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Heat-related knowledge, perceptions, and barriers among oil spill cleanup responders

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ABSTRACT

Despite increased risk for heat-related illnesses (HRI) among oil spill cleanup responders, little research has examined factors related to the issue. This study assessed occupational heat-related knowledge, perceptions, and barriers among responders during cleanup activities. A total of 65 responders completed an online survey which examined occupational heat stress during cleanup activities. Of the respondents, most had 25 or more years' experience, worked for companies with 19 or fewer employees, were not classified as safety and health professionals, had a Bachelor's degree or higher, and worked in the northern or central regions of the United States. While most respondents were knowledgeable of heat stress, the items in which respondents were least knowledgeable were: identifying the difference between heat exhaustion and heat stroke, the appropriate use of salt tablets, the effects of air conditioning on acclimatization, and previous heat-related illness (HRI) as a risk factor. For knowledge of heat stress, there was a significant difference in the employment classification scores for non-safety and health professionals and safety and health professionals. Respondents reported that they tended to perceive that heat stress can be severe and that HRI's may affect workers. Regarding self-efficacy, most respondents felt confident in contacting emergency medical services for HRI, recognizing signs and symptoms of HRI, and knowing what to do if a coworker became ill. Oil spill cleanup responders are at high risk for HRI, injury, and death and findings illustrate the need to improve heat stress knowledge within training programs with emphasis on non-professionals.

1. Introduction

Oil spill cleanup responders are at heightened risk for heat-related illnesses (HRI) and injuries from heat stress. Heat stress can result in occupational illnesses and injuries during situations where the total heat load (environmental and metabolic) exceeds the abilities of the body to maintain the heat balance. Loss of heat balance, the equilibrium between body heat production and environmental gain, and the heat loss to the environment, may lead to heat stress. Heat can be transferred to the environment by convection (e.g., breeze, fan), evaporation (e.g., sweat evaporating), conduction (e.g., contact with a cool object), and behavioral mechanisms (e.g., leave the area, remove clothing, drink water) (National Institute for Occupational Safety and Health [NIOSH, 2016]; Taylor et al., 2008). Heat-related illnesses (heat rash, heat syncope, heat cramps, rhabdomyolysis, heat exhaustion, and heat stroke) vary in severity, with heat stroke potentially resulting in death. Heat-related occupational injuries may also occur from sweaty palms, fogged-up safety glasses, dizziness, or reduced brain function responsible for reasoning ability (NIOSH, 2016). Other heat injuries, such as burns, may occur as a result of contact with hot surfaces, steam, or fire.

Despite efforts to prevent heat stress, heat-related deaths, illnesses, and injuries continue to occur in workplaces. The incidence of HRI in the United States has not been well documented by surveillance systems specific to occupational injury and illness (NIOSH, 2016). Since HRI are often not recognized, and only illnesses involving days away from work are reported, the actual number of occupational HRI and deaths is not known. Additionally, estimates of the number of workers exposed to heat are not available. Workers exposed to extreme heat or work in hot environments, either indoors or outdoors, or even those engaged in strenuous physical activities, may be at risk for HRI.

To address the hazards of heat stress, NIOSH (2016) published the *Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments*. This publication assessed the potential safety and health hazards encountered in hot environments, regardless of the workplace, and recommended a standard to protect workers from those hazards. Recommendations included: using limits related to the calculation of environmental temperature and metabolic heat; medical

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monitoring programs; training programs; and heat controls, such as engineering or work practice controls (NIOSH, 2016).

1.1. Heat stress risk factors

Many risk factors can contribute to heat stress and some are more difficult to address than others. Risk factors associated with HRI may be environmental or individual. Environmental factors are characteristics of the workplace setting, while individual risk factors are unique to each worker and may impact each worker with individual variation (NIOSH, 2016). Environmental factors that put workers at additional risk for HRI include: high temperatures and humidity; direct sun exposure or indoor radiant heat sources (e.g., ovens, furnaces); and limited air movement (NIOSH, 2016). Individual risk factors can include: not drinking enough fluids; physical exertion, personal protective equipment (PPE) and clothing; physical condition and health problems; medications; pregnancy; lack of acclimatization; and advanced age (NIOSH, 2016).

