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Occupational cooling practices of emergency first responders in the United States: A survey

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ABSTRACT

Despite extensive documentation directed specifically toward mitigating thermal strain of first responders, we wished to ascertain the degree to which first responders applied cooling strategies, and what opinions are held by the various agencies/departments within the United States. An internet-based survey of first responders distributed to the International Association of Fire Chiefs, International Association of Fire Firefighters, National Bomb Squad Advisory Board and the USA Interagency Board and their subsequent departments and branches. Individual first responder departments were questioned regarding the use of pre-, concurrent, post-cooling, types of methods employed, and/or reasons why they had not incorporated various methods in first responder deployment. Completed surveys were collected from 119 unique de-identified departments, including those working in law enforcement (29%), as firefighters (29%), EOD (28%) and HAZMAT technicians (15%). One-hundred and eighteen departments (99%) reported heat strain/illness to be a risk to employee safety during occupational duties. The percentage of departments with at least one case of heat illness in the previous year were as follows: fire (39%) HAZMAT (23%), EOD (20%) and law enforcement (18%). Post-cooling was the scheduled cooling method implemented the most (63%). Fire departments were significantly more likely to use post-cooling, as well as combine two types of scheduled cooling compared to other departments. Importantly, 25% of all departments surveyed provided no cooling whatsoever. The greatest barriers to personnel cooling were as follows – availability, cost, logistics, and knowledge. Our findings could aid in a better understanding of current practices and perceptions of heat illness and injury prevention in United States first responders.

Keywords: Heat Stress, Industry, Thermoregulation, Personal Cooling Systems

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INTRODUCTION

Emergency first responders including firefighters, law enforcement, explosive ordnance disposal (EOD) and hazardous materials (HAZMAT) crews encounter day-to-day deployments and training as varied as it is dangerous. The associated risks are in part mitigated by a required level of personal protection with occupationally specific clothing and equipment. Unfortunately the requisite protective clothing increases the risk of heat illness and injury due to compromised heat loss mechanisms. In 2015, across all United States industries there were 2,220 nonfatal illnesses and injuries caused by heat exposure at work, leading to 37 deaths [1]. Three-hundred and fifty of these non-fatal injuries occurred in first responders (i.e. police officers, firefighters) [1]. The delicate balance between employee safety with the task at hand, and end-user functionality, has seen the development of resources outlining protocols and standards with the aim to improve performance and reduce heat strain of the worker. Resources include independent research [2, 3, 4, 5], recommendations from occupational standard agencies [6, 7], and a certified standard for personal cooling system testing methods [8]. The National Institute for Occupational Safety and Health recommends alleviating the risk of heat strain in first responders via a number of methods, including where possible, control of the environment, administrative controls (e.g. limiting workloads, and appropriate training), improving hydration practices, and implementing auxiliary body cooling [6]. Auxiliary cooling may be used before (pre-cooling), during (concurrent cooling) or between operations (recovery cooling).

It is important to consider situationally specific needs and constraints when selecting the application of a cooling system, including the amount of cooling needed, convenience, available budget, and system functionality. Manufacturers of cooling systems have developed and targeted products for specific occupations or operations, therefore limiting their use in other fields. Equally, other manufacturers offer generalised systems that may not sufficiently assimilate with the clothing or equipment of certain first responder services. Scientific research into personal cooling has overwhelmingly centred on athletic and sporting populations with positive results [9, 10, 11]. On face value, it may seem that results of studies cooling athletes are transferable to an occupational population, given both groups can use personal cooling to reduce thermal strain. However, this may not be the case

considering difference exists between first responders and athletes in their experience of exertional heat stress and fitness [12, 13], the commercially available cooling systems designed and marketed toward them (e.g. light weight and breathable vs. fire retardant), and the inherent differences in scheduling, structured lengths and foreseeable environmental conditions of sporting competition compared to first responders unpredictable work intensities, environments and deployment lengths, and requisite protective clothing/equipment. The dynamic nature of operations present practical implications that further contrast to athletes with the possibility of inadequate preparation of heat stress management through the timely implementation personal cooling, achieving adequate sleep and following hydration protocols [6].

