	**overall**	51 [20.7, 60.4]; 0 to 100	37.1 [6.1, 57.2]; 2.1 to 100	0.287	50 [24.1, 55.6]; 2.1 to 100	25.8 [3.1, 75]; 0 to 100	0.327
	before	5.5 [0, 11.4]; 0 to 13	5.4 [2.1, 23.5]; 0 to 25	0.740	5.6 [0, 11.1]; 0 to 25	4.3 [2.2, 12.4]; 0 to 13	0.884
	after	11.6 [8.9, 42.5]; 0 to 50	14.2 [4.8, *]; 4.8 to 31.3	0.937	11.6 [9.1, 18.5]; 0 to 50	40 [4.2, *]; 4.2 to 50	0.469
	during	100 [92.9, 100]; 32.6 to 100	100 [30, 100]; 0 to 100	0.609	100 [83, 100]; 0 to 100	100 [83.3, 100]; 66.7 to 100	0.801
Winter	**overall**	35.1 [8.3, 50]; 0 to 100	50 [14.7, 56.4]; 0 to 100	0.361	21.7 [7.1, 50]; 0 to 100	52 [31.1, 64.8]; 0 to 100	0.012
	before	2.2 [0, 5.9]; 0 to 15.6	4.4 [0, 18.3]; 0 to 21.7	0.347	2.2 [0, 12]; 0 to 21.7	4 [0, 9.2]; 0 to 9.5	0.951
	after	6.8 [0, 14.9]; 0 to 20.6	9.1 [3.6, *]; 3.6 to 66.7	0.548	7.1 [0, 20.6]; 0 to 66.7	7.8 [6.5, *]; 6.5 to 9.1	1.00
	during	100 [43.8, 100]; 0 to 100	100 [75, 100]; 0 to 100	0.634	100 [43.2, 100]; 0 to 100	100 [56.3, 100]; 0 to 100	0.980
Spring	**overall**	64.3 [30.6, 100]; 0 to 100	51 [5.7, 100]; 0 to 100	0.411	51.9 [14.3, 100]; 0 to 100	83.3 [20, 100]; 5.7 to 100	0.667
	before	6.4 [0, 13.3]; 0 to 20	10.3 [5.7,*]; 5.7 to 14.8	0.643	3.7 [0, 12]; 0 to 14.8	11.1 [5.7, *]; 5.7 to 20	0.250

	after	33.3 [14.3, 47.2]; 0 to 50	67.6 [35.3, *]; 35.3 to 100	0.381	33.3 [14.3, 39.8]; 0 to 44.4	75 [50, *]; 50 to 100	0.095
	during	100 [100, 100]; 0 to 100	66.7 [0, 100]; 0 to 100	0.023	100 [33.3, 100]; 0 to 100	100 [75, 100]; 40 to 100	0.821

Adults at non-SSSs were more likely to wear their hat before school hours in the cooler months compared to adults at SSSs. Adults at SSSs were more likely to wear their hat during school hours in spring. Adults at non-government schools were more likely to wear their hat overall in winter compared to those adults at government schools (Table 13)

Table 14: Median [inter-quartile range]; range of adult hat-wearing proportions (%) from Townsville primary schools: stratified by Index of community socio-educational advantage (ICSEA) score and sun-protection policy score

		ICSEA group			**Sun-protection policy score**		
Season	**Time**	**≤ average**	**> average**	**p value**	**≤ median**	**> median**	**p value**
warmer months	**overall**	50 [31.1, 66.7]; 11.1 to 100	66.7 [13.8, 71.9]; 0 to 73.7	0.697	47.9 [24.4, 65.7]; 0 to 75.3	57.3 [33.7, 70.4]; 11.1 to 100	0.499
	before	5.8 [1.6, 11.3]; 0 to 26.7	0 [0, 0]; 0 to 0	0.087	4.8 [0, 8.3]; 0 to 26.7	5.6 [1.6, 12.5]; 0 to 20	0.585
	after	29.7 [25, 50]; 0 to 100	18.1 [15.1, 0]; 15.1 to 21.1	0.154	28.6 [15.9, 50]; 0 to 100	27.3 [22.1, 31]; 21.1 to 31.5	0.825
	during	83.3 [50, 100]; 0 to 100	66.7 [20, 96.7]; 0 to 100	0.342	75 [50, 100]; 0 to 100	96.7 [50, 100]; 0 to 100	0.569
cooler months	**overall**	42.2 [28.3, 64.3]; 6.2 to 100	34.7 [29.4, 56.4]; 25.5 to 68.8	0.825	45 [33, 65.2]; 8.3 to 100	35.7 [25, 58.7]; 6.2 to 92.9	0.309

