4-23-2022

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10.1007/s42322-022-00094-1
Fortington, L. V., Goode, N., Finch AO, C. F., & Salmon, P. M. (2022). Heat and sun related medical concerns in Australian led outdoor activities: a three-year prospective study. Journal of Outdoor and Environmental Education, 1-13. https://doi.org/10.1007/s42322-022-00094-1

Journal of Outdoor and Environmental Education
https://doi.org/10.1007/s42322-022-00094-1

ORIGINAL PAPER

Heat and sun related medical concerns in Australian led outdoor activities: a three-year prospective study

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Accepted: 3 February 2022

Abstract

Active participation in the outdoors is beneficial for health and wellbeing. However, the impact of extreme weather, particularly heat, on safe participation is causing concern for organisations who lead these activities. Local mitigation strategies and acute management of heat- and sun-related illness (HSRI) are generally well understood by researchers and medical practitioners, however, cases continue to occur so further understanding of why this happens is required. This study aimed to identify the number, nature and contributory factors of HSRI in Australian led outdoor activities in order to seek opportunities for their prevention. This study presents a descriptive analysis of contributory factors to HSRI occurring during led outdoor activities. Cases were prospectively collected across 3 years (2014-2017) from a national Australian incident reporting system. Cases were included by identification of keywords linked with sun or heat exposure. From 2,015 incident cases, 48 cases were included: 25 termed heat stroke and 23 as "other adverse outcomes related to sun or heat." One in three (35%) cases occurred during outdoor walking or running, and one in four occurred while camping. A total 146 contributory factors were identified. These factors were attributed to the activity participant (e.g. competence, decision making); equipment and resources (e.g. food/drink, dehydration); and environment (e.g. hot weather.). Mild to moderate HSRI was identifiable by signs/symptoms. Contributory factors were linked to the individual participant. Potentially, these factors could be mitigated through system focused approaches. Awareness of wider responsibility for preventing HSRI should be promoted across led outdoor activities.

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Published online: 23 April 2022

Keywords Heat stress disorders · heat stroke · hyperthermia · prevention

Introduction

Regular participation in sport and recreational activities, many of which are enjoyed outdoors, is beneficial for health and wellbeing (Dickson et al., 2008). However, outdoor activity can present a risk of adverse health events related to weather, including exposure to the sun and heat, hereafter referred to as heat illness. The challenge of heat illness is that it is not simply an extreme hot weather issue. In addition to the activity undertaken, the combination of environmental-factors such as temperature, humidity or wind speed, and internal- or person- factors related to individual metabolic heat production, can all contribute to adverse outcomes (Lipman et al., 2019). The impact of heat on individual health can range from feeling unwell, to dehydration or even more severe life-threatening conditions such as heat stroke (Casa et al., 2015). Local, event-level risk factors associated with exercise-related heat illness are generally well understood by experts and appropriate countermeasures are relatively straightforward to implement, such as changing the start time of events, providing extra breaks and ensuring there is adequate shade and water available for participants and spectators (Bergeron et al., 2011; Lipman et al., 2019; Naughton & Carlson, 2008). Beyond these localised, and specific measures, there is little known about the broader, systemic risk factors and associated opportunities for mitigation in unstructured outdoor activity settings.

There is a growing interest in the impact of the environment on sport, exercise and active recreation, reflected through an increasing volume of research (Gamage et al., 2020a). Original epidemiological studies on heat illness have originated largely from the USA (Binkley et al., 2002; Kerr et al., 2013) and South Africa. Research tends to be sport- or event-specific (Bahr & Reeser, 2012; Tripp et al., 2015) focused on performance outcomes (Bongers et al., 2015) or provides recommendations for first aid or medical recognition and management of exertional heat illnesses (Lipman et al., 2019). For organised sport, what is known is largely derived from administrative databases wherein heat illness is reported as a secondary outcome amongst musculoskeletal injuries (Gamage et al., 2020b). These studies are valuable for planning and management of organised sporting events and gaining specialist knowledge on individual risks, particularly in elite levels where high performance, despite high temperatures, is a key requirement. Much less is known about the prevalence and risks of heat illness in community sport and leisure activities, and specifically, the led outdoor recreation sector. Led outdoor recreation is characterised as facilitated or instructed activities within outdoor education and recreation settings that have an associated learning goal (Salmon et al., 2010). Such activities include bushwalking, camping, kayaking and abseiling.