Despite the wealth of evidence based recommendations [6, 7, 8] and research [3, 4, 13, 14, 15, 16, 17] directed specifically toward mitigating heat stress in industry and emergency first responders, little work has focused on whether or not recommendations, policies and evidence have been able to influence current heat management practice of end users. In the few studies to survey occupational heat management there have been some concerning trends [18, 19, 20]. For example, a recent survey of working practices of 130 fire service instructors in the United Kingdom revealed that over two-thirds of respondents were not allocated a set period of time in preparation for (73%) or recovery from (70%) live fire scenarios [20]. Exacerbating these findings, 41% of respondents were unfamiliar with any hydration guidelines or recommendations despite their presence within their organisation [6, 21, 22].

In the wake of the Fukushima Daiichi nuclear power plant disaster, the Japanese government cited heat illness prevention as a priority for occupational safety management in HAZMAT decontamination workers [23]. Kakamu et al. [19] surveyed current practice amongst 528 male radioactive decontamination workers to better understand the preventative factors for heat illness within the industry. Almost half (48%) of respondents reported regular symptoms of heat illness (e.g. cramps, syncope, vomiting) [19]. However, preventative measures including personal cooling systems (e.g. cool vest or refrigerant body cooling) were implemented by only 24% of respondents.

Another paper by House [18], surveyed members of the British Royal Navy comprising of 121 helicopter pilots, observers and aircrew. They were asked to report their incidence, sources, education, prevention and current practices in regards to heat strain. Only 12% of respondents reported air-conditioning or personal cooling systems being used to reduce heat strain in operations, though 55% of respondents proposed these to be used as worthwhile cooling strategies.

To the authors' knowledge, current practices for the prevention of heat strain within emergency first responders in the United States has not been reported. Therefore, this study aimed to survey and disseminate the presence of heat strain and identify the perceived effectiveness and barriers of currently used cooling systems in first responder departments based in the continental United States.

METHODS

Survey Construction

The survey (see Supplement 1) consisted of a combination of 20 multiple choice, Likert-type scale and open-ended qualitative questions. The survey was intended to define 1) the first responder service/department, 2) locale where work is conducted, 3) the incidence and severity of heat strain and/or illness in the past 12 months, and 4) the current practice of pre-, concurrent, and intermediate/recovery-cooling; more specifically evaluating the perceived effectiveness and barriers/limitations to each type of cooling. We queried common cooling methods derived from the scientific literature, technical reports and the commercial marketplace which included: *Passive* systems – cold/ice water immersion, cold water/ice slurry ingestion, ice application (including garments), ice-based phase change systems, non-ice phase change systems, evaporative cooling systems, rest periods, doffing/opening clothing; *Active* systems – fan exposure, cold air exposure, cold air inhalation, venturi tube systems, thermoelectric liquid cooled systems, vapour compression liquid or air systems. Two, third-party independent industry representatives reviewed the survey questions for appropriate language, understanding and context. Throughout the survey definitions of terms (e.g. heat strain; pre-cooling) and associated images (e.g. example cooling systems; Köppen-Geiger climate map [24]) were provided to aid in clarity of answers.

Survey Distribution

In August 2016, after ethical clearance from the Queensland University of Technology, the United States Department of Defence (Combating Terrorism Technical Support Office) circulated an e-mail link to a de-identified online survey (KeySurvey, WorldAPP, USA) the National Fire Protection Association (NFPA) list servers for programs related to hazardous materials and to the Interagency Board (IAB – over 100 department chiefs, deputy chiefs, or emergency managers), International Association of Fire Fighters (IAFF – represent over 250 agencies in the United States and Canada), International Association of Fire Chiefs (IAFC – represent over 11,000 fire chiefs), and National Bomb Squad Commanders Advisory Board (NBSCAB – represent over 460 certified bomb squads across the United States). The final data was then compiled after the survey closed at the end of the northern hemisphere spring, in November 2016.

Data Collation and Statistical Analysis

Results of the survey were collated using the reporting software provided by the survey host site (KeySurvey, WorldAPP, USA). Further consolidation and tabulation of data were then performed using spreadsheet software (Excel 2013, Microsoft, USA). Köppen-Geiger climate categorisation [24] was analysed at all three levels for the entire sample to determine areas where no respondents conducted work. For simplicity, data was then arranged as per the first climate type category (i.e. Tropical [A], Arid [B], Temperate [C], Cold [D]) and illustrated in Figure 1. Categorical variables are assembled as sample count and percentages, while ordinal variables in means and standard deviation. In the presentation of results, percentage values were rounded to the nearest percentage point. Pearson's chi-square analysis was performed to determine the significance of current practice of cooling types and combination of cooling between different departments. Where significant differences were identified, Bonferroni post hoc analysis of adjusted residuals were conducted to take into account multiple comparisons in order to reduce Type I error rates [25]. Statistical analyses were performed using SPSS (v25, IBM Corporation, USA).