	before	9.3 [0, 15.4]; 0 to 23.5	2.8 [0.5, 10.7]; 0 to 13	0.505	9.3 [1.8, 16]; 0 to 23.5	4.1 [0, 11.3]; 0 to 16.1	0.313
	after	13.2 [9.5, 27.8]; 0 to 50	0 [0, 0]; 0 to 0	0.235	12 [4.5, 31.9]; 0 to 50	14.7 [6.6, 25.1]; 0 to 40	0.963
	during	100 [88.8, 100]; 0 to 100	75 [63.5, 100]; 58.3 to 100	0.448	100 [73.4, 100]; 16.7 to 100	100 [59.2, 100]; 0 to 100	0.650
Summer	**overall**	50 [33.3, 71.4]; 0 to 100	33.3 [7.5, 55.3]; 0 to 60.6	0.150	51.5 [19.6, 69.4]; 0 to 100	50 [31.3, 57.9]; 15.8 to 100	0.985
	before	6.5 [0, 14.3]; 0 to 26.7	0 [0, 0]; 0 to 0	0.154	6.2 [0, 13.6]; 0 to 26.7	0 [0, *]; 0 to 16.3	0.692
	after	25 [16.7, 50]; 0 to 100	18.1 [15.1, 0]; 15.1 to 21.1	0.333	16.7 [7.5, 62.5]; 0 to 100	28.3 [22.1, 45.4]; 21.1 to 50	0.286
	during	100 [50, 100]; 0 to 100	100 [33.3, *]; 33.3 to 100	0.889	100 [58.3, 100]; 0 to 100	50 [50, 100]; 0 to 100	0.378
Autumn	**overall**	50 [19, 55.6]; 2.1 to 100	25.8 [6.5, 75]; 0 to 100	0.479	52.8 [25.4, 65.3]; 2.1 to 100	40 [12.2, 55.6]; 0 to 100	0.295
	before	5.5 [1.6, 11.4]; 0 to 25	5.4 [0, *]; 0 to 13	0.859	7.1 [2.9, 14.2]; 0 to 25	2.9 [0, 12.2]; 0 to 13	0.270
	after	12.9 [10.7, 37.8]; 4.2 to 50			13.1 [8.3, 50]; 0 to 50	11.1 [4.8, 31.3]; 4.2 to 40	0.445
	during	100 [89.3, 100]; 0 to 100	100 [66.7, *]; 66.7 to 100	0.154	100 [100, 100]; 0 to 100	100 [66.3, 100]; 32.6 to 100	0.410
Winter	**overall**	35.1 [8.4, 52.2]; 0 to 100	37.5 [12.5, 63.5]; 0 to 75	0.898	35.1 [7.7, 53.4]; 0 to 100	36.7 [13, 52]; 0 to 75	0.825

