SMJ **Singapore Medical Journal**

ONLINE FIRST PUBLICATION

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Relationship between weather parameters and risk of exertional heat injuries during military training

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Singapore Med J 2021, 1–19

https://doi.org/10.11622/smedj.2021183

Published ahead of print: 15 December 2021

Online version can be found at

http://www.smj.org.sg/online-first

ABSTRACT

Introduction: The Singapore Armed Forces (SAF) collaborated with the Meteorological Service Singapore (MSS) to study the relationship between weather parameters and the incidents of exertional heat injury (EHI) to mitigate the risk of EHI in a practical manner.

Methods: Data from the SAF's heat injury registry and MSS' meteorological data from 2012 to 2018 were used to establish a consolidated dataset of EHI incidents and same-day weather parameters rank-ordered in deciles. Poisson regression modelling was used to determine the incidence rate ratios (IRRs) of the EHI, referencing the first decile of weather parameters. Two frames of analysis were performed - the first described the relationship between the weather parameters and the adjusted IRR for the same day (D), and the second described the relationship between the weather parameters and the adjusted IRR on the following day (D+1).

Results: For wet-bulb temperature, the IRR on D+1 approximated unity for the first nine deciles but rose to 3.09 at the tenth decile. For dew-point temperature, the IRR on D+1 approximated unity for the first nine deciles but rose to 3.48 at the tenth decile. By designating a single dew-point temperature cut-off at ≥ 25.1°C (transition between the ninth and tenth decile), the adjusted IRR on D +1 was 2.26 on days with dew-point temperature ≥ 25.1°C,.

Conclusion: Integrating the data from the SAF and MSS demonstrated that a dew-point temperature ≥ 25.1°C on D correlates statistically with the risk of EHI on D +1and could be used to supplement the risk mitigation system.

Keywords: dew point temperature, exertional heat injury, weather parameters

INTRODUCTION

To facilitate safe training in a tropical climate, the Singapore Armed Forces (SAF) has strengthened its heat injury risk mitigation systems over time, reducing the exertional heat injury (EHI) incidences from 50 cases per 10,000 training individuals to about five cases per 10,000 individuals from 1990 to 2008.(1) The EHI risk mitigation measures included managing human factors such as heat acclimatisation, education, and hydration regime with *ad libitum* principles; equipment factors such as improved materials; environmental factors such as a work-rest cycle calibrated on the wet-bulb globe temperature (WBGT); and operating a comprehensive incident management system. SAF collaborated with the Meteorological Service Singapore (MSS) to determine whether there were weather parameters that could help further mitigate the risk of EHI. By integrating the SAF's EHI data and MSS' weather parameter data, we studied how weather information could be used to prospectively predict EHI risk and applied in a pragmatic manner.

In 2012, the SAF established a heat injury registry (HIR) to capture all cases of suspected heat injuries sustained during training for the purpose of safety review and system improvement. During training, soldiers suspected as suffering from heat injuries receive on-site care, early evacuation to an SAF medical facility and referral to hospitals for further management. The registry captures all cases that the initial treating physicians had classified as 'suspected heat injuries'. A senior SAF physician who was not involved in direct care of the patient would make a definitive classification of the nature of the heat injury (exhaustion vs. heat exhaustion vs. heat stroke) in accordance with the Ministry of Health clinical practice guidelines.(2) (Table 1 in the supplementary material lists the data fields captured in the HIR.)

Singapore lies just north of the equator near latitude 1.5° north. Its diurnal temperate ranges from a minimum of 23°C–25°C to a maximum of 31°C–33°C, with a mean relative humidity of 84%.(3) The MSS, a division under the National Environment Agency, records a comprehensive set of weather parameters via a dense network of automatic weather stations sited across Singapore and maintains an extensive database of weather parameters that include dry-bulb temperature, wet-bulb temperature, dew-point temperature and relative humidity at 20 locations across the island, as illustrated in Fig. 1. Fig. 2 illustrates the monthly averages of these parameters in Singapore from 2012 to 2018. (Table 2 in the supplementary material lists the definition of the weather parameters and the derivation of these parameters.)

