'Heat-Smart' schools during physical education (PE) activities: Developing a policy to protect students from extreme heat

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Abstract

National and state surveys of school sun protection policies and practices demonstrate that being a member of a SunSmart Program improves sun protection practices in primary schools, often lead by Health and Physical Education (HPE) teachers. Australia's major Sunsmart program implemented in primary schools has largely focused on limiting children's exposure to ultraviolet radiation (UVR) to reduce the risk of developing skin cancer later in life. Yet another major hazard during outdoor physical education activities is the impact of extreme heat on school students. With physical education (PE) often occurring in hot environments and involving higher intensities (and heart rates), exposure to heat influences are raised. This research reports on a social-ecological model (SEM) review and text mining analysis of key heat protection policies and practices for the development of a five stage Heat Smart action plan in schools. The five stage action plan of Heat Smart strategies can be used to counteract extreme heat exposure during PE and ensure school students continue to meet key national physical activity and curricular objectives.

Introduction

It has been demonstrated from state and national evaluation surveys that being involved in Cancer Council's SunSmart Program can enhance sun protective practices (hats, sunscreen, shade & sunglasses) across Australian primary school settings (Sharplin, Smith & Roth, 2013). Yet another potential weather risk to primary school students is exposure to extreme heat, especially within the 'outdoor discipline' of physical education (PE). Although there are guidelines and 'tips' for a number of Australian states from organisations such as Sports Medicine Australia (SMA) and the Cancer Council itself (an emphasis on skin cancer prevention) around the protection of students from heat-related influences in schools, broader investigation into heat protective practices in schools is warranted. Exposure to extreme heat can negatively influence students in alternative ways via cardiovascular, thermoregulation, discomfort, cognitive and hydration impairments (McArdle, Katch & Katch, 2006; Tatterson, Hahn, Martini & Febbraio, 2000; Nadel, Cafarelli, Roberts & Wenger, 1979; González-Alonso et al., 1999). If exposure to extreme heat is left untreated or protected, this can lead to severe heat illness, rashes, cramps, exhaustion and heat stroke (Bergeron, McLeod & Coyle, 2007; Cooper, Ferrara & Broglio, 2006; Glazer, 2005; Howe & Boden, 2007). Health and Physical Education (HPE) teachers are the most likely staff within education settings to encourage and administer weather protective practices and programs (Sharplin, Smith & Roth, 2013) due to the outdoor nature of the discipline. As students can have reduced physical activity

levels above just 22 degrees (Remmers et al., 2017), ensuring school students are adequately protected from extreme heat during PE has the potential to be a key strategy to improve students' physical activity engagement. In Australia there is a distinct need to consider a range of physical activity participation strategies with just 19% of students meeting the national physical activity guidelines (Active Healthy Kids Australia, 2016).

Literature review

In the United States, emergency department admissions over a decade between 1997 and 2006 revealed that children were the most reported age group to hospital with exertional heat influence, largely from physical activity and sport participation (Nelson, Collins, Comstock & Mckenzie, 2011). Statistics from Japan's Sporting Council have also revealed that accidental death due to heat stroke has occurred on 133 occasions during school hours between 1975 and 2009 from sports such as rugby, baseball, football, kendo, judo, mountaineering and track and field (Hatori, 2013). Previously, it was recognised that students were much more likely to be negatively influenced by the heat than adults due to different physiological make-up with larger surface-to-body heat absorbing ratio, less ability to sweat and a higher level of metabolic heat production. Although recent findings have contrasted children's susceptibility to heat, deeming such assertions as inconclusive (Somboonwong, Sanguanrungsirikul & Pitayanon, 2012). The increased prevalence and susceptibility of students to illness from heat exposure can be attributed to more behavioural influences, including not receiving adequate hydration during physical activity participation (Decher et al., 2008). It has been reported that students often reach dehydration in hot climates by not hydrating effectively (Somboonwong et al., 2012) and students who are not hydrated suffer from impaired concentration, cognition and ability to remember content (Benton & Burgess, 2009). With PE often occurring in hot environments and involving higher intensity (and heart rates), an exposure to heat influences in schools is raised (Doecke, 1992; Somboonwong et al., 2012).

In 1992, Doecke reported that the incidence of heat illness across 17 Australian secondary schools in a tropical climate (for example, sun burn, headache, nausea, dehydration) spiked during the humid, wet season months between October (build up to monsoonal weather) and March (end of the monsoon season). Climates of extreme heat can result in students appearing 'listless' or 'restless', complain about the heat/humidity and voice negative feelings about physical activity throughout a school year (Doecke, 1992). It has also been established that temperatures above 20-24 degrees Celsius and humidity levels beyond 50% significantly impair student learning (Earthman, 2002). Moreover, higher temperatures can slow the acquisition and retention of information received by individuals (Batra & Garg, 2005). This level of heat exposure is further reinforced by a mandatory requirement in many jurisdictions of at least 100-150 minutes of PE each week (Education & Training Victoria, 2017; Department of Education Western Australia, 2013; Education & Training ACT, 2017) for Australian students to learn in, through and about movement (Arnold, 1979). The risks associated with extreme heat and heat illness are further confounded with predictions of an increased occurrence of heat illness from global warming (Bunyavanich, Landrigan, McMichael & Epstein, 2003; Solomon, 2007), especially for those that participate in outdoor PE within tropical climates and during summer heat wave events. A crowded curriculum, geographical location and timetabling considerations can leave exposure to extreme heat during allocated PE time unavoidable (Doecke, 1992).