	before	2.7 [0, 9.4]; 0 to 21.7	0 [0, *]; 0 to 4	0.723	1.4 [0, 10.4]; 0 to 21.7	3.1 [0, 9.3]; 0 to 15.6	0.886
	after	7.1 [1.8, 16.8]; 0 to 66.7	0 [0, 0]; 0 to 0	0.401	7.1 [0, *]; 0 to 9.1	9.7 [2.7, 32.1]; 0 to 66.7	0.548
	during	100 [87.5, 100]; 0 to 100	62.5 [40.6, 93.8]; 37.5 to 100	0.252	100 [46.9, 100]; 0 to 100	100 [56.3, 100]; 0 to 100	0.940
Spring	**overall**	51.9 [20, 100]; 0 to 100	90 [20, 100]; 0 to 100	0.763	51 [33.3, 83.3]; 0 to 100	100 [15.6, 100]; 5.7 to 100	0.254
	before	7.4 [0.9, 13.9]; 0 to 20			0 [0, *]; 0 to 3.7	11.1 [7.4, 17.4]; 5.7 to 20	0.036
	after	35.3 [28.6, 50]; 0 to 100			39.8 [21.4, 62.5]; 0 to 100	33.3 [33.3, 33.3]; 33.3 to 33.3	0.857
	during	100 [66.7, 100]; 0 to 100	90 [20, 100]; 0 to 100	0.447	100 [36.7, 100]; 0 to 100	100 [95, 100]; 0 to 100	0.287

School ICSEA scores and sun-protection policy scores were not found to significantly influence adult hat-wearing compliance rates (Table 14).

Table 15: Median [inter-quartile range]; range of adult hat-wearing proportions (%) from Townsville primary schools: stratified by student enrolment figure

		Student enrolment figure			
Season	**Time**	**≤ 399**	**400-799**	**800+**	**p value**
warmer months	**overall**	41.7 [22.2, 66.7]; 0 to 100	50 [22.2, 62.5]; 11.1 to 75	66.7 [40.3, 69]; 33.7 to 70.4	0.480
	before	0 [0, 20]; 0 to 26.7	6.5 [5.6, 8.5]; 0 to 14.6	3.5 [0.5, 9.5]; 0 to 19.1	0.552

	after	20.8 [4.2, 81.3]; 0 to 100	30 [22.1, 48.6]; 15.1 to 50	29.7 [29.7, 29.7]; 29.7 to 29.7	0.692
	during	58.3 [45.8, 100]; 0 to 100	75 [40, 100]; 0 to 100	100 [84.2, 100]; 66.7 to 100	0.097
cooler months	**overall**	53.6 [27.1, 86.3]; 8.3 to 100	41.4 [32, 64.3]; 6.2 to 83.3	42.2 [25.3, 48]; 10.7 to 66.7	0.613
	before	0 [0, 6.3]; 0 to 12.5	9.8 [5.2, 16.2]; 0 to 23.5	3.6 [1.7, 12.5]; 0 to 17.5	0.063
	after	2.7 [0, 9.6]; 0 to 11.1	21.4 [12.1, 36.5]; 10.5 to 50	24 [24, 24]; 24 to 24	0.006
	during	100 [92.9, 100]; 16.7 to 100	100 [64.1, 100]; 0 to 100	100 [62.5, 100]; 27.8 to 100	0.872
Summer	**overall**	50 [20.8, 81.7]; 0 to 100	50 [15.6, 63.3]; 0 to 100	50 [42.6, 78.3]; 33.3 to 100	0.673
	before	13.3 [0, *]; 0 to 26.7	7.2 [4.4, 14.8]; 0 to 16.3	0 [0, 8]; 0 to 13.3	0.320
	after	16.7 [0, *]; 0 to 25	25 [18.1, 65.8]; 15.1 to 100	50 [50, 50]; 50 to 50	0.255
	during	83.3 [50, 100]; 0 to 100	75 [25, 100]; 0 to 100	100 [75, 100]; 33.3 to 100	0.339
Autumn	**overall**	53.8 [50, 96.4]; 25 to 100	50 [10.5, 65.6]; 0 to 100	23.2 [7.7, 51.4]; 2.1 to 54.4	0.051
	before	12.5 [0, *]; 0 to 25	5.4 [0, 11.1]; 0 to 23.5	5.5 [2.3, 11.3]; 0 to 13	0.966