METHODS

This observational study used data from the SAF's HIR and MSS' meteorological data from January 2012 to December 2018. The weather parameters of all 20 weather stations were analysed to identify the weather station most representative of conditions across the island, but more importantly, to allow findings to be subsequently utilised in a pragmatic and routine manner. For each day and each weather parameter, the average of the parameter values was calculated. The weather station with the smallest absolute difference in the parameter to the average for each day was determined. The weather station at Changi was consequently defined as the most representative weather station, as it had the most frequent occurrences of smallest absolute difference across all days in the dataset. Its weather parameter data was used in this study.

A consolidated dataset of the daily incident case counts captured in the HIR and the corresponding mean weather parameters (for dry-bulb temperature, wet-bulb temperature, dew-point temperature and relative humidity) was established. Daily means for each weather parameter were rank-ordered and assigned to corresponding deciles in an ascending order. This study assumed that the daily probability of an incident case followed a Poisson distribution and derived the effect estimates in the form of incidence rate ratios (IRRs) through Poisson regression modelling to allow the first decile of each weather parameter to reflect the baseline condition. The study also used a multivariable regression model to adjust the IRRs for the following confounding factors: year of the case, month of the year and day of the week.

Two frames of analysis were performed. The first frame described the relationship between the four daily mean weather parameters rank-ordered in 10 ascending deciles, the corresponding case count and the adjusted IRR for the same day (D). The second frame described the relationship between the four daily mean weather parameters rank-ordered in the same 10 deciles and the daily case count on the following day (D+1). Thus, the adjusted IRR of heat injury was determined for D+1 based on the case count of D+1 but the weather parameter of D. This would identify the weather parameter on D that could be used to prospectively stratify the risk of EHI on D+1. All analyses were conducted using Stata Statistical Software: Release 13 (StataCorp LP, College Station, TX, USA).

RESULTS

Over the period of 2,556 days from 1 January 2012 to 31 December 2018, a total of 187 cases of heat exhaustion and heat stroke were captured on the SAF HIR. EHI occurred throughout the year, although fewer cases were registered in the nominally cooler period between November and February, which coincides with the northeast monsoon period. Table I shows the distribution of EHI cases over this period.

Through the two frames of analysis, the adjusted IRRs of EHIs for the four weather parameters on both D and D+1 were determined for days with complete weather parameters and are presented in Tables II–V.

With regard to the daily mean dry-bulb temperature (Table II), the IRR at D generally rose across deciles, as expected from the current understanding of the mechanism of thermoregulatory failure and heat injury risk. It was observed that the 95% confidence interval

(CI) of the adjusted IRR of EHI occurring in D + 1 included unity across all the deciles. The daily mean dry-bulb temperature is, thus, not useful for stratifying the risk of EHI on D+1.

With regard to the daily mean wet-bulb temperature (Table III), the IRR at D generally rose across deciles. The IRR on D+1 approximated unity for the first nine deciles but rose to 3.09 (95% CI 1.45–6.57, $p = 0.003$) at the tenth decile. Thus, the daily mean wet-bulb temperature has a potential application in the risk stratification of EHI on D+1.

With regard to the daily mean dew-point temperature (Table IV), the IRR at D generally rose across deciles. The IRR on D+1 approximated unity for the first nine deciles but rose to 3.48 (95% CI 1.61–7.53, $p = 0.002$) at the tenth decile. Thus, the daily mean dew-point temperature has a practical application in the risk stratification of EHI on D+1.

With regard to the daily mean relative humidity (Table V), the 95% CI of the adjusted IRR of EHI occurring in D and D+1 included unity when compared across deciles. Daily mean humidity is, thus, not useful for stratifying the risk of EHI on D+1.

DISCUSSION

The four basic elements of the thermal environment, namely air temperature, mean radiant temperature, relative humidity and air movement, exert their combined effects on heat load and restriction to evaporation.[4,5] A review article published in 1960 studied 19 indexes related to weather elements and articulated the need to synthesise these elements into a single index to express the impact of the thermal environment on human health and performance, and for their subsequent routine use in regulatory guidelines.[6]

Over time, the WBGT became the most widely used index of environmental heat stress owing to its comprehensiveness, simplicity and ability to be used outdoors. In the 1950s, the US Army and Marine Corps used the WBGT information to control serious outbreaks of heat-related illness in training camps.[6] Similarly, the SAF uses the WBGT as the primary indicator of environmental heat risk.