Epidemiological data on the occurrence of heat illness in led outdoor activities is needed because there is an expectation of an increase in the number of hot weather days experienced globally, including in Australia (Hughes et al., 2016;

Townsend et al., 2003). Therefore, activity providers need to be prepared to manage their programs and participants in hot weather. Information on how individuals, both those responsible for delivering the activity and the people who participate in them, action safety measures is also important to assist in the education and training of activity leaders. Preparation towards safe participation in the heat also needs to be balanced with continued encouragement of physical activity and the other benefits of being outdoors. Thus, this study aimed to identify the number and nature of heat illnesses reported during a three-year period of national surveillance for any adverse or near miss events in led outdoor recreation activities across Australia. The cases were analysed by key contributory factors to identify potential intervention points for early awareness and prevention of heat related health problems in outdoor activity settings.

Methods

Ethical approval

The University of the Sunshine Coast Human Research Ethics Committee approved the conduct and reporting of this study (A13454).

Data collection

This study draws on data from the Understanding and Preventing Led Outdoor Accidents Data System (UPLOADS) National Incident Dataset, collected between 1st June 2014 to 31st May 2017 (McLean et al., 2020). The reliability and validity of UPLOADS has been reported in detail, with the system undergoing refinement to meet satisfactory levels for users both entering and analysing the data (Finch et al., 2019; Goode et al., 2017)

Organisations who provide led outdoor activities within Australia were invited to take part in the UPLOADS project, via their national or state body and other professional association newsletters. Interested organisations nominated a senior staff member in a safety-related role to be the 'system administrator.' The administrator was responsible for undertaking training in the system, collecting and entering data, and providing training to other staff within their organisations on reporting incidents. The UPLOADS reporting tool allowed organisations to contribute anonymous incident reports into a National Incident Dataset. (McLean et al., 2020) Organisations were also able to save the data they enter for their own records. Participation data was submitted by organisations to the research team at 3-monthly intervals using a separate spreadsheet, which were later combined.

To initiate an incident report, the supervisor (the person in charge of the activity at the time of event) entered information about the case in terms of who was involved (age, sex, role), where the event occurred (geographic location, activity) and when the event took place (time of day, season). An open-text response was completed to describe the relevant events, an incident narrative, the reporter's

explanation of what occurred, and the treatment received. A manager (the person who oversaw the activity supervisor) subsequently completed additional information on what they thought may have contributed to the event and other relevant organisation-level aspects (number of participants in event, experience of activity leaders).

Reportable events included both near misses and incidents associated with adverse outcomes, using the following definitions:

- **Adverse outcome**. Any event resulting in a negative impact, including missing/overdue people; equipment or environmental damage; injury; illness; fatality; or social or psychological impacts.
- **Near miss**. Any serious mishap that has the potential to cause an adverse event but fails to do so because of chance or because it is intercepted. For example, during a rock-climbing activity an instructor notices that a participant's carabineer was not locked. If the student had fallen, this may have led to a serious injury.

The severity of the outcome of the event was rated from 0 (no impact) to 6 (unsurvivable). In addition, users were asked to identify what they thought the worst likely outcome of the event for those involved could have been –in other words, if no intervention had taken place what would the worst possible outcome for the person have been given the scenario. To encourage reporting of all events (not just those considered as most serious), organisations were instructed to report any adverse outcome with an actual severity of 1 or greater and near miss with a potential severity of 2 or greater (details of which are incorporated in Table 2). Decisions about which events were entered into UPLOADS, and the ratings of their actual and possible worst outcome rested with each organisation's nominated data administrator.

Data coding

De-identified data from all organisations were extracted from the central database. (McLean et al., 2020) Two researchers coded the qualitative data (entered as open-text narratives) by identifying and labelling the contributing factors and their relationships, using pre-defined codes. Disagreements in coding were resolved through discussion.

The coding scheme addressed two levels of influence (Goode et al., 2019):

- Organisational or system level to describe the Australian led outdoor activity system with 14 codes for actors, artefacts and activity context (Goode et al., 2017)
- Contributing factors to describe specific contributing factors within each of the system levels, with a total of 107 codes (McLean et al., 2020)

Case identification

Cases in which injuries/illness were linked to sun or heat exposure were extracted from the full dataset by searching the text narratives of the event description and outcomes. A total of 2,015 incident cases of any nature were available. The following sequential steps were used for excluding cases that were not deemed as HSRI:

- 1732 cases were first removed by narrative search (did not include “hot”, “dehydr”, “exhaust”, “exert”, “sun”, “heat” and “faint” or treatment received did not include “cool in shade”, “hydr”, “rehydr”, “powerade”, “icy pole”).
- 52 cases were removed because they had injuries determined to be unrelated to heat or sun exposure, specified as: "Injury to muscle, fascia and tendon”, "Superficial injury (e.g. abrasion, blister, insect bite)”, "Open wound”, “Dislocation, sprain and strain”, "Fracture”, "Crushing injury”, "Toxic effects of substances chiefly nonmedicinal as to source."
- 27 cases of illness injuries determined to be unrelated to heat or sun exposure, specifically recorded as: "Asthma”, "Non-specific fever”, “Abdominal problem”, "Menstrual”, "Allergic reaction”, "Asthma".
- 3 cases of social/psychological conditions, unrelated to heat, were removed
- 103 cases were removed following specific manual review, including the following grouped cases: 32 cases were general sickness/headache/gastro related; 28 cases were burns, scalds or blisters, linked to term heat e.g. from a fire (but not sun burn); 6 asthma/breathing related with terms of exertion (but not heat exertion); 6 head colds or wet/cold exposure with terms linked to heat or hot in the treatment of the cases. The remaining 31 cases were a mix of causes, including having insufficient data, incidents with cars/trailers, back pain and snakes in area. The reasons for these other cases being initially identified were linked to day of week “the event happened on Sunday”), descriptions leading to event (“it was a warm and sunny day”), and the event itself (“the snake was out seeking heat/laying in sun”).

After these exclusions, the 48 cases were retained for analysis.

Data analysis

Data were managed in Excel and Stata (version 15.1), with the *strpos* function used to identify words/terms within the text string variable narratives. Descriptive analyses (n, %) were presented for case characteristics (age, sex, role, activity) and severity of heat illness (actual and potential). Organisational (system) level and contributory factors were summarised and presented in tabular format, with text narrative descriptive examples provided (reworded to remove identifying information.)

Table 1 Descriptive information on 48 cases of sun/heat related illness in led outdoor activities

Variable	n	%
Age		
Child	27	56.3%
Adult	6	12.5%
Unknown	15	31.3%
Role		
Participant	34	70.8%
Other	8	16.7%
Missing	6	12.5%
Sex		
Male	17	35.4%
Female	22	45.8%
Missing	9	18.8%
Activity		
Walking/running outdoors	17	35.4%
Camping tents	12	25.0%
River activities	5	10.4%
Other, mixed*	14	29.2%

*Other mixed includes those activities where there were fewer than 5 cases (“Archery” “Caving" "Residential camps" "Survival” “Travelling" "Curriculum based activities" and “Ocean activities”)

Results

Characteristics of cases

Of the 48 cases of HRI were identified for inclusion in analysis, 25 were specified as being heat stroke and 23 cases were coded as “other adverse outcomes related to sun or heat.” Most cases (n=43) were reported as adverse events and five were near miss events. Table 1 presents basic demographic data of those impacted by HRI. Most cases were children, in a participant role, and there was a mix of males and females impacted. Most cases (35%) occurred during outdoor walking or running, with a further 25% reported as occurring while camping. Most cases (69%) were minor in nature, with the potential severity identified as being moderate (58%) (Table 2).

Organisational and contributory factors

Across the 48 cases, 146 contributory factors were assigned (range 0-3 per event) across 6 organisational levels (Table 3). The most frequent noted organisational levels were the activity participant (total of 47 contributory factors), activity environment (46 contributory factors) and activity equipment and resources (44 contributory factors). The remaining nine contributory factors were spread across three

Table 2 Actual and potential severity ratings for 48 cases of HRI

	Severity rating	Actual severity definition	Potential severity definition	Actual severity score	Potential severity score
0	No impact	Requires no treatment	An incident where the potential outcome has a negligible consequence	2	4
1	Minor	Requires localised care (non-evacuation) with short term effects	An incident where the potential outcome to risks has a low consequence	33	7
2	Moderate	Requires ongoing care (localised or external, i.e. evac or not) with short to medium term effects	An incident where the potential outcome to risks can cause moderate injuries or illnesses	8	28
3	Serious	Requires timely external care (evacuation) with medium to long term effects	An incident where the potential outcome to risks encountered is such that it may cause major irreversible damage or threaten life	4	4
4	Severe	Requires urgent emergency assistance with long term effects	An incident where the potential outcome to risks encountered is certain death	1	2
5	Critical	Requires urgent emergency assistance with serious ongoing long-term effects	Not applicable	0	1
6	Unsurvivable	Fatality	Not applicable	0	2

Table 3 Organisational level and specific factors identified as contributory to sun/heat cases (n=146 factors)