Students have reported having lower enjoyment for school physical activities in hot conditions (Hyndman & Chancellor, 2015) and during hotter months across a school year (Hyndman, Chancellor & Lester, 2015; Hyndman, 2017). Another major concern for PE is that SMA (2007-2011) advises that physical activities need to be postponed or cancelled when the 'wet bulb

globe index' (a combination of temperature & humidity readings) reaches a level of 30 and above. Shannon and colleagues (2009) discovered that in tropical areas such as Darwin, the average wet globe bulb temperature (WGBT) exceeds 30 all year round, which would suggest from the SMA index that no physical activity should be undertaken in such climates (other than swimming). With over one million Australians living in the tropical climate of Northern Australia (Australian Government, 2015) and no formal heat protection policy for Australian schools, a national school-based 'Heat Smart' program based upon strategies identified within the present study can be highly beneficial. The aim of this research is to therefore review and identify key heat protection practices for the development of a Heat Smart action plan for schools to increase and protect students' engagement in PE activities during extreme heat.

Methods

Social-ecological model framework

Given the complex nature of a school setting, the social-ecological model (SEM) framework was employed within this paper as a guide to the multiple levels within school environments that can be understood and addressed to develop and enforce heat protection policies, especially for physical educators that are often based outdoors. Addressing multiple levels of an environment via a SEM can then provide sustainable change via policy to improve school heat protection, similarly to school sun protection practices (Reeder, Jopson & Gray, 2012). Identifying supportive strategies to counteract extreme heat exposure can ensure school students continue to meet key national physical activity and PE curriculum objectives. This research is underpinned by a SEM analysis of key heat protection policies and practices that can be used by programs in schools to increase students' engagement during outdoor PE activities during periods of extreme heat.

The SEM framework can be used to provide a theoretical framework to analyse, explore and understand the multiple factors that can be influenced by heat at the intrapersonal (individual), interpersonal (social), physical environment and policy levels (Wattchow et al., 2015). The SEM framework is described as a 'personal-environment' fit by providing an understanding of the multiple levels of influence that can affect behaviour and is used to broadly analyse educational problems in a given setting (O'Connor, Alfrey, & Payne, 2012; Wattchow et al., 2015). The SEM framework allows the broad influences on a particular behaviour (for example, heat protection) to be comprehensively understood in order to develop and implement more effective program solutions that address each of the levels of influence for lasting behavioural effects (O'Connor et al., 2012; Wattchow et al., 2015). To ensure existing and potential strategies for heat protection could be identified, a review was conducted of heat protection implementation, investigations, reports and/or guidelines relating to heat influences in schools.

As many of the guidelines were organisation based (for example, governments, education departments, sporting organisations; Tables 1-4) and non-academic peer reviewed reports, a general web search was conducted through the Google search engine platform. Key words were developed from initial exploratory work for Northern Territory schools (Hyndman, 2015) that included 'heat guidelines for students', 'heat policies in schools', 'heat recommendations in schools', 'heat influences on students' physical activity', 'influence of heat in schools', 'influence of heat on school sport'; and 'extreme heat in schools.' The inclusion criteria for the study was for the selected report to be either academic-based (thesis or peer reviewed journal article), a sporting organisation, government organisation, education organisation, health organisation or an environmental organisation. Additionally, the reports also had to include dialogue on heat protective strategies within the context of schools. The multiple layers of heat

protection policies, recommendations and practices that were identified were then screened according to a SEM framework. Recommendations and practices were screened at the following SEM levels (Jeanes, Magee & O'Connor, 2014):

- *Individual SEM level:* If the recommendation included biological, physiological, genetic and psychological components. Other individual SEM framework components include motives, attitudes, intentions and beliefs;
- *Social SEM level:* If the recommendation comprised of socio-cultural factors that interact with individuals to impact on behaviour. Social SEM level contextual factors include family, friends, organisations, teachers, students and coaches. Within schools, teachers are constantly interacting with students, other staff and parents from day to day;
- *Physical environment SEM level:* If the recommendation related to products and structures within an environment that can increase or decreased the desired behaviours (for example, heat protection). Physical environmental features are often divided into both built environmental features and natural environmental features that can influence individuals; and
- *Policy SEM level:* If the recommendation related to policies, laws and regulations that can impact on individuals'.

Each of the reports then underwent a Leximancer text mining analyses to determine major themes emerging from the literature collected.