While the WBGT index takes into account these four elements, their weighted contribution to the index is fixed through the coefficients in the formula:

$WBGT = 0.7T_w + 0.2T_g + 0.1T_d$, where

T_w = Natural wet bulb temperature influenced by humidity

T_g = Globe thermometer temperature influenced by radiant heat

T_d = Dry-bulb temperature affected by ambient air temperature

A rise in humidity and consequent reduction in evaporative capacity of the environment reduce evaporation.[7-9] Evaporation as the means to lose heat is more significant at higher temperatures, and WBGT underestimates the heat stress of restricted evaporation, because the fixed weight of 0.7 for wet-bulb thermometer is excessive at low temperatures and inadequate at high temperatures.[10] It was demonstrated in controlled laboratory tests that at a WBGT of 31.7°C, the heart rate, rectal and skin temperature, and sweat rate of exercising men were much greater in an environment of high humidity and low air movement (restricted evaporation) than in an environment of low humidity and high air movement.[11] Considering the limitations of WBGT, there is a need to identify another parameter related to the thermal environment to supplement the current risk mitigation system.

The results of the data analysis showed that the daily mean dew-point temperature and mean wet-bulb temperature could be used to prospectively stratify the risk of EHI, because the IRR for D+1 was significant only at the tenth decile; this would provide a threshold for early warning for a few days (about 10%) and avoid alert fatigue and desensitisation. As statistical correlation does not imply causation, the utilisation of this statistical correlation should only be supplementary to the existing risk mitigation system.

Comparing the two parameters, the raw data showed that many EHI incidents occurred at the boundary of the ninth and tenth decile for mean wet-bulb temperature in contrast to dew-point temperature, which had a more distinct spread. Dew-point temperature could, thus, serve as a better supplementary parameter for practical application than wet-bulb temperature would. Further analysis of dew-point temperature is detailed below. (Analysis of wet-bulb temperature is provided in Table 3 of the supplementary material)

Dew-point temperature is the temperature to which air must be cooled in order to reach saturation of water vapour (assuming air pressure and moisture content are constant). When air is cooled to below the dew-point temperature, water vapour is released into the atmosphere in the liquid form.[12] Dew-point temperature indicates the absolute amount of moisture in the air, in contrast to relative humidity, which indicates the amount of moisture in the air compared to the amount of moisture that the air is able to hold at that temperature.

The dataset was further analysed by designating a single dew-point temperature cut-off at ≥ 25.1°C (the transition between the ninth and tenth decile). On days with dew-point temperature ≥ 25.1°C, the adjusted IRR on D was 2.39 (95% CI 1.58–3.62, $p < 0.001$), compared with the days with dew-point temperature < 25.1°C, and the adjusted IRR on D+1 was 2.26 (95% CI 1.49–3.42, $p < 0.001$), as illustrated in Table VI.

Operationally, the dew-point temperature ≥ 25.1°C on D can be used as a supplementary trigger to issue a system-wide alert of higher risk of EHI at the start of the training day D+1 to ensure tight compliance with existing preventive measures for the day. There would be less alert fatigue and desensitisation, as the alert would only be issued in about 10% of the training days.

A literature review of PubMed, Cochrane, Embase and ProQuest databases by using the search terms ‘dew point temperature’, ‘dew point’ and ‘heat injuries’ did not return any studies that demonstrated a significant correlation between dew-point temperature and the risk of heat injuries. More primary research can be conducted to understand the relationship between physiological thermoregulatory mechanisms, especially evaporative heat loss, and thresholds in relation to the dew-point temperature.

This study has some limitations. Many factors influence the risk of EHI. The findings from this study are premised on the climate and weather patterns in Singapore and the existing risk mitigation systems that comprehensively addressed human factors, equipment factors and training safety policies. While the findings will not be universally applicable, the approach to integrate the data of EHI and weather parameters for analysis have identified statistical correlations that have a practical application.

In conclusion, integration and application of the data from SAF and MSS from 2012 to 2018 demonstrated that a dew-point temperature ≥ 25.1°C on D statistically correlates with an increased risk of EHI on D+1, with an IRR of 2.26 (95% CI 1.49–3.42, $p < 0.001$). This finding can be practically applied to supplement the current EHI risk mitigation system.