LEVEL **Specific factor**	**n**	%
ACTIVITY ENVIRONMENT		
Weather conditions	29	19.9
Hot weather	17	11.6
ACTIVITY PARTICIPANT		
Compliance with procedures, violations & unsafe acts	2	1.4
Experience & competence	15	10.3
Judgement and decision-making	7	4.8
Mental and physical condition	6	4.1
Allergic reaction	1	0.7
Planning & preparation for activity, trip	1	0.7
Equipment	1	0.7
Situation awareness	7	4.8
Awareness of environment	5	3.4
Inattention	2	1.4
ACTIVITY EQUIPMENT AND RESOURCES		
Documentation	1	0.7
Equipment, clothing and Personal Protective Equipment	4	2.8
Food & drink	24	16.4
Dehydration	13	8.9
Medication	2	1.4
ACTIVITY LEADER		
Communication, instruction & demonstration	3	2.1
Judgement and decision making	1	0.7
Supervision and leadership of activity	3	2.1
SUPERVISORS, FIELD MANAGER		
Activity or program design	1	0.7
PARENTS & CARERS		
Communication	1	0.7
OTHER ORGANISATION LEVELS (no factors identified)		
REGULATORY BODIES & PROFESSIONAL ASSOCIATIONS	0	-
SCHOOLS	0	-
LOCAL AREA GOVERNMENT	0	-
HIGHER-LEVEL MANAGEMENT	0	-
OTHER PEOPLE IN ACTIVITY ENVIRONMENT (NOT IN ACTIVITY GROUP)	0	-
ACTIVITY GROUP FACTORS	0	-
OTHER PEOPLE IN ACTIVITY GROUP (NOT ACTIVELY PARTICIPATING)	0	-

organisational levels, namely activity leader, supervisors/field manager and parents/carers.

At the activity-participant level, the main contributory factors were "experience and competence" (32% of cases in this level), "judgement and decision making" (15%), "situation awareness" (15%), "mental and physical condition" (13%) and "awareness of environment" (11%). At the activity-environment level, the main contributory factors were weather conditions (63%) and hot weather (37%), while for activity-equipment and resources level, the specific descriptors were food and drink (55%) and dehydration (30%). Example of the key points from text narrative describing the relevant events were as follows:

- Hot weather, unusual activity levels and low fluid intake led to dehydration and headaches
- Must not have re-applied sunscreen between breaks even though the participant was told to apply.
- Dehydration due to weather and inexperience
- The principle cause is listed as failure to apply sunscreen, constituting lack of preparation.
- Headache caused by unusual physical activity on a hot day where fluid intake was low.
- Participant was feeling unwell at the end of the day and complaining of a headache. On questioning it was discovered they had not consumed an appropriate amount of water during the day.
- The parents observed that such an incident was "not unusual" and that the participant had nosebleeds before. This was not mentioned in the participant's medical consent form.

No contributory factors were recorded across the following organisational levels:

- Regulatory bodies & professional associations
- Schools
- Local area government
- Higher-level management
- Other people in activity environment (not in activity group)
- Activity group factors
- Other people in activity group (not actively participating)

Discussion

Heat-related illness is becoming a greater concern in Australia with higher day and night temperatures experienced during the summer months and an increasing number of extreme heat days. (Bureau of Meteorology & Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2018) Alongside the positive push for populations to be more physically active, the challenging environmental extremes in which activities occur needs to be considered. Drawing on data from a prospective collection of incidents in Australian led outdoor activities, this study presents

important new understanding of mild to moderate cases of HSRI that are useful to inform safe participation.

There were 43 incidents of HSRI and five near misses from a database of 2,015 events (HSRI = 2.4% of all cases, n=48). Although there were relatively few cases and most were of a minor severity, half of the cases had the potential to be more severe, according to the submitted reports submitted by the led-outdoor activity providers. It is important to understand what contributed to these minor-moderate HSRI cases because there is currently very little published data available. (Gamage et al., 2020a) Understanding the situations and conditions under which HSRI develops provides important insight for intervention points to prevent deterioration in active populations.

The reported contributory factors in this study, presented in Table 3, reflected a more historical viewpoint of reductionist incident causation. (Goode et al., 2019) No event was found in our data that linked to any organisational level of government, local council or professional bodies. Rather, events were most commonly linked to localised factors of the activity-environment and activity-resources, specifically weather conditions / hot weather and dehydration / food and drink. One reason for the reporting of the more localised and direct contributory factors could be the activity providers' familiarity with these factors but this was not able to be assessed.