Leximancer

The Leximancer text mining software uniquely extracts and illustrates weighted term classification between key words and develops concept maps that display the rate at which concepts and significantly related terms appear close to each other within the text. Leximancer is for text mining major themes through a process of spatial and relational analyses to reveal the relevance of the semantic networks from the literature. The software can be used to determine the relationship between concepts and the occurrences of concepts how related terms from the documents appeared close together within the text (Pill, Harvey & Hyndman, 2017; Hyndman & Pill, 2017). The findings from the text mining of the school heat policy reports, guidelines and investigations were analysed manually to confirm the themes from the original literature. This process ensured that the research process could be enriched and to enhance the data interpretation.

Results and discussion

Individual level social-ecological model components that could be considered for a 'Heat Smart' school policy program

The findings across the school heat policy reports, guidelines and investigations at the individual level included components of knowledge, information, awareness of intensities, nutritional considerations, communications methods, hydration and sleep considerations (Table 1).

Table 1. *A guide to individual level strategies that could be considered in a potential Heat Smart Schools Program (including state and national sources).*

Individual level component	***Source***
• Access to information resources	• SMA, 2007-2011
• Acquire adequate fitness and acclimatisation	• SMA, 2007-2011; Education Queensland, 2016; Hatori, 2013
• Adjust and be flexible with activity intensity in hot conditions	• SMA, 2007-2011
• Avoid caffeinated drinks	• Climate Council, 2015
• Consider ages and gender of participants	• Education Queensland, 2016
• Diverse communication methods (e.g. text messages, newsletter, websites, social media) relating to heat illness prevention	• SMA, 2007-2011
• Eat balanced meals regularly with good protein and vitamins	• Hatori, 2013
• Increase the amount of rest in hot conditions	• Climate Council, 2015
• Professional development on heat influences	• Doecke, 1992
• Stay hydrated	• Australian Education Union, 2014; SMA, 2007-2011
• Sufficient sleep when recovering from the heat	• Hatori, 2013

Social level social-ecological model components that could be considered for a 'Heat Smart' school policy program

The findings within the present study revealed there was an emphasis on roles relating to the heat, parental preparation of heat protection mechanisms, staff mentoring and leadership around heat protection (Table 2).

Table 2. *A guide to social level strategies that could be considered in a potential HeatSmart Schools Program (including state and national sources).*

Social level component	***Source***
• Allocate responsibilities according to heat guidelines	• SMA, 2007-2011
• Consider who is participating beyond students and staff in outdoor physical activity events e.g. officials, coaches, sports trainers, spectators	• SMA, 2007-2011
• Consideration for parents to freeze water for cooled water provision for students	• NSW Government, 2016
• Encourage others to drink adequate amounts of water	• Climate Council, 2015
• Heat preparation guidance letters to parents, students and staff prior to expected hotter temperatures	• Australian Education Union, 2014
• Mentoring other staff on the facilitation of outdoor physical activities in the heat	• Doecke, 1992
• Parental education to ensure child has water bottle for hydration	• NSW Government Education, 2016

Physical environment level social-ecological model components that could be considered for a 'Heat Smart' school policy program

Within the present study it was revealed that physical environment components that could protect against the heat were based around shade, ventilation, hydration access/techniques and temperature/hydration monitoring (Table 3).

Table 3. *A guide to physical environment level strategies that could be considered in a potential HeatSmart Schools Program (including state and national sources).*

Physical environment level component	***Source***
• Access more shaded areas	• Australian Education Union, 2014; SMA, 2007-2011; NSW Government, 2016; SA Government, 2016
• Avoid surfaces that exhibit radiant heat that include concrete, black asphalt or black rubberised synthetic surfaces which can intensify hot conditions	• Doecke, 1992; SMA, 2007-2011
• Hydration programs	• Somboonwong, et al., 2012
• Increasing amount of drinking taps/ fountains	• Australian Education Union, 2014
• Programs to develop more naturally shaded areas	• Doecke 1992; Hatori, 2013
• Providing access to air conditioned facilities	• Doecke, 1992; NSW Government, 2016; Australian Education Union, 2014
• Providing more ventilated activity areas during PE	• Doecke, 1992; Hatori, 2013; Australian Education Union, 2014; SMA, 2007-2011
• Schools to provide access to cooled/ iced water facilities*	• Hatori, 2013
• Use of electrolytes in drinks	• SMA, 2007-2011
• Use of fans, water sprays or other devices	• Doecke, 1992; NSW Government, 2016; Australian Education Union, 2014; SMA, 2007-2011
• Use of heat illness chart to guide planning of outdoor physical activities	• Hatori, 2013; SMA, 2007-2011
• Use of urine charts to check for dehydration	• NSW Department of Health, 2017
• Use temperature gauges in class	• Shannon, Stewart & Stewart, 2009; Australian Education Union, 2014
• Wet sponging during activities	• Hatori, 2013; Hockey Australia, 2016; SMA, 2007-2011

* Reported as the most significant strategy to cool 'core' body temperature in sporting athletes.

Policy level social-ecological model components that could be considered for a 'Heat Smart' school policy program

It was revealed in the present study that timing of physical activity, clothing considerations, heat protection monitoring and communication procedures and emergency/illness procedures were key heat protective mechanisms to be considered at the policy SEM level of influence.