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FIGURES

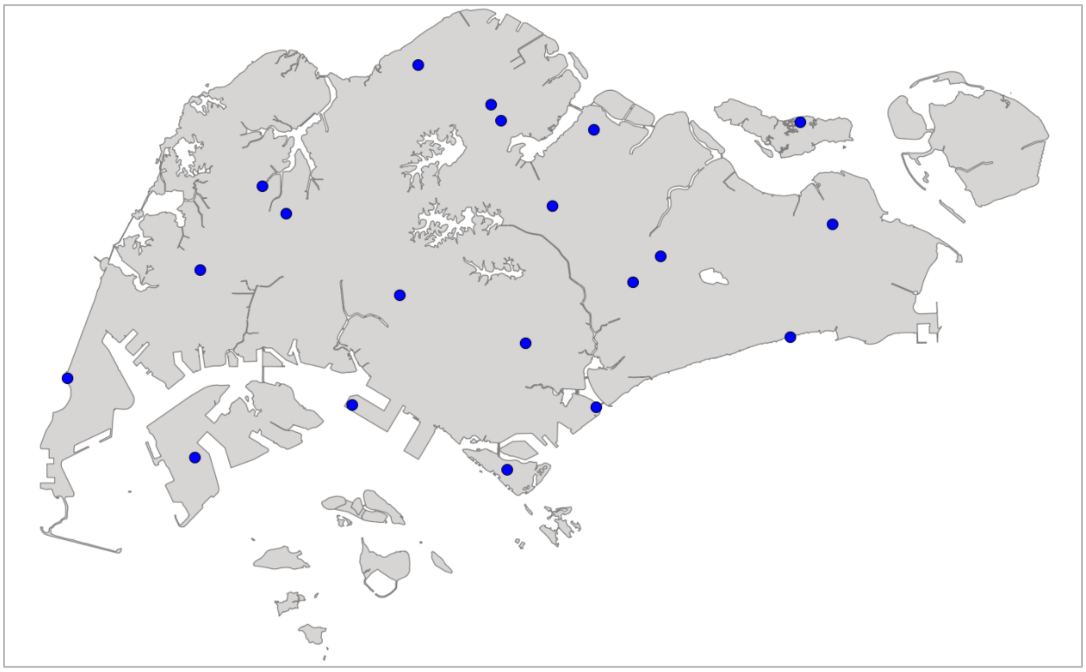

Fig. 1 Figure shows the dense network of 20 weather stations (blue dots) that measure the weather parameters used in this study across Singapore.

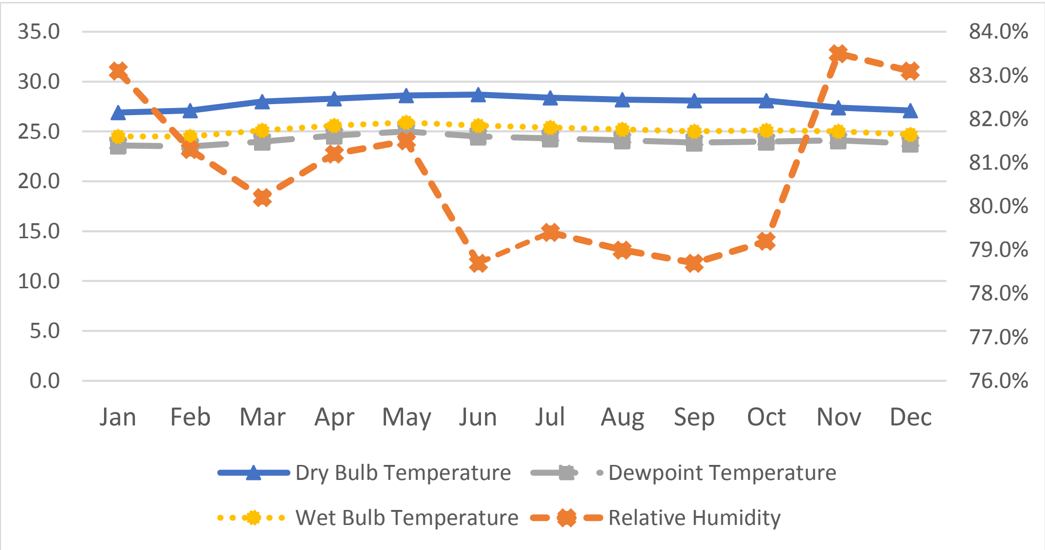

Fig. 2 Graph shows the average monthly dry-bulb temperature (°C), wet-bulb temperature (°C), dew-point temperature (°C) and relative humidity (%) in Singapore from 2012 to 2018.