RESULTS

INSERT TABLE 1 APPROXIMATELY HERE

Sample Characteristics

Completed surveys were collected from 119 unique departments located across the continental United States (Table 1), including those working in law enforcement (29%), as firefighters (29%), EOD (28%) and HAZMAT technicians (15%). The first level of classified climate regions by which the majority of the work conducted by responders is displayed in Figure 1.

INSERT FIGURE 1 APPROXIMATELY HERE

Heat Strain, Illness and Injury

One-hundred and eighteen departments (99%) reported heat strain/illness to be a risk to employee safety during occupational duties. Fifty-six departments (47%) cited at least one case of heat illness in the past 12 months within their department. The response for each department type were as follows; fire (39%), HAZMAT (23%), EOD (20%) and law enforcement (18%). Across all respondents citing heat illness in the past year, the severity ranged from work cessation (21%) through to death (2%). Forty-two percent of all respondents reporting incidents had reductions in productivity as employees needed to modify their work capacity or take leave from work (Table 2).

INSERT TABLE 2 APPROXIMATELY HERE

Adoption and Effectiveness of Pre-, Concurrent and Post-cooling

Across all of the departments, respondents reported the use of pre- (33%), concurrent (35%) and post-cooling (60%). The respective breakdown of EOD, fire, HAZMAT and law enforcement for each cooling type is as follows (Figure 2); pre-cooling (36, 35, 39, 24%), concurrent cooling (42, 29, 39, 30%), post-cooling (64, 76, 56, 42%). Statistical analysis showed no significant differences between departments for use of pre- or concurrent cooling strategies. However, it was revealed that compared to their counterparts, fire departments and law enforcement were significantly more ($\chi^2 = 5.290$; $p = 0.02$) and less ($\chi^2 = 6.003$; $p < 0.01$) likely to implement post-cooling, respectively (Figure 2).

Fire departments had the greatest adoption of at least one type of cooling (91%) followed by HAZMAT (78%), EOD (76%) and law enforcement (58%). The use of no-cooling, any single cooling type, the combination of any two or all three cooling types (pre-, concurrent, and post-cooling) is presented in Figure 3. EOD, fire, HAZMAT and law enforcement reported no-cooling (24, 9, 22, 42%), any single cooling type (33, 44, 33, 30%), any two cooling types (18, 44, 33, 15%) and all three cooling types (24, 3, 11, 12%), respectively. There were no significant differences between departments using any single or all three cooling strategies. Though, compared to other departments law enforcement was significantly more likely to use no cooling (chi square = 7.896; $p < 0.01$). While fire departments were significantly less likely to use no form of cooling (chi square = 6.401; $p < 0.01$) compared to other first responder departments. Fire departments also demonstrated significantly greater use of any two forms of cooling (chi square = 6.970; $p < 0.01$) than all other departments (Figure 3).

Respondents considered the two most effective strategies for each scheduled cooling as follows – pre-cooling: cold water immersion and cold water/ice slurry ingestion; concurrent: venturi tubed garments and ice-based liquid cooling systems; and post-cooling: rest in air-conditioning and ice application (Figure 4).

INSERT FIGURES 2, 3 AND 4 APPROXIMATELY HERE

Barriers to Cooling

When offered to specify any possible reason(s) as to what may be preventing the use of cooling the rank order of barriers from responders were as follows: availability (47%), cost (31%), logistics/time (25%), lack of evidence/knowledge (21%), effectiveness (16%), employee comfort/durability (16%) (Figure 5).

INSERT FIGURE 5 APPROXIMATELY HERE

DISCUSSION

To the best of our knowledge this is the first survey of occupational cooling practices in first responder departments across the continental United States. Looking across all department types, the key findings from this survey are 1) 99% of surveyed departments recognise heat illness/injury as a risk to employee safety, 2) post-

cooling was the most likely cooling method to be used (60%), 3) fire departments were significantly more likely to implement post-cooling, as well as combine two types of scheduled cooling compared to other departments, 4) 25% of departments provided no cooling whatsoever, while 36% of departments use only a single cooling method.