Table 4. *A guide to policy level strategies that could be considered in a potential HeatSmart Schools Program.*

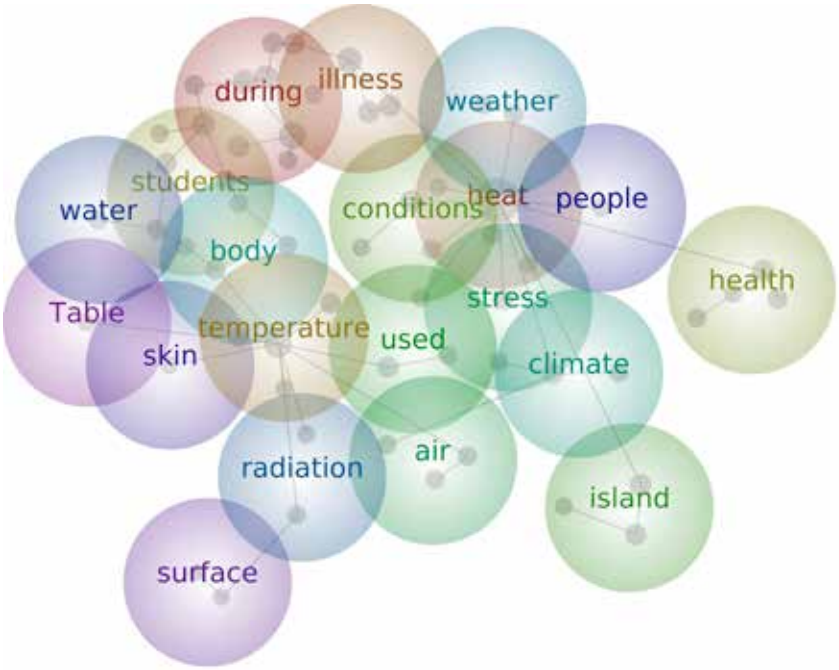
Physical environment level component	***Source***
• Activities at the end of the year require shade	• Doecke, 1992; NT Department of Education, 2016
• Cancellation of activities when it is too hot	• South Australian Government, 2016; Education Queensland, 2016; SMA, 2007-2011
• Clothing should allow easy evaporation of sweat	• Education & Training ACT, 2017; NT Department of Education, 2016; SMA, 2007-2011
• Clothing and hat sun protection	• SMA, 2007-2011; Australian Education Union, 2014
• Develop and create a heat management plan	• Australian Education Union, 2014
• Fundraising programs to raise money for a more heat protective environment during hot weather	• Doecke, 1992
• Guidelines should cater to geographical location	• SMA, 2007-2011
• Hats and clothing should be made from protective/reflective materials	• SMA, 2007-2011
• Heat warning systems	• World Health Organisation (WHO), 2003; Australian Education Union, 2014
• Modifying school uniforms in hot weather	• Australian Education Union, 2014; SMA, 2007-2011
• Monitoring timetabling allocations and length of PE classes	• Australian Education Union, 2014; NSW Government, 2016
• Outdoor activities should be scheduled around the 11am to 3pm heat risk period	• Doecke, 1992; NSW Government, 2016; NT Department of Education, 2016
• Postponing activities when it is too hot	• Hatori, 2013; NT Department of Education, 2016; Australian Education Union, 2014; SMA, 2007-2011; NSW Government, 2016
• Prepare a communication strategy for the school community	• SMA, 2007-2011

Physical environment level component	*Source*
• Referring to SMA sporting guidelines during extreme heat	• NT Department of Education, 2016; South Australian Government, 2016
• Review shade structures	• Education Queensland, 2016; Australian Education Union, 2014: SMA, 2007-2011
• Rotating air conditioning access for classes	• NSW Government, 2016; Australian Education Union, 2014
• Seeking insight from the Bureau of Meteorology relating to local weather conditions	• SMA, 2007-2011
• Sports carnivals/sports days should be conducted where shade is available	• Doecke, 1992; NT Department of Education, 2016
• When ill, avoid exercising in hot conditions	• SMA, 2007-2011

Leximancer text mining themes from the heat influence literature

Key themes that emerged from the Leximancer text mining analyses at the individual SEM level included illness, health, skin, stress and body. At the social level, there were little themes other than 'students' and 'people' identified. Yet from the Leximancer text mining analyses at the physical environment SEM level from the heat literature, guidelines were weather, conditions, climate, heat, air, temperature (could also be physical body temperature), radiation, island, water and surface. There were no policy level themes identified from the literature, although many of the themes identified at the other levels (especially physical environment) could inform policy according to climatic conditions (Figure 1).