1.2. Oil spill cleanups

Although there is a significant body of literature on the topic of heat stress, numerous gaps exist and present opportunities to more thoroughly understand this issue, particularly when examining worker populations in high risk industries, such as many outdoor worker professions. Previous incidents of large-scale oil spills, have documented that heat stress is a current problem for oil spill cleanup responders (King and Gibbins, 2011; Michaels and Howard, 2012; NIOSH, 2016). During the Deepwater Horizon oil spill response there were 978 heat stress incidents reported (Michaels and Howard, 2012). Such workers are placed in stressful situations, where there is great demand for a task to be completed quickly, resulting in physically strenuous activity. In addition, these workers often wear PPE (e.g., Tyvek coveralls, boots, gloves) to protect themselves from the oil and chemicals used during cleanup, thereby, creating additional heat burden and stress (NIOSH, 2016).

Moreover, many oil spill cleanup companies are considered small businesses, that tend to have a variety of factors negatively affecting their overall occupational safety and health, including: a lack of resources; greater time demands on managers; poor manager attitudes about safety; and fewer employees to engage in activities such as safety committees (De Kok, 2005; Hasle and Limborg, 2006; Lentz and Wenzl, 2006; Parker et al., 2007; Sinclair and Cunningham, 2014). Small businesses are also burdened with higher injury and fatality rates than larger businesses (Buckley et al., 2008; Mendeloff, 2006; Page, 2009; Sinclair and Cunningham, 2014). Due to this difference in injury and fatality rates, there is ongoing interest in how to modify or eliminate associated factors and create safer work environments for the large workforce found in small businesses.

Preventing heat stress by implementing controls, such as providing hydration and rest breaks, may also lack efficiency among oil spill cleanup responders. Workers may experience barriers that prevent them from taking the breaks that their body needs to cool down. Even if HRI are present among workers, there are first aid steps that can be taken to reduce the severity and prevent death. However, workers must feel that they are capable of both identifying a HRI and implementing the appropriate first aid. A lack of appropriate knowledge may affect all of these factors, putting oil spill cleanup workers who are already at high risk, even further in harm's way.

1.3. The health belief model

Given the need for increasing knowledge related to heat stress and ways to overcome barriers to applying that knowledge, a theory-based approach to understanding current knowledge and barriers among oil spill cleanup responders is warranted. The health belief model posits that a person will take health related action based upon perceptions, self-efficacy, and barriers related to the outcome of their actions. This model asserts that health-related behavior is determined by whether individuals: (a) perceive themselves to be susceptible to a particular problem; (b) see this problem as a serious one; (c) are convinced that treatment or prevention activities are effective yet not overly costly in terms of effort; and (d) receive a prompt or cue to take action (Rosenstock, 1966). Thus, use of this theory-based approach is warranted, as it may provide insight for program needs and why a heat stress prevention plan, which often relies heavily on training and controls, may not work well within a certain population. A comprehensive review of the literature did not reveal the use of the health belief model in occupational settings related to heat, but one study did describe its use in relation to heat waves. The researchers sought to determine the predictors of perceived risk using a heat wave scenario and identify the health belief model constructs that could predict adaptive behaviors during a heat wave (Akompab et al., 2013). For a hypothetical example related to occupational heat stress, one might say that a worker may choose to adhere to a heat stress prevention program if he: (a) sees a coworker die from heat stroke; (b) sees first aid steps taken when a coworker displayed signs of heat exhaustion and did not die; (c) sees how easy it is to access water and take a rest break as needed; and/or (d) had been instructed during heat stress training about a variety of steps to prevent HRI. By utilizing this model, training and educational materials can be modified to provide a more useful heat stress prevention plan for oil spill cleanup responders.