Almost all respondents (99%) classified heat illness/injury as a risk to employee safety, with 47% having had at least one employee experience heat illness during operations in the previous year. Similar rates of heat illness have been reported in radiation decontamination workers in Japan (48%) [19] and Naval Aircrew in the United Kingdom (58%) [18]. Most likely as a consequence of combining encapsulation and high metabolic demands [26], HAZMAT and fire departments reported the greatest rates of heat illness/injury in the previous year, 72% and 65% respectively. Epidemiological reports into occupational heat illness in Washington State between 2000-2009 noted fire fighters had the highest prevalence and susceptibility to heat illness/injury even at lower ambient temperatures than many other outdoor occupations [27]. Personal protective clothing is primarily designed to mitigate the extrinsic threats faced by first responders while attempting to preserve functionality during physical workloads. The subsequent encapsulation of the user can result in challenging physical consequences by creating a microclimate within the layer(s) of clothing, dampening heat loss at the surface of the skin [15]. From our results, 94% of the most severe case of heat illness and injury (i.e. medical attention, hospitalisation or death) in the previous year were reported in fire and HAZMAT departments.

Not all departments who identified heat illness/injury as a risk to employee safety provide personal cooling as a risk mitigation strategy with 60% of all departments practicing post-cooling, and only 33% and 35% reported using pre-cooling or concurrent cooling, respectively. A recent survey by Watkins et al. [20] of fire services in the United Kingdom revealed that many departments lacked basic hydration, personal cooling and recovery protocols. Our results do show that fire departments' surveyed in the United States had a relatively high adoption of scheduled occupational cooling strategies, with 91% providing at least one form of cooling. Fire departments had significantly higher rates of post-cooling (76%). Whilst, law enforcement had the lowest implementation of any

form(s) of cooling, potentially as a result of the greater breadth of duties, time on task and required levels of protective clothing compared to other surveyed first responders.

The lack of stakeholder education and knowledge of cooling strategies is an important barrier to consider [14]. An illustration of this lack of knowledge can be seen in our results and those from House [18], where periods in air-conditioning during work breaks, transport and/or briefings were suggested by respondents to be the most effective method of cooling (Figure 4). This is despite an abundance of research over many decades, in both athletic and occupational settings, showing a number of alternative pre-, concurrent and post-cooling systems to be superior to air-conditioning [9, 28, 29]. In a further example, 474 hired farm workers in North America showed limited understanding of adult acclimatisation times for working in the heat (73% stating only 0-14h needed), while 35% failed to recognise a history of heat-related illness to be a predictor of future heat strain [30]. One might suggest that the scientific community has yet to distil evidence-based heat illness prevention research into something easily or readily digestible to the end-user.

The current survey shows the multiple reasons why cooling is not accessible to first responders can be a result of multiple factors. The greatest barriers to personnel cooling included availability, cost, logistics, and knowledge (Figure 5). Rowlinson and Jia [31] provided a behavioural based institutional analysis of heat illness within the Hong Kong construction industry. They identified contributing factors of heat illness across various environmental (e.g. climate), societal (e.g. culture), industrial (e.g. workplace norms), organisational (e.g. training), and individual levels (e.g. risk perception). When adequate knowledge and availability of preventive measures are provided to workers (e.g. proactive and reactive interventions to signs and symptoms), only individual behavioural failures (e.g. passive negligence or overt resistance) become the primary cause of incidence of heat strain [31].

Recognising that heat illness/injury is largely preventable if adequate education is given to interested and influential stakeholders [32], one area research could have a meaningful impact is that of end-user knowledge through the refinement and dissemination of the scientific literature. It is paramount for research focussing on preventing heat illness reaches the people with the power to influence protocols and behaviour within at-risk

departments. Whether that is through university-industry partnerships, public health interventions [14] or ensuring 'job ready' mandated industry training [6]. However this can be difficult despite the wide array of documentation pertaining to managing heat stress advocating personnel cooling [6, 7, 33, 34]. Many guidelines are often detailed and technical in their approach of advising occupational health and safety professionals, researchers and governing/legislative bodies. The recommendations found in these resources may go unheeded in first responder departments without specialised, informed decision makers, and the means of acquiring the requisite physiological/environmental monitoring devices. Further complicating the practical challenges of complying with any recommendations are the wide variances in expected compliance depending upon local jurisdictions and industry specific regulations.