Figure 1. *Key themes from Leximancer text mining of heat policy documents and investigations.*



It is clear that there are many strategies that could be utilised for heat protection during PE. This is the first published Australian investigation to the author's knowledge to explore the different potential strategies, guidelines and policies relating to students' heat protection in the school environment for PE. This paper empasises the number of different sources and organisations advocating for heat protection, yet it also notes a lack of uniformity. The most commonly utilised school heat policy report relating to heat protection has been SMA's hot weather guidelines (2007-2011) (which includes heat illness, beat the heat and SmartPlay strategies). In contrast to the national unity and success of the Cancer Council's 'Sunsmart' policies in schools (Sharplin, Smith & Roth, 2013; Dudley et al., 2015), there is variance across heat policy reports, guidelines and investigations. The findings emphasise the importance of developing a unified Heat Smart program for Australian schools relating to heat protection. This study provides insight into the multiple levels of influence and themes to develop a Heat Smart action plan for this crucial and often overlooked area of school health.

The most comprehensive guides and tips for schools within the study were revealed to come from SMA's resources (SMA, 2007-2011). Yet it should be acknowledged that the SMA resource is intended for widespread organisations such as state and national sporting bodies, sporting assemblies, government authorities, clubs, physical activity groups, associations, leagues, recreation centres, event organisers, fitness providers and of course schools (SMA, 2007-2011). Given the success of the 'school-based' Sunsmart program, this suggests that there is room for a more school-specific heat protection program, especially given that students spend the majority of their time within school environments for PE, recess time, after school and sporting excursions. Moreover, the skills learnt during school PE are largely transferred to such sporting and community contexts (Australian Government, 2009). The SEM findings from the literature demonstrate that there are a host of heat protective considerations at the individual level (knowledge, information access, awareness, nutrition, sleep, communication & hydration), social level (roles and responsibilities, home-based preparation, mentoring & staff leadership), physical environment level (shade, ventilation, hydration access/techniques & monitoring of conditions) and policy SEM influences (timing, clothing, monitoring of conditions and various protective procedures according to illness and emergency). The findings create a broad understanding of the heat influences on students and teachers within school PE, demonstrates the many influences that could be detrimental to health and provides a multi-level guide to develop a heat protection program/policy.

Hydration considerations continue to be a big concern for student learning and physical activity participation and some of the strategies revealed in the study were based around electrolytes, preparation of drinks, increasing drinking taps, cooled water, hydration programs and fluid reminders during activities. The brain has been described as becoming impaired under 'conditions of thirst' at the neuropsychological level and can result in the impaired sense of touch, motor control, planning behaviour, impaired emotions, decision making and auditory processing (Benton & Burgess, 2009). Students' sweat rate can be a useful guide to hydration and teachers should ensure students have access to frequent drinks breaks, activity-to-rest ratios and continued access to shaded or ventilated areas (if present). With the emergence of cooling clothing materials to enhance sporting performance (Webster, Hollan, Sleivert, Laing & Niven, 2005), there is also scope for strategies around the modified school uniforms such as ice vests and material that provide elements of thermal comfort. A previous study by Norrish and colleagues (2012) revealed that modifying school uniforms to be more suitable for physical activities can have an impact on physical activity participation. The consideration of uniform modification in a national Heat Smart program is therefore warranted.

Physical education is vital for students to develop physical activity habits across the lifespan (Telama, 2009). The main concern from the impact of heat is that if PE classes are held in intense

heat, students may become vulnerable to heat injury and impaired learning (Somboonwong, et al., 2012). Therefore, when preparing a quality PE program, the quantity and intensity of the physical activities needs to be taken into consideration. As Shannon and colleagues (2009, p.272) note;

"Ill informed decisions may be detrimental to students, staff and other relevant stakeholders in two ways:

1. *The loss of time to be physically active due to cancellation of activities during moderate to high risk conditions when the activities could safely occur with appropriate modifications and provisions; and*
2. *Placing the health and safety of students, staff and other stakeholders at risk by continuing to run an activity, as previously scheduled, during extreme risk conditions."*

Synthesis

From the review of various heat-protection implementations, investigations, reports and/or guidelines in schools, five key action areas from the research based around the Ottawa Charter for Health Promotion (World Health Organisation, 1986) have been developed of what a national school heat policy can encompass. These include:

Action Area 1: School policy

- Adopt flexible scheduling of outdoor activities according to the heat conditions by duration/intensity. Start earlier or later in the day when the heat is less intense and ensure children have more rest breaks. The school should have alternative venues to modify and relocate activities during extreme heat when temperatures exceed 30 degrees and humidity levels exceed 60%.
- Schools should consider modifying uniforms to combine UV protection with cooling fabrics and ice vests to reduce body temperatures and "thermal stresses" during extreme heat.
- Schools need to be set up to deal with incidences of heat illness and emergencies and to encourage regular rotations to shaded/cooler areas. This includes developing communication procedures (text, internet, email, social media) to notify staff and students of high-risk heat conditions.

Action Area 2: Environment

- Ensure extra shade from both man-made structures (tents, sails and umbrellas) and natural features such as trees to provide cooler environments for outdoor activities during extreme heat.
- Use large industrial fans and ensure indoor spaces have open doors/windows or air-conditioning access during activities, especially during rest periods.
- Provide more water fountains, cooled water facilities and electrolytes for fluid retention and regularly monitor outdoor weather conditions. Ice and water spray bottles could also be used as cooling aids.
- Display heat guidelines and charts in prominent locations in the school for reminders about hydration and feelings according to the temperature.