	after	4.2 [0, *]; 0 to 11.1	14.2 [10.8, 45]; 4.8 to 50	13.8 [13.8, 13.8]; 13.8 to 13.8	0.106
	during	100 [100, 100]; 85.7 to 100	100 [75, 100]; 0 to 100	100 [49.6, 100]; 32.6 to 100	0.504
Winter	**overall**	22.8 [0, 54.2]; 0 to 100	35.2 [9.5, 51.8]; 0 to 100	35.1 [23.4, 53.4]; 21.1 to 75	0.577
	before	0 [0, *]; 0 to 5.9	6.2 [0, 15.9]; 0 to 19.9	2.7 [0, 9.2]; 0 to 21.7	0.064
	after	3.2 [0, 8.4]; 0 to 9.1	10.1 [4.5, 53.3]; 3.6 to 66.7	20.6 [20.6, 20.6]; 20.6 to 20.6	0.183
	during	100 [37.5, 100]; 0 to 100	100 [46.9, 100]; 0 to 100	100 [56.3, 100]; 23 to 100	0.990
Spring	**overall**	33.3 [0, 91.7]; 0 to 100	57.6 [31.9, 100]; 0 to 100	100 [36.5, 100]; 11.1 to 100	0.708
	before	0 [0, *]; 0 to 20	10.3 [5.7, *]; 5.7 to 14.8	9.1 [3.7, *]; 3.7 to 11.1	0.808
	after	100 [100, 100]; 100 to 100	35.3 [14.3, 47.2]; 0 to 50	33.3 [33.3, 33.3]; 33.3 to 33.3	0.218
	during	75 [0, 100]; 0 to 100	100 [46.7, 100]; 0 to 100	100 [100, 100]; 90 to 100	0.360

School size was not found to consistently significantly influence adult hat-use (Table 15).

Table 16: Median [inter-quartile range]; range of adult hat-wearing proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school ownership within SunSmart school (SSS) status

		Non-Government			Government		
		non-SSS	SSS	P value	non-SSS	SSS	P value
All observations (any hat)	**Overall**	58.3 [10.6, *]; 10.6 to 100	47.9 [39.6, 62.1]; 31.7 to 100	0.811	44.4 [34, 59.6]; 16.7 to 75	48.4 [33.3, 57.4]; 20.8 to 66.8	0.976
	Before	16.4 [6.1, *]; 6.1 to 26.7	5.9 [1.5, 9.4]; 0 to 20	0.327	10.2 [4, 15.8]; 0 to 18.7	2.6 [0, 7.1]; 0 to 15.6	0.057
	After	43 [31.5, *]; 31.5 to 54.6	21.1 [10.2, 45]; 5.3 to 50	0.381	17.4 [7.1, 30.3]; 0 to 35.3	13.2 [7.9, 29.9]; 0 to 37.3	0.768
	During	87.5 [0, *]; 0 to 100	86 [61.7, 100]; 50 to 100	0.811	77.8 [45.8, 91.7]; 32.5 to 100	96.4 [62.5, 100]; 50 to 100	0.186
Warmer months	**Overall**	43.9 [12.4, *]; 12.4 to 75.3	66.7 [25.5, 71.2]; 11.8 to 75	0.909	46.1 [22.2, 59.6]; 11.1 to 66.7	50 [36.1, 64.7]; 0 to 100	0.483
	Before	16.2 [5.7, *]; 5.7 to 26.7	9.6 [0, 13.8]; 0 to 20	0.643	4.3 [0, 11.6]; 0 to 19.1	4.1 [0, 6.5]; 0 to 14.6	0.875
	After	65.8 [31.5, *]; 31.5 to 100	21.1 [15.1, *]; 15.1 to 50	0.400	12.5 [0, *]; 0 to 25	29.1 [22.9, 45.8]; 16.7 to 50	0.143
	During	41.7 [0, *]; 0 to 83.3	75 [45, 100]; 0 to 100	0.436	66.7 [45.8, 100]; 0 to 100	100 [62.5, 100]; 0 to 100	0.148
Cooler months	**Overall**	54.6 [6.2, *]; 6.2 to 100	39.3 [22.5, 67.2]; 10.7 to 83.3	0.811	43.3 [31.6, 60.6]; 12.5 to 100	41.4 [28.5, 59.9]; 8.3 to 92.9	0.784
	Before	6.2 [6.2, 6.2]; 6.2 to 6.2	2 [0, 10.7]; 0 to 13	0.750	13.9 [4.1, 17.3]; 0 to 23.5	3.7 [0, 9.5]; 0 to 16.1	0.072