Resistance within departments based in traditions or norms, or difficulty in integrating with clothing/equipment due to product design. For instance, sociological and hierarchical structures present in all workplaces including military-style discipline, over-motivation/competition, and budgetary pressures can increase the risk of heat illness/injury by stifling effective preventive measures [35]. Therefore, given the importance in influencing key stakeholders within first responder departments, further scientific literature should also concentrate on the cost to a workplace prone to heat illness/injury. Our survey suggests considerable losses in productivity cited by 72% of respondents, ranging from short-term modifications in work capacity or complete absence of employees. There is a paucity of public health literature outlining the associated costs-benefits of not implementing proactive cooling strategies to mitigate heat illness. A single data set from Washington State government analyses the cost-benefit impact of heat illness prevention programs and suggests an economic upside due to lower worker compensation costs, indirect medical costs and losses in productivity [36].

Interpretation of our data is subject to certain limitations. First, a survey is a reflection of the current practice at a particular point in time. The dynamic nature of funding arrangements, assimilation of information, and public, political or supervisory pressures could alter cooling procedures and attitudes within these workforces since data collection. Secondly, this data is derived from a relatively low sample, with each survey completed by an individual, speaking on behalf of their department. Our survey likely saw underreporting of heat illness and injury

due to a combination of factors including the presentation of symptoms obscuring the diagnosis of heat as the contributing factor to an accident, illness or death; and employees failing to report illness or injury to employers in fear of job security, and over-motivation and competitive nature within professions culture [35, 37]. Thirdly, the first responders surveyed skewed towards those based in temperate to cold environments in the continental United States. Our findings may not be comparable with those of other spatial locales, such as tropical climates, where inhabitants have superior heat tolerance [38], but face greater risks as a result of sporadic heat waves [39]. Finally, though the purpose of this survey was to elicit a greater understanding of current cooling practices to alleviate heat illness in first responders, an important factor not considered was that of current knowledge and protocols regarding employee acclimation or acclimatisation. Adaptations may include adjustments in cardiovascular, pulmonary, haematological and thermoregulatory function that elicit reversible transient heat tolerance [40]. In 2006 across strenuous, outdoor professions in California, including construction, agriculture and first responders, 80% of all reported heat illness cases took place within the first four days of work commencing [41]. Future work should survey current practice and understanding of contemporary evidence-based acclimation/acclimatisation protocols. This survey should be used as an initial indication of practices within a cross-section of United States first responders.

CONCLUSION

This is the first study to survey present applications of personal cooling systems in emergency first responders residing in the United States. Heat illness and injury was cited almost exclusively to be a risk to employee safety, with approximately half of respondents having experienced employee heat illness in the previous year. Fire departments reported the greatest rates of heat illness and injury. Concurrent cooling and pre-cooling had half the rate of adoption compared to post-cooling. Fire departments had significantly higher rates of post-cooling relative to other first responder departments. No cooling whatsoever was provided to one quarter of all departments surveyed, with law enforcement having significantly lower implementation rates of any form of cooling. Firefighters were also significantly more likely to combine at least two forms of scheduled cooling. Our findings

could aid in a better understanding of current practices and perceptions of heat illness and injury prevention in United States first responders.

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Figure 1. Simplified Köppen-Geiger climate classification of respondents. Adapted from Peel et al. [24].

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Figure 2. Current practice of scheduled cooling ($n = 118$). * Significantly different ($p < 0.01$) cooling used to all other departments; # significantly different ($p = 0.02$) cooling used to all other departments. EOD – explosive ordinance disposal; HAZMAT – hazardous materials.

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Figure 3. Current practice of combining scheduled cooling ($n = 118$). EOD – explosive ordinance disposal; HAZMAT – hazardous materials. * Significantly different ($p < 0.01$) cooling used to all other departments.

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Figure 4. Responses to the perceived effectiveness of cooling systems (mean \pm SEM).