Action Area 3: Training

- Develop personal skills so staff and students know how and where to access heat protective strategies in the school. This includes maintaining adequate nutrition, keeping food safe (at lower temperatures to prevent being spoiled), gaining adequate sleep and monitoring hydration practices and fluid loss.
- Develop communication methods within schools relating to heat illness and where to access support or facilities through a developed heat-protective resource map and guide. Train staff how to detect heat illness in others and to treat, mentor, role-model and protect others.

Action Area 4: Prevention

- Teachers to take into account medical characteristics of students, age, fitness and level of acclimatisation when undertaking activities in hot conditions. Regularly monitor any students or staff who appear distressed from the heat.
- Implement heat-protective policy according to relevant Australian Curriculum content of "being healthy safe and active", demonstrate heat-protective behaviours for safety, and identify actions, plan and promote heat strategies to develop health, safety and wellbeing.

Action Area 5: Community

- Notify parents about school heat conditions and ask them to provide their children with cooled water and modified uniforms during heatwaves. Also give parents an insight into the school procedures in place to protect the students from the heat.
- Include information on the school's heat-protective procedures in school newsletters. Parents can use this beyond the classroom. Schools should gain feedback from the community on strategies and ideas for further protection of staff and students during heatwaves.
- Put on events to help raise funds for heat-protective facilities in schools. Include parents to have different heat-protective roles and responsibilities during outdoor school events.

Summary, conclusions and implications

As the climate continues to warm via global warming with increased frequency of extreme weather and heat wave events (Bunyavich et al., 2003; Solomon, 2007), temperatures are projected to rise substantially and more protective strategies will be required according to a heat-health burden. This paper importantly outlines a host of protective strategies for another major outdoor health influence on students. The SEM framework provides an important guide to understand the key influences that could be addressed in a proposed 'Heat Smart' program. The paper reports on an inconsistency in heat protection messages and information for schools and PE teachers practicing outdoors. The findings suggest that the development of the proposed five Heat Smart program key action areas is warranted for building (1) *healthy school policy* (flexible scheduling of activities, uniform adaption); (2) *heat supportive environments* (shade provisions, hydration strategies, development of heat protective guidelines and charts); (3) *heat protective community action* (development of communicative methods to parents such as social media, provision of preparatory information to parents, feedback from the community on strategies); (4) *heat protective community skills* (skill development on accessing heat protective resources; monitoring hydration skills; nutritional considerations;); and (5) *a*

focus on the prevention of heat illness (monitoring of staff & students; aligning with curricular content). Advocating for policy change for a heat protection program is vital for developing and maintaining physical activity participation levels and the learning of students during PE activities. As Shannon and colleagues (2009, p.276) state, *"School staff must understand the mechanisms of escalating risk and be supported to undertake action to reduce the level of risk through appropriate policies, procedures, resources and action plans."*

References

Active Healthy Kids Australia. (2016). Report Cards. Retrieved November 1, 2016 from: *http://www.activehealthykidsaustralia.com.au/report-cards/*

Arnold, P. J. (1979). *Meaning in movement, sport, and physical education*. London: Heinemann.

Australian Education Union. (2014).What to do in cases of extreme heat. Retrieved June 21, 2016 from: *http://www.aeuact.org.au/what_to_do_in_cases_of_extreme_temperature*

Australian Government. (2009). The future of sport in Australia (Crawford Report). Retrieved January 5, 2016 from: *http://apo.org.au/node/19766*

Australian Government. (2015). White Paper on Developing Northern Australia. Retrieved March 22, 2016 from: *http://www.industry.gov.au/ONA/WhitePaper/index.html*

Bar-Or, O. (1989). Temperature regulation during exercise in children and adolescents. *Perspectives in exercise science and sports medicine*, *2*, 335-367.

Batra, P., & Garg, R. (2005). Effect of temperature on memory. *Journal of the Indian Academy of Applied Psychology*, *31*(1-2), 43-48.

Benton, D., & Burgess, N. (2009). The effect of the consumption of water on the memory and attention of children. *Appetite*, *53*(1), 143-146.

Bergeron, M. F., McLeod, K. S., & Coyle, J. F. (2007). Core body temperature during competition in the heat: national boys' 14s junior tennis championships. *British Journal of Sports Medicine*, *41*(11), 779-783.

Bunyavanich, S., Landrigan, C. P., McMichael, A. J., & Epstein, P. R. (2003). The impact of climate change on child health. *Ambulatory Pediatrics*, *3*(1), 44-52.

Chia, M., Mukherjee, S., & Huang, D. (2015). Thirst for Drink Knowledge: How Singaporean Youth Athletes Measure Up in an Exercise Hydration Knowledge Questionnaire. *International Journal of Sports Science & Coaching*, *10*(5), 841-850.