Table I. Heat injury cases (n = 187) by month with corresponding daily mean dry-bulb temperature, wet-bulb temperature, dew-point temperature and relative humidity from 2012 to 2018.

Month	Mean (standard deviation)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
No. of EHI cases	6	10	17	24	24	30	6	18	14	14	8	16
Daily dry-bulb temperature (°C)	26.9 (1.1)	27.1 (0.9)	28.0 (0.9)	28.3 (0.9)	28.6 (0.9)	28.7 (1.0)	28.4 (1.0)	28.2 (0.9)	28.1 (0.9)	28.1 (1.0)	27.4 (0.7)	27.1 (0.9)
Daily relative humidity (%)	83.1 (5.8)	81.3 (6.0)	80.2 (5.7)	81.2 (5.1)	81.5 (4.3)	78.7 (5.3)	79.4 (4.4)	79.0 (4.4)	78.7 (5.1)	79.2 (6.1)	83.5 (4.9)	83.1 (6.9)
Daily mean wet-bulb temperature (°C)	24.5 (0.9)	24.5 (0.8)	25.1 (0.6)	25.6 (0.4)	25.9 (0.4)	25.6 (0.6)	25.4 (0.5)	25.2 (0.4)	25.0 (0.5)	25.1 (0.5)	25.0 (0.5)	24.7 (0.8)
Daily mean dew-point temperature (°C)	23.6 (1.2)	23.5 (1.1)	24.0 (0.8)	24.6 (0.5)	25.0 (0.5)	24.5 (0.8)	24.3 (0.5)	24.1 (0.5)	23.9 (0.7)	23.9 (0.7)	24.1 (0.7)	23.8 (1.1)

Table II. IRR on D and D + 1 for daily heat injury risk by decile of daily mean dry-bulb temperature using Poisson regression model controlling for the year, month, and day of the week.

Decile	Range of daily mean dry-bulb temperature (°C)	Effect estimate									
		D (n = 186 cases of EHI)					D + 1 (n = 187 cases of EHI)				
		Count of days	EHI case count	IRR	95% CI	p-value	Count of days	EHI case count	IRR	95% CI	p-value
1	23.0–26.5	259	5	1.00	-	-	259	15	1.00	-	-
2	26.5–26.9	250	12	2.49	0.87–7.11	0.088	250	10	0.65	0.29–1.45	0.294
3	27.0–27.3	261	11	2.39	0.82–6.94	0.109	260	14	0.94	0.45–1.97	0.865
4	27.3–27.6	249	20	4.20	1.55–11.4	0.005	249	18	1.07	0.53–2.17	0.851
5	27.6–28.0	254	16	3.29	1.18–9.12	0.022	254	18	1.02	0.50–2.08	0.952
6	28.0–28.3	259	13	2.64	0.91–7.62	0.073	259	15	0.81	0.38–1.71	0.573
7	28.3–28.6	250	21	4.22	1.53–11.6	0.005	250	16	0.83	0.39–1.77	0.633
8	28.6–28.9	255	30	6.22	2.30–16.8	<0.001	255	32	1.70	0.87–3.31	0.122
9	28.9–29.3	255	25	5.52	1.99–15.3	0.001	255	24	1.13	0.54–2.37	0.737
10	29.3–30.7	253	33	6.40	2.30 to 17.8	<0.001	253	25	1.12	0.53 to 2.36	0.762

Table III. IRR on D and D+1 for daily heat injury risk by decile of daily mean wet-bulb temperature using Poisson regression model controlling for the year, month and day of the week.

Decile	Range of daily mean wet bulb temperature (°C)	Effect estimate									
		D (n = 186 cases of EHI)					D + 1 (n = 187 cases of EHI)				
		Count of days	EHI case count	IRR	95% CI	p-value	Count of days	EHI case count	IRR	95% CI	p-value
1	21.7–24.3	256	9	1	-	-	256	12	1	-	-
2	24.3–24.6	254	15	1.75	0.75–4.04	0.194	254	13	1.09	0.49–2.41	0.839
3	24.6–24.9	262	11	1.28	0.52–3.15	0.597	262	15	1.26	0.57–2.77	0.564
4	24.9–25.0	254	14	1.64	0.69–3.90	0.264	254	16	1.32	0.61–2.89	0.480
5	25.1–25.2	251	19	2.42	1.06–5.50	0.036	250	19	1.74	0.82–3.70	0.149
6	25.2–25.4	259	11	1.17	0.47–2.90	0.745	259	20	1.49	0.70–3.17	0.301
7	25.4–25.6	245	22	2.72	1.20–6.15	0.016	245	12	0.96	0.42–2.24	0.934
8	25.6–25.7	258	21	2.49	1.07–5.74	0.032	258	16	1.24	0.56–2.78	0.597
9	25.7–26.0	260	20	2.33	1.00–5.45	0.051	260	21	1.64	0.75–3.58	0.211
10	26.0–27.0	244	44	5.38	2.37–12.2	<0.001	244	42	3.09	1.45–6.57	0.003