	After	9.1 [9.1, 9.1]; 9.1 to 9.1	40 [5.3, *]; 5.3 to 50	01.00	21.4 [15, 32.8]; 14.2 to 35.3	11.1 [0, 18.1]; 0 to 28.6	0.050
	During	100 [100, 100]; 100 to 100	100 [63.5, 100]; 0 to 100	0.436	100 [50, 100]; 43.3 to 100	100 [96.4, 100]; 16.7 to 100	0.512

Adult hat-wearing rates at non-government SSSs and non-SSSs and at government SSSs and non-SSSs were found to be statistically similar (Table 16).

Table 17: Median [inter-quartile range]; range of adult hat-wearing proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school ICSEA score within SunSmart status

		≤ average ICSEA score			**> average ICSEA score**		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations	**Overall**	46.8 [30, 62.2]; 10.6 to 100	48 [37.4, 57.3]; 28.3 to 100	01.00	n/a	48.2 [30.2, 62.8]; 20.8 to 64.2	
	Before	10.2 [5.3, 17.1]; 0 to 26.7	4.6 [0.5, 8.2]; 0 to 20	0.074	n/a	2.8 [0.5, 5.8]; 0 to 6.5	
	After	25.2 [14.2, 35.3]; 0 to 54.6	19.8 [10.9, 36.5]; 0 to 50	0.650	n/a	15.1 [0, *]; 0 to 21.1	
	During	80.6 [41.7, 94.4]; 0 to 100	98.2 [66.7, 100]; 50 to 100	0.106	n/a	62.5 [54.6, 94.4]; 50 to 100	
Warmer months	**Overall**	46.1 [22.2, 61.5]; 11.1 to 75.3	53.7 [34.7, 67]; 11.8 to 100	0.391	n/a	66.7 [13.8, 71.9]; 0 to 73.7	
	Before	5.6 [0.8, 16.6]; 0 to 26.7	6.2 [1.6, 11.3]; 0 to 20	01.00	n/a	0 [0, *]; 0 to 0	

	After	28.3 [6.3, 82.9]; 0 to 100	29.7 [25, 50]; 16.7 to 50	0.788	n/a	18.1 [15.1, *]; 15.1 to 21.1	
	During	66.7 [37.5, 95.8]; 0 to 100	100 [62.5, 100]; 0 to 100	0.073	n/a	66.7 [20, 96.7]; 0 to 100	
Cooler months	**Overall**	45 [30.5, 62.4]; 6.2 to 100	41.8 [25.1, 64.9]; 8.3 to 92.9	0.828	n/a	34.7 [29.4, 56.4]; 25.5 to 68.8	
	Before	12.5 [4.2, 17.1]; 0 to 23.5	2.6 [0, 9.8]; 0 to 16.1	0.053	n/a	2.8 [0.5, 10.7]; 0 to 13	
	After	17.4 [11.7, 30.4]; 9.1 to 35.3	12 [5.3, 28.6]; 0 to 50	0.510	n/a	0 [0, *]; 0 to 0	
	During	100 [50, 100]; 43.3 to 100	100 [96.4, 100]; 0 to 100	0.711	n/a	75 [63.5, 100]; 58.3 to 100	

When schools were grouped according to ICSEA score, there were zero non-SSSs with above average ICSEA scores. Adult hat-wearing rates were not statistically different at all schools with below average ICSEA scores, regardless of SunSmart status (Table 17).

Table 18: Median [inter-quartile range]; range of adult hat-wearing proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school sun-protection policy score within SunSmart school (SSS) status.