Climate Council. (2015). Keeping School Kids Safe During a Heatwave. Retrieved August 23, 2016 from: *https://www.climatecouncil.org.au/uploads/6188af0af90005a3259292362b80d348.pdf*

Cooper Jr, E. R., Ferrara, M. S., & Broglio, S. P. (2006). Exertional heat illness and environmental conditions during a single football season in the southeast. *Journal of Athletic Training*, *41*(3), 332.

Decher, N. R., Casa, D. J., Yeargin, S. W., Ganio, M. S., Levreault, M. L., Dann, C. L., ... & Brown, S. W. (2008). Hydration status, knowledge, and behavior in youths at summer sports camps. *Int J Sports Physiol Perform*, *3*(3), 262-278.

Department of Education Western Australia. (2013). Physical Activity Policies and Guidelines. Retrieved June 5, 2017 from: *http://www.det.wa.edu.au/curriculumsupport/physicalactivity/detcms/navigation/physical-activity-in-schools/policies-and-guidelines/*

Doecke, P. (1992). Geographical influences upon curriculum development. Charles Darwin University, Darwin. Retrieved September 16, 2015, from http://espace.cdu.edu.au/eserv/cdu:6034/Thesis_CDU_6034_Doecke_P.pdf.

Dudley, D. A., Winslade, M. J., Wright, B. J., Cotton, W. G., McIver, J. L., & Jackson, K. S. (2015). Rationale and study protocol to evaluate the SunSmart policy intervention: a cluster randomised controlled trial of a primary school-based health promotion program. *BMC Public Health*, *15*(1). DOI: 10.1186/s12889-015-1371-8

Earthman, G. I. (2002). School facility conditions and student academic achievement. *UCLA's Institute for Democracy, Education, & Access*. Retrieved May 28, 2016 from: *https://escholarship.org/uc/item/5sw56439*

Edmonds, C. J., & Burford, D. (2009). Should children drink more water?: the effects of drinking water on cognition in children. *Appetite*, *52*(3), 776-779.

Education and Training ACT. (2017). Physical Education and Sport. Retrieved June 5, 2017 from: *http://www.det.act.gov.au/__data/assets/pdf_file/0006/18492/PEandSportPolicy.pdf*

Education and Training Victoria. (2017). Physical and Sport Education. Retrieved June 5, 2017 from: *http://www.education.vic.gov.au/school/principals/spag/curriculum/Pages/sport.aspx*

Education Queensland. (2016). Managing excessive heat in schools. Retrieved May 22, 2016 from: *http://education.qld.gov.au/schools/healthy/wellbeing-guidelines/heat.html*

Glazer, J. L. (2005). Management of heatstroke and heat exhaustion. *Am Fam Physician*, *71*(11), 2133-2140.

González-Alonso, J., Teller, C., Andersen, S. L., Jensen, F. B., Hyldig, T., & Nielsen, B. (1999). Influence of body temperature on the development of fatigue during prolonged exercise in the heat. *Journal of Applied Physiology*, *86*(3), 1032-1039.

Hatori, Y. (2013). Heat Stroke in Schools. *JMAJ-Japan Medical Association Journal*, *56*(3), 179-185.

Hockey Australia. (2016). Extreme weather guidelines. Retrieved April 17, 2016 from: *http://www.hockey.org.au/LinkClick.aspx?fileticket=SdLoWndnJ0A%3D&portalid=2*

Hovell, M. F., Wahlgren, D. R., & Adams, M. A. (2009). The logical and empirical basis for the behavioral ecological model. *Emerging theories in health promotion practice and research*, *2*, 347-385.

Howe, A. S., & Boden, B. P. (2007). Heat-related illness in athletes. *The American Journal of Sports Medicine*, *35*(8), 1384-1395.

Hyndman, B. (2015). What is the impact of sweating out HPE in top-end NT schools? *ACHPER Blog Series.* Retrieved October 5, 2016 from: *https://www.achper.org.au/blog/blog-what-is-the-impact-of-sweating-out-hpe-in-top-end-nt-schools.*

Hyndman, B. (2017). *Contemporary School Strategies for Healthy Students.* Singapore: Springer Nature.

Hyndman, B. P., Chancellor, B., & Lester, L. (2015). Exploring the Seasonal Influences on Elementary School children's Enjoyment of Physical Activity during School Breaks. *Health Behavior and Policy Review*, *2*(3), 182-193.

Hyndman, B., & Chancellor, B. (2015). Engaging children in activities beyond the classroom walls: a social–ecological exploration of Australian primary school children's enjoyment of school play activities. *Journal of Playwork Practice*, *2*(2), 117-141.

Hyndman, B., & Pill, S. (2017). What's in a concept? A Leximancer text mining analysis of physical literacy across the international literature. *European Physical Education Review*. DOI: *https://doi.org/10.1177/1356336X17690312.*

Jeanes, R., Magee, J., & O'Connor, J. (2014). Through Coaching: Examining a Socio-ecological Approach to Sports Coaching. In *The Socioecological Educator* (pp. 89-107). Springer Netherlands.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2006). *Essentials of exercise physiology*. Lippincott Williams & Wilkins.