Most cases involved children. Children are at particular risk of heat illness as they are less able to self-regulate their body temperatures and risk exposures in terms of, for example, adequate preparation and hydration. (Bergeron et al., 2011). Dehydration and intake of food/drink could be better identified as system-level factors as children are reliant on leadership of those delivering their activities to ensure this is well managed on their behalf. For example, a study of junior cricketers in Sri Lanka found that because children were not aware of risks associated with heat and humidity, responsibility needs to fall to support staff (e.g. coaches, teachers, parents) and competition management (e.g. umpires, match officials) to monitor players and initiate appropriate countermeasures. (Gamage et al., 2019) Such measures could include provision of physical resources such as water and other hydration fluids, ice, cold towels, and shade as well as enforcement of breaks and use of sunscreen. In general activity settings, government and sports/recreation agencies are well positioned to provide new resources and policies, including specification of mitigation strategies for extreme weather and participants at risk (Chalmers et al., 2020; Gamage et al., 2020b). While of course it is not possible to control the weather and conditions, the led outdoor activity sector can ensure safety for its participants through strong leadership that understands injury risks and enforces safe practices. It is essential that trip leaders understand their participants may not be proactive towards heat protection and sun smart measures. These safety practices should be reinforced at regular moments throughout the trip.

The accuracy and completeness of the data presented here in terms of contributory factor identification and incident severity ratings are potentially limited by the practices of those who entered the data. Formal training, as well as supporting data entry and coding guidelines, were provided to all of the participating organisations and their nominated UPLOADS data managers in an attempt to minimise differences in reporting practices. However, it is possible that not all

contributory factors were identified by the trip leaders who entered the data and some may have not selected data options that might have related to their actions suggesting that factors like their supervision of children may not have been optimal in terms of sun smart and hydration practices. In such cases, the prevalence of such contributory factors reported here might be lower than the actual case and this could have been exacerbated by the reliance on data reports from one person only. The quality of the data collected through UPLOADS has previously been commented McLean et al., 2020) in relation to the absence of reporting some contributory factors from the dataset. A process of continuous improvement to the UPLOADS system and its report structures was implemented so as to improve data quality over time (Finch et al., 2019).

There is no clinical validation of the information entered to the UPLOADS system so diagnoses provide insight to the presenting problems but without confirmation of diagnoses. In this study, half of the cases were described in the dataset as "heat stroke." Medically, heat stroke is the most severe of heat illnesses, with central nervous system dysfunction when core body temperature surpasses 40.5°C.(Casa et al., 2005) Heat stroke can result in death if not identified for critical care procedures to be enacted rapidly. Reporting the mild and moderate signs and symptoms of cases in this database as heat stroke will not impact the outcome for the cases involved. However, if reported as such, these cases could portray a much more serious risk from events than is experienced. The need for consistent terminology has been raised in previous research (Gamage et al., 2020a; McMahon et al., 2021), with our study further reinforcing the importance of this for improved accuracy in reporting participation risk. The 2019 Update in *Wilderness Medical Society Practice Guidelines for the Prevention and Treatment of Heat Illness* provides definitions of heat illnesses that could form a strong start point for the sector to operationalise for laypersons to apply when entering data to an incident reporting system. (Lipman et al., 2019)

A strength of this study was the prospectively collected data across a three-year period. However, the focus of reporting was not specific for HSRI. Cases are reported by activity providers, without medical qualifications thereby limiting our ability to provide definitive conclusions on the severity and inclusion of cases relating to HSRI. Further, the data was extracted from a national database that was in its first years of use and was not inclusive of all activities or providers nor was it geographically representative for all Australian States and Territories.

Conclusion

This study presents a range of factors contributing to 48 reported cases of heat and sun related illness in led outdoor activities. Cases were mostly mild to moderate in nature with contributory factors largely attributed to the individual choices and behaviours. Many included cases were in children where individual responsibility is difficult to intervene or enforce. Stronger awareness of the potential

influence that organisational and policy level interventions can have is suggested as an additional point of intervention for prevention of HSRI in this setting.

Funding This project was supported by funding from the Australia Research Council (ARC) in partnership with Australian Camps Association, Outdoor Council of Australia, The Outdoor Education Group, Sport and Recreation Victoria, Victorian YMCA Accommodation Services Pty Ltd, Outdoors Victoria, Outdoor Recreation Industry Council (Outdoors NSW), Outdoors WA, Outdoors South Australia, Queensland Outdoor Recreation Federation, Wilderness Escape Outdoor Adventures, Venture Corporate Recharge, and Christian Venues Association (LP150100287). Open Access funding enabled and organized by CAUL and its Member Institutions.

Declaration

Conflict of interest None declared

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