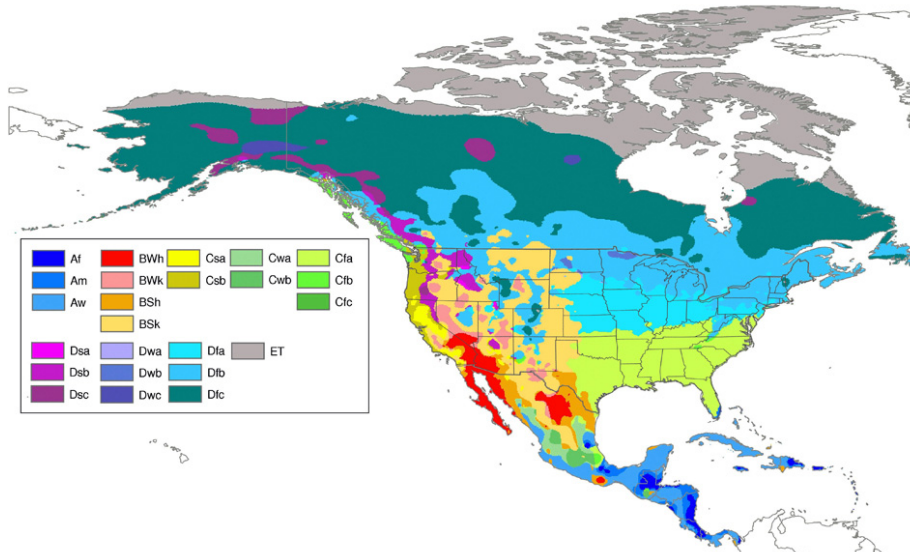
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Figure 5. Responses to the question ($n = 89$): “Please indicate any barriers that prevent your department from using any cooling strategies”. Note the respondents were allowed to choose multiple answers, thus the total percentages sum to $>100\%$.

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Q1) Which department/service are you a part of?

- Fire
- Law Enforcement
- Emergency Medical Technicians
- Search and Rescue
- Explosive Ordinance Disposal
- Hazmat
- Military
- Other (please specify)



Peel MC, Finlayson BL & McMahon TA (2007), Updated world map of the Köppen-Geiger climate classification, Hydrol. Earth Syst. Sci., 11, 1633-1644.

Q2) Please indicate from the climate map ALL geographical location(s) where work from your department takes place?

Q3) Please indicate from the climate map in which geographical location does the MAJORITY of your departments work take place?

Q4) Would you classify HEAT STRAIN and/or HEAT ILLNESS as an identified risk to employee safety during occupational duties?

- Yes
- No

Q5) Does your department currently employ PRECOOLING strategies before occupational duties or training to combat heat strain?

- Yes
- No

Q6) Please identify ANY of the following PRECOOLING technique(s) currently used by your department:

- Water Immersion
- Cold Air Exposure
- Ice Exposure or Application (including garments)
- Cold Air Inhalation

- Ice Slurry Ingestion
- Other (please specify)

Q7) How EFFECTIVE do you believe those PRECOOLING technique(s) you currently use to be?

Not at all	A little	Somewhat	Quit a lot
------------	----------	----------	------------

- Water Immersion
- Cold Air Exposure
- Ice Exposure or Application (including garments)
- Cold Air Inhalation
- Cold Liquid Beverages
- Ice Slurry Ingestion
- Other (please specify) _____

Q8) Please provide ANY model(s) and/or brand name(s) relating to each of the PRECOOLING technique(s) you currently use:

- Water Immersion: _____
- Cold Air Exposure: _____
- Ice Exposure or Application (including garments): _____
- Cold Air Inhalation: _____
- Cold Liquid Beverages: _____
- Ice Slurry Ingestion: _____
- Other (please specify): _____

Q9) Please indicate ANY barriers that prevent your department from using PRECOOLING strategies:

- Employee Comfort/Durability
- Effectiveness
- Financial Cost
- Logistics/Time
- Availability
- Lack of Evidence/Knowledge
- Other (please specify): _____

Q10) Does your department currently employ INTERMITTENT/RECOVERY COOLING strategies to combat heat strain between or following work periods?

- Yes
- No

Q11) Please identify ANY of the following INTERMITTENT/RECOVERY COOLING technique(s) currently used by your department:

- Doffing/Opening Equipment or Clothing
- Rest Periods in the Ambient Environment
- Rest Periods in Air Conditioning
- Fan Exposure (including misting fans)
- Cold Water/Ice Bath Immersion (e.g. arm, feet)
- Ice Exposure or Application (including garments)
- Cold Liquid Beverages
- Ice Slurry Ingestion
- Other (please specify): _____

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Q12) How EFFECTIVE do you believe those INTERMITTENT/RECOVERY COOLING technique(s) you currently use to be?