Murray, B. (2007). Hydration and physical performance. *Journal of the American College of Nutrition*, *26*(sup5), 542S-548S.

Nadel, E. R., Cafarelli, E., Roberts, M. F., & Wenger, C. B. (1979). Circulatory regulation during exercise in different ambient temperatures. *Journal of Applied Physiology*, *46*(3), 430-437.

Nelson, N. G., Collins, C. L., Comstock, R. D., & McKenzie, L. B. (2011). Exertional heat-related injuries treated in emergency departments in the US, 1997–2006. *American Journal of Preventive Medicine*, *40*(1), 54-60.

New South Wales Government. (2016). Going to a Public School: supporting students during hot weather. Retrieved June 5, 2016 from: *http://www.schools.nsw.edu.au/gotoschool/a-z/hotweather.php*

New South Wales Department of Health. (2017). Environmental health branch: Beat the heat. Retrieved June 7, 2017 from: *http://www.health.nsw.gov.au/environment/beattheheat/Pages/default.aspx*

Norrish, H., Farringdon, F., Bulsara, M., & Hands, B. (2012). The effect of school uniform on incidental physical activity among 10-year-old children. *Asia-Pacific Journal of Health, Sport and Physical Education*, *3*(1), 51-63.

Northern Territory (NT) Department of Education. (2016). Sun safety in schools (heat policy). Retrieved October 21, 2016 from: *https://education.nt.gov.au/__data/assets/pdf_file/0006/268899/Sun-Safety-in-Schools-policy.pdf*

O' Connor, J., Alfrey, L., & Payne, P. (2012). Beyond games and sports: a socio-ecological approach to physical education. *Sport, Education and Society*, *17*(3), 365-380.

Pill, S., Harvey, S., & Hyndman, B. (2017). Novel research approaches to gauge global teacher familiarity with game-based teaching in physical education: an exploratory# Twitter analysis. *Asia-Pacific Journal of Health, Sport and Physical Education*, 8(2), 161-178.

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 Education Research*, 27(5): 844-856.

Remmers, T., Thijs, C., Timperio, A., Salmon, J., Veitch, J., Kremers, S. P., & Ridgers, N. D. (2017). Daily Weather and Children's Physical Activity Patterns. *Medicine and Science in Sports and Exercise*, 49(5), 922-929.

Shannon, H., Stewart, I., & Stewart, K. (2009). Preventing physical activity induced heat illness in school settings. *Proceedings of the 26th ACHPER International Conference: Creating Active Futures*, 8-10 July 2009, Queensland University of Technology, Brisbane, Queensland.

Sharplin G., Smith A. & Roth, F. (2013). The national survey of Australian primary schools' sun protection policy and practices: Evaluating the national SunSmart schools program. Cancer Council SA: Adelaide.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57(1), 1-23.*

Solomon, S. (Ed.). (2007). *Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

Somboonwong, J., Sanguanrungsirikul, S., & Pitayanon, C. (2012). Heat illness surveillance in schoolboys participating in physical education class in tropical climate: an analytical prospective descriptive study. *BMJ open*, *2*(4), e000741.

South Australian (SA) Government. (2016). Hot weather policy. Retrieved June 12, 2016 from: *https://www.sa.gov.au/topics/education-skills-and-learning/health-wellbeing-and-special-needs/hot-weather-policy*

Sports Medcine Australia (SMA). (2007-2011). Hot weather. Retrieved June 21, 2015 from: *http://sma.org.au/resources-advice/policies-guidelines/hot-weather/*

Stokols, D. (1992). Establishing and maintaining healthy environments: toward a social ecology of health promotion. *American Psychologist*, *47*(1), 6-22.

Tatterson, A. J., Hahn, A. G., Martini, D. T., & Febbraio, M. A. (2000). Effects of heat stress on physiological responses and exercise performance in elite cyclists. *Journal of Science and Medicine in Sport*, *3*(2), 186-193.

Telama, R. (2009). Tracking of physical activity from childhood to adulthood: a review. *Obesity facts*, *2*(3), 187-195.

Wattchow, B., Jeanes, R., Alfrey, L., Brown, T., Cutter-Mackenzie, A., & O'Connor, J. (2015). *The Socioecological Educator*. Springer.

Webster, J., Holland, E. J., Sleivert, G., Laing, R. M., & Niven, B. E. (2005). A light-weight cooling vest enhances performance of athletes in the heat. *Ergonomics*, *48*(7), 821-837.

World Health Organisation (WHO). (1986). The Ottawa Charter for Health Promotion. Retrieved July 2, 2016 from: *http://www.who.int/healthpromotion/conferences/previous/ottawa/en/*

World Health Organisation (WHO). (2003). Heat waves: Risks and response. Retrieved June 2, 2016, from: *www.euro.who.int/__data/assets/pdf_file/0008/96965/E82629.pdf*

Zander, K. K., Botzen, W. J., Oppermann, E., Kjellstrom, T., & Garnett, S. T. (2015). Heat stress causes substantial labour productivity loss in Australia. *Nature Climate Change*, 5, 647-651.