		≤ median policy score			**> median policy score**		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations	**Overall**	48.1 [38.5, 62.5]; 16.7 to 100	48.2 [38.1, 57.6]; 20.8 to 66.8	0.605	21.9 [10.6, 0]; 10.6 to 66.2	48.2 [36.5, 60.3]; 31.5 to 100	0.365
	Before	12.9 [4.2, 18.2]; 0 to 26.7	3.6 [0, 7.5]; 0 to 8.4	0.034	6.7 [6.1, 0]; 6.1 to 7.3	4.6 [1, 10.8]; 0 to 20	0.513

	After	24.8 [3.6, 49.7]; 0 to 54.6	21.8 [12.8, 36.5]; 0 to 50	0.808	25.2 [17.4, 0]; 17.4 to 31.5	12.1 [5.3, 25.6]; 0 to 40	0.383
	During	84 [56.2, 100]; 33.3 to 100	66.7 [59.2, 100]; 50 to 100	0.809	32.5 [0, 0]; 0 to 81.3	92.6 [77.1, 100]; 50 to 100	0.031
Warmer months	**Overall**	50 [32.1, 62.6]; 22.2 to 75.3	45.7 [23.3, 66.7]; 0 to 67.9	0.882	12.4 [11.1, 0]; 11.1 to 62.5	62 [35.9, 72.9]; 11.8 to 100	0.136
	Before	6.2 [0, 21]; 0 to 26.7	4.8 [0, 6.6]; 0 to 8	0.491	5.6 [5.4, 0]; 5.4 to 5.7	7.8 [0.5, 13.9]; 0 to 20	01.00
	After	50 [0, *]; 0 to 100	28.6 [16.7, 50]; 15.1 to 50	01.00	28.3 [25, 0]; 25 to 31.5	25.4 [21.1, *]; 21.1 to 29.7	0.667
	During	66.7 [50, 91.7]; 33.3 to 100	100 [40, 100]; 0 to 100	0.710	0 [0, 0]; 0 to 100	100 [75, 100]; 50 to 100	0.225
Cooler months	**Overall**	48 [33.2, 74.6]; 12.5 to 100	42.2 [32, 64.3]; 8.3 to 83.3	0.605	28.3 [6.2, 0]; 6.2 to 58.7	38.5 [25, 63.2]; 10.7 to 92.9	0.536
	Before	15.4 [2.1, 17.5]; 0 to 23.5	3.6 [1.2, 9.3]; 0 to 9.5	0.101	8.2 [6.2, 0]; 6.2 to 10.1	1 [0, 12.5]; 0 to 16.1	0.711
	After	14.2 [9.1, *]; 9.1 to 35.3	11.6 [0, 33.9]; 0 to 50	0.714	21.4 [17.4, 0]; 17.4 to 25.4	11.3 [4, 28]; 0 to 40	0.429
	During	100 [68.8, 100]; 50 to 100	100 [68.8, 100]; 16.7 to 100	0.882	71.7 [43.3, 0]; 43.3 to 100	100 [75, 100]; 0 to 100	0.769

When schools were grouped according to their total policy score, adult hat-wearing rates at non-SSSs with less developed policies were found to be higher than hat-wearing rates at SSSs with less developed policies before school hours. Adult hat-wearing rates were higher at SSSs with more developed sun-protection policies during school hours overall. Adult hat-use during the warmer and cooler months was statistically similar at all schools, regardless of policy score (Table 18).

Table 19: Median [inter-quartile range]; range of adult hat-wearing proportions (%) at Townsville primary schools overall, before, after and during school hours: stratified by school size within SunSmart school (SSS) status