Not at all	A little	Somewhat	Quit a lot
------------	----------	----------	------------

- Doffing/Opening Equipment or Clothing
- Rest Periods in the Ambient Environment
- Rest Periods in Air Conditioning
- Fan Exposure (including misting fans)
- Cold Water/Ice Bath Immersion (e.g. arm, feet)
- Ice Exposure or Application (including garments)
- Cold Liquid Beverages
- Ice Slurry Ingestion
- Other (please specify) _____

Q13) Please provide any model(s) and/or brand name(s) relating to each of the INTERMITTENT/RECOVERY COOLING technique(s) you currently use:

- Fan Exposure (including misting fans)
- Cold Water/Ice Bath Immersion (e.g. arm, feet)
- Ice Exposure or Application (including garments)
- Cold Liquid Beverages
- Ice Slurry Ingestion
- Other (please specify): _____

Q14) Indicate ANY barriers that prevent your department from using INTERMITTENT/RECOVERY COOLING strategies:

- Employee Comfort/Durability
- Effectiveness
- Financial Cost
- Logistics/Time
- Availability
- Lack of Evidence/Knowledge
- Other (please specify): _____

Q15) Does your department currently employ CONCURRENT COOLING strategies to combat heat strain during operational training or duties whilst wearing PPE/PPC?

- Yes
- No

Q16) Please identify ANY of the following CONCURRENT COOLING technique(s) currently used by your department:

- Evaporative Cooling Systems
- Ice-based Phase Change Systems
- Non-ice Phase Change Systems
- Vapour Compression Air Cooled Systems
- Venturi/Vortex Tube Systems
- Ice-based Liquid Cooled Systems
- Vapour Compression Liquid Cooled Systems
- Thermoelectric Liquid Cooled Systems
- Other (please specify): _____

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Q17) How EFFECTIVE do you believe those CONCURRENT COOLING technique(s) you currently use to be?

Not at all	A little	Somewhat	Quite a lot
------------	----------	----------	-------------

- Evaporative Cooling Systems
- Ice-based Phase Change Systems
- Non-ice Phase Change Systems
- Vapour Compression Air Cooled Systems
- Venturi/Vortex Tube Systems
- Ice-based Liquid Cooled Systems
- Vapour Compression Liquid Cooled Systems
- Thermoelectric Liquid Cooled Systems
- Other (please specify) _____

Q18) Please provide any model(s) and/or brand name(s) relating to each of the CONCURRENT COOLING technique(s) you currently use:

- Evaporative Cooling Systems
- Ice-based Phase Change Systems
- Non-ice Phase Change Systems
- Vapour Compression Air Cooled Systems
- Venturi/Vortex Tube Systems
- Ice-based Liquid Cooled Systems
- Vapour Compression Liquid Cooled Systems
- Thermoelectric Liquid Cooled Systems
- Other (please specify): _____

Q19) Please indicate ANY barriers that prevent your department from employing CONCURRENT COOLING strategies:

- Employee Comfort/Durability
- Effectiveness
- Financial Cost
- Logistics/Time
- Availability
- Lack of Evidence/Knowledge
- Other (please specify): _____

Q20) Please provide any other relevant comment on heat strain related issues or cooling systems in your workplace:

Table 1. Occupational characteristics of respondents

FIRST RESPONDER DEPARTMENT	SAMPLE (%)
Law Enforcement	34 (29)
Explosive Ordinance Disposal	33 (28)
Firefighting	34 (29)
Hazardous Materials	18 (15)
Total	119

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Table 2. Heat illness and injury