Table IV. IRR on D and D + 1 for daily heat injury risk by decile of daily mean dew-point temperature using Poisson regression model controlling for the year, month and day of the week.

Decile	Range of daily mean dew-point temperature (°C)	Effect estimate									
		D (n = 186 cases of EHI)					D + 1 (n = 183 cases of EHI)				
		Count of days	EHI case count	IRR	95% CI	p-value	Count of days	EHI case count	IRR	95% CI	p-value
1	18.8–23.1	255	14	1.00	-	-	255	11	1.00	-	-
2	23.1–23.6	253	11	0.75	0.33–1.67	0.481	253	13	1.18	0.52–2.68	0.693
3	23.6–23.9	256	18	1.29	0.62–2.67	0.494	256	17	1.58	0.72–3.49	0.254
4	23.9–24.1	255	15	1.07	0.50–2.28	0.866	255	21	1.98	0.92–4.25	0.079
5	24.1–24.2	255	18	1.45	0.70–3.03	0.321	255	15	1.44	0.64–3.24	0.382
6	24.3–24.4	261	22	1.54	0.76–3.14	0.231	261	17	1.57	0.71–3.47	0.270
7	24.4–24.6	244	15	1.15	0.53–2.46	0.725	243	13	1.33	0.58–3.09	0.501
8	24.6–24.8	256	16	1.23	0.57–2.63	0.597	256	18	1.80	0.81–4.00	0.149
9	24.8–25.0	246	13	0.92	0.41–2.06	0.836	246	17	1.53	0.68–3.48	0.307
10	25.0–26.3	252	44	3.07	1.51–6.27	0.002	252	41	3.48	1.61–7.53	0.002

Table V. IRR on D and D + 1 for daily heat injury risk by decile of daily mean relative humidity using Poisson regression model controlling for the year, month and day of the week.

Decile	Range of daily mean humidity levels (%)	Effect estimate									
		D (n = 187 cases of EHI)					D + 1 (n = 186 cases of EHI)				
		Count of days	EHI case count	IRR	95% CI	p-value	Count of days	EHI case count	IRR	95% CI	p-value
1	57.0–73.7	255	19	1.00	-	-	259	17	1.00	-	-
2	73.8–76.0	254	26	1.31	0.71–2.40	0.385	250	23	1.36	0.72–2.57	0.344
3	76.0–77.6	254	20	1.10	0.58–2.10	0.762	260	19	1.20	0.61–2.33	0.600
4	77.6–79.2	255	18	1.03	0.53–2.00	0.920	249	20	1.37	0.71–2.64	0.354
5	79.2–80.5	255	24	1.26	0.68–2.33	0.472	254	20	1.22	0.63–2.38	0.556
6	80.5–82.2	254	24	1.23	0.65–2.31	0.522	259	13	0.76	0.36–1.61	0.480
7	82.3–83.9	255	12	0.68	0.32–1.44	0.308	250	21	1.44	0.73–2.83	0.290
8	83.9–85.7	254	18	0.95	0.48–1.88	0.883	255	16	0.99	0.48–2.04	0.978
9	85.7–88.0	253	16	0.86	0.42–1.75	0.673	255	20	1.32	0.66–2.64	0.430
10	88.0–99.7	254	10	0.59	0.26–1.35	0.212	253	17	1.31	0.62–2.77	0.476

Table VI. Incidence rate ratio (IRR) on D and D + 1 for daily heat injury risk using cut-off value of daily mean dew-point temperature ≥25.1°C in a Poisson regression model controlling for the year, month and day of the weeks