		≤ 399 students			400-799 students			800+ students		
		non-SSS	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**	**non-SSS**	**SSS**	**P value**
All observations	**Overall**	58.3 [37, 87.5]; 16.7 to 100	47.6 [28.3, 57.1]; 20.8 to 100	0.268	42.5 [19.1, 53.6]; 10.6 to 66.2	48.4 [38.4, 60.9]; 31.7 to 66.8	0.388	40.4 [38.7, *]; 38.7 to 42	40.3 [39.3, 59]; 31.5 to 61.3	0.667
	Before	12.5 [0, *]; 0 to 26.7	0 [0, 5.9]; 0 to 20	0.383	7.8 [6.7, 14.9]; 6.1 to 16.6	7.4 [2, 8.4]; 0 to 15.6	0.530	10.8 [2.9, *]; 2.9 to 18.7	3.7 [1.5, 6.5]; 1 to 10.8	0.667
	After	27.3 [0, *]; 0 to 54.6	5.3 [0, 13.2]; 0 to 13.9	0.857	25.2 [15.8, 33.4]; 14.2 to 35.3	28.6 [13.6, 38.7]; 10.5 to 50	0.797	n/a	25.6 [25.6, 25.6]; 25.6 to 25.6	
	During	75 [45.8, 93.8]; 33.3 to 100	83.3 [58.3, 100]; 50 to 100	0.639	65.3 [24.4, 83.2]; 0 to 88.9	100 [62.9, 100]; 50 to 100	0.088	100 [100, 100]; 100 to 100	88.8 [62.5, 100]; 51.9 to 100	0.333
Warmer months	**Overall**	58.3 [29.2, 73.2]; 22.2 to 75.3	35 [11.8, 66.7]; 0 to 100	0.412	36.1 [12.1, 59.6]; 11.1 to 62.5	57.3 [36.6, 68.2]; 19.3 to 75	0.181	42.1 [41.9, *]; 41.9 to 42.2	66.7 [38.6, 70]; 33.7 to 70.4	0.500
	Before	13.3 [0, *]; 0 to 26.7	0 [0, 15.9]; 0 to 20	0.571	5.6 [1.4, 8.2]; 0 to 9.1	6.6 [6.2, 11.3]; 5.9 to 14.6	0.190	11.2 [3.2, *]; 3.2 to 19.1	2.9 [0, 6.2]; 0 to 11.1	0.429
	After	50 [0, *]; 0 to 100	20.8 [16.7, *]; 16.7 to 25	01.00	28.3 [25, *]; 25 to 31.5	36.5 [19.6, 50]; 15.1 to 50	0.857	n/a	29.7 [29.7, 29.7]; 29.7 to 29.7	
	During	58.3 [37.5, 79.2]; 33.3 to 83.3	75 [37.5, 100]; 0 to 100	0.610	58.3 [0, 87.5]; 0 to 100	100 [45, 100]; 0 to 100	0.272	100 [100, 100]; 100 to 100	100 [75, 100]; 66.7 to 100	0.500
Cooler months	**Overall**	54.6 [22.9, 100]; 12.5 to	52.7 [25, 66.7]; 8.3 to	0.530	37.1 [22.8, 60.6]; 6.2 to	41.4 [33.3, 66.5]; 13.3 to	0.529	48 [45, *]; 45 to 51	34.4 [25.1, 44]; 10.7 to	0.222

	100	92.9		66.2	83.3			66.7	
Before	6.3 [0, *]; 0 to 12.5	0 [0, 0]; 0 to 0	0.400	15.4 [8.2, 20.1]; 6.2 to 23.5	9.3 [1, 12.8]; 0 to 16.1	0.151	9.8 [2.1, *]; 2.1 to 17.5	3.6 [1.2, 11.3]; 0 to 13	0.643
After	9.1 [9.1, 9.1]; 9.1 to 9.1	0 [0, 8.2]; 0 to 11.1	0.667	21.4 [15, 32.8]; 14.2 to 35.3	20.3 [11.6, 42.5]; 10.5 to 50	0.914	n/a	24 [24, 24]; 24 to 24	
During	100 [62.5, 100]; 50 to 100	100 [92.9, 100]; 16.7 to 100	0.927	87.5 [46.7, 100]; 43.3 to 100	100 [84.4, 100]; 0 to 100	0.364	100 [100, 100]; 100 to 100	87.5 [50.7, 100]; 27.8 to 100	0.429

Adult hat-wearing proportions were not found to be significantly influenced by student enrolment figure when SunSmart status was considered (Table 19).