QUESTION	SAMPLE (%)
Is heat strain and/or heat illness classified as an identified risk to safety in occupational duties? (n = 119)	
Yes	118 (99) ^a
No	1 (1) ^a
In the past 12 months has any employee exhibited heat illness during occupational duties? (n = 118)	
Yes	56 (47) ^a
<i>Law Enforcement</i>	10 (18) ^b
<i>Explosive Ordinance Disposal</i>	11 (20) ^b
<i>Fire</i>	22 (39) ^b
<i>Hazardous Materials</i>	13 (23) ^b
No	62 (53) ^a
<i>Law Enforcement</i>	23 (37) ^b
<i>Explosive Ordinance Disposal</i>	22 (36) ^b
<i>Fire</i>	12 (19) ^b
<i>Hazardous Materials</i>	5 (8) ^b
Did the incident(s) of heat illness require the following? (n = 56)	
Work Cessation	12 (21) ^a
<i>Law Enforcement</i>	4 (33) ^b
<i>Explosive Ordinance Disposal</i>	5 (42) ^b
<i>Fire</i>	2 (17) ^b
<i>Hazardous Materials</i>	1 (8) ^b
Onsite First-Aid	20 (36) ^a
<i>Law Enforcement</i>	4 (20) ^b
<i>Explosive Ordinance Disposal</i>	6 (30) ^b
<i>Fire</i>	6 (30) ^b
<i>Hazardous Materials</i>	4 (20) ^b
Onsite Medical/Physician Attention	9 (16) ^a
<i>Law Enforcement</i>	1 (11) ^b
<i>Explosive Ordinance Disposal</i>	0 (0) ^b
<i>Fire and Hazardous Materials</i>	5 (56) ^b
<i>Hazardous Materials</i>	3 (33) ^b
Hospitalisation	8 (14) ^a
<i>Law Enforcement</i>	0 (0) ^b
<i>Explosive Ordinance Disposal</i>	0 (0) ^b
<i>Fire</i>	7 (88) ^b
<i>Hazardous Materials</i>	1 (12) ^b
Death	1 (2) ^a
<i>Fire</i>	1 (2) ^b
No Response	6 (11) ^a
Please indicate if any of the incident(s) were severe enough to require... (n = 56)	
Workload Monitoring	7 (12) ^a
Reduced Duties	9 (16) ^a
Time Off Work (<1 week)	8 (14) ^a
Time Off Work (>1 week)	0 (0) ^a

None of the Above	11 (20) ^a
No Response	21 (38) ^a

^a Percentage of total respondents to the question; ^b Percentage derived from department type within each response.

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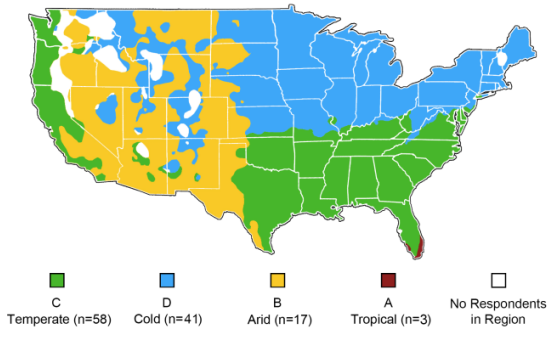


Figure 1

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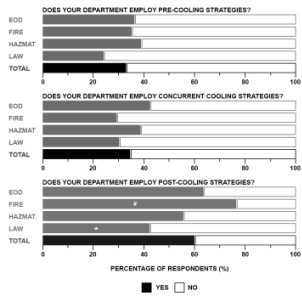


Figure 2

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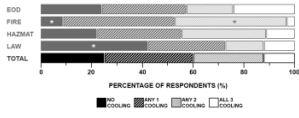


Figure 3

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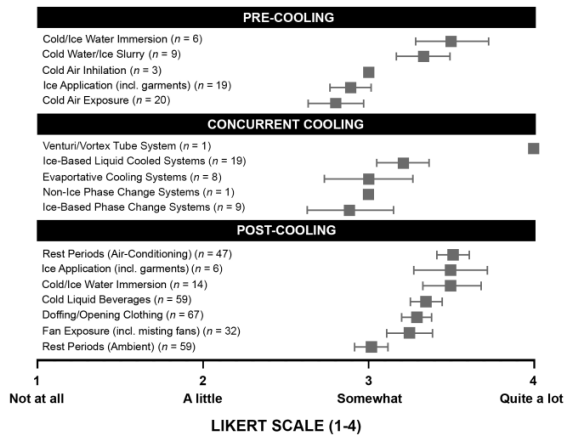


Figure 4

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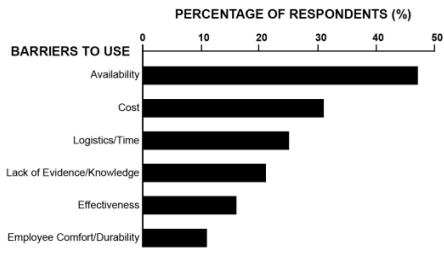


Figure 5

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