Range of daily mean dew-point temperature (°C)	Effect estimate									
	D (n = 187 cases of EHI)					D + 1 (n = 186 cases of EHI)				
	Count of days	EHI case count	IRR	95% CI	p-value	Count of days	EHI case count	IRR	95% CI	p-value
18.8–25.0	2,296	146	1.00	-	-	2,295	143	1.00	-	-
≥25.1	237	40	2.39	1.58–3.62	<0.001	237	40	2.26	1.49–3.42	<0.001

SUPPLEMENTARY MATERIAL

Heat category	WBGT (°C)	Work:Rest (min)
White	≤29.9	60:15
Green	30.0–30.9	45:15
Yellow	31.0–31.9	30:15
Red	32.0–32.9	30:30
Black	≥33.0	15:30

Fig. 1 The SAF Work Rest Cycle in accordance with the on-site measured WBGT.

Table I. Data captured in the SAF Heat Injury Registry.

	Information pertaining to	**Data**
1	Suspected heat injury victim	Demographics and characteristics of victim Military service category Year of service Military vocation Service unit
2	Suspected heat injury event	Date of event Time of event Place of event Nature of training WBGT at the time of event Attire of victim during event
3	Clinical presentation	Presenting symptoms Glasgow coma scale (GCS) Core temperature Heart rate, respiratory rate, blood pressure Peripheral capillary oxygen saturation (SpO2) Capillary blood glucose ECG findings
4	Medical interventions by SAF medical teams	Attending medical centre Cooling measures used Use of body-cooling unit Timelines of on-site intervention, medical centre management, evacuation to hospital, arrival in hospital On-site provisional diagnosis
5	Hospital investigations and medical interventions	Full blood count Blood electrolytes and creatinine Liver enzymes and function Troponin T Creatinine kinase Radiological investigations Hospital diagnosis
6	Final classification and reasons	

Table II. Weather parameters used in this study, their definitions and the method of derivation.

Weather parameter	**Definition**	**Method of derivation**
Dry-bulb temperature	The temperature of the air in the surrounding environment measured by a thermometer freely exposed to air but shielded against direct radiation from the sun.	Measured by instruments
Wet-bulb temperature	The lowest temperature to which air is cooled owing to the evaporation of water into the air at a given pressure.	Derived through the mathematical equation $$\frac{R}{100} f(p) e_w(T) = f(p) e_w(T_w) - 6.53 \times 10^{-4} (1 + 0.000944 T_w) p (T - T_w)$$ $$f(p) = 1.0016 + 3.15 \times 10^{-6} p - 0.074 p^{-1}$$ $$e_w(t) = 6.112 \exp(\frac{17.62t}{243.12 + t})$$ where T_w is the dew-point temperature, R is the measured relative humidity and p is the measured atmospheric pressure.
Dew-point temperature	The temperature at which moist air becomes saturated and condensation of water vapour occurs.	Derived through the mathematical equation $$t_d = \frac{243.12 \ln(C)}{17.62 - \ln(C)}$$ $$C = \frac{R}{100} \exp(\frac{17.62\, T}{243.12 + T})$$ where t_d is the dew-point temperature, R is the measured relative humidity and T is the measured dry-bulb temperature.
Relative humidity	The ratio of the actual amount of water vapour in the air at a given temperature and the amount of water vapour when the air is saturated (i.e. no longer able to hold all the water vapour) at the same temperature.	Measured by instruments

Table III. Incidence rate ratio (IRR) on D and D+1 for daily heat injury risk using cut-off value of daily mean wet-bulb temperature ≥ 26.0°C in a Poisson regression model controlling for the year, month and day of the week.

Range of daily mean wet-bulb temperature (°C)	**Effect estimate**									
	D (n = 186 cases of EHI)					**D + 1 (n = 186 cases of EHI)**				
	Count of days	**EHI case count**	**IRR**	**95% CI**	**p-value**	**Count of days**	**EHI case count**	**IRR**	**Count of days**	**p-value**
18.8–25.9	2,253	139	1.00	-	-	2,252	143	1.00	2,252	-
≥ 26.0	290	47	2.38	1.60–3.54	< 0.001	290	45	2.08	290	< 0.001

Dew-point temperature was a better parameter than wet-bulb temperature, because at its cut-off ≥ 25.1°C, 237 high-risk days (possibly less alert fatigue and desensitisation) would identify 40 EHI case counts at a higher IRR of 2.26, compared with wet-bulb temperature at its cut-off ≥ 26.0°C.