1.4. Study purpose

Exposure to heat stress in an occupational environment, risk factors for HRI, and possible preventive steps often create a complex world of possibilities that may be either protective or detrimental to workers, such as, oil spill cleanup responders. In our previous work (Jacklitsch et al., 2018), we assessed heat-related training and educational materials currently used and desired by oil spill cleanup responders, and in this paper we aim to more thoroughly inform researchers and those in the safety and health field about oil spill cleanup responders' knowledge, perceptions, self-efficacy, and barriers related to their work in hot environments and exposure to heat stress, which are important when planning future heat stress preventions plans. In order to gain increased understanding of such factors, constructs from the health belief model were used for this pilot study. Constructs included perceived severity (of heat stress itself), self-efficacy (for identifying HRI and using first aid), and perceived barriers (to taking hydration and rest breaks).

The present study examined the following research questions:

(1) How knowledgeable are oil spill cleanup responders in regards to heat stress (e.g., HRI, risk factors, first aid, and prevention)?
(2) To what extent does heat stress knowledge among oil spill cleanup responders differ based on number of years of experience, company size, employment classification, highest education achieved, and current climate region?
(3) Does the perceived severity of heat stress in an oil spill response situation among oil spill cleanup responders differ based on number of years of experience, company size, employment classification, highest education achieved, and current climate region?
(4) Does the self-efficacy of oil spill cleanup responders in relation to (a) recognizing a HRI and (b) performing appropriate first aid differ based on number of years of experience, company size, employment classification, highest education achieved, and current climate region?
(5) Do perceived barriers to how often oil spill cleanup responders choose to take a hydration or rest break differ based on number of years of experience, company size, employment classification, highest education achieved, and current climate region?

2. Methods

2.1. Participants and procedures

A purposive convenience sample of United States oil spill cleanup companies ($N = 440$) was obtained through stakeholder networks and an online directory of oil spill cleanup contractors (cleanupoil.com). Oil spill cleanup companies were invited to participate in the survey. Based on the unknown population of oil spill cleanup responders targeted, a pilot study sample of 440 potential participating companies were contacted for potential participation. The companies contacted were instructed that survey participants needed to be individuals who respond to oil spill cleanup activities. Responders had to be at least 18 years of age. Participation was voluntary and confidential, and no incentives were offered. Contacts were sent a cover letter describing the purpose and the link to the online survey, via email. Following the initial cover letter, three follow-up contacts were made to those who had not yet completed the survey. This study was approved by the principal investigator's IRB.

Upon clicking the survey link, participants arrived at the welcome page that provided them with the purpose of the survey, assurance that responses were confidential and that participation was voluntary. Electronic consent was required to continue to the survey. Surveys took on average 10–15 min to complete. Confidentiality was preserved, as the survey did not request participants' names, email address, or IP address. In addition, there were no personal identifiers collected in the survey. Surveys in which the majority of questions were left unanswered were eliminated from the study. The survey remained open online for a two-month period, and all survey reminders had been sent. Sixty-five participants completed surveys.

2.2. Instrumentation

An online survey was developed to assess participants' knowledge, perceptions, needs, and attitudes in regards to heat stress. While other heat-related survey instruments were reviewed, the questions found were not always suitable for the targeted audience of oil spill cleanup responders of this project (Akompab et al., 2013; Dehghan at al., 2015; Hunt, 2011; Lam et al., 2013; Li et al., 2016; Stoecklin-Marois et al., 2013; Xiang et al., 2015). A panel of experts was used to establish face and content validity. The panel consisted of NIOSH subject matter experts familiar with oil spill cleanup activities and heat stress. In addition, the panel included health survey researchers who had extensive expertise in survey design, health behavior, and the health belief model.

Surveys were administered online and hosted by SurveyMonkey. The survey was divided into eight sections (i.e., employment information, heat experiences, knowledge, perceived severity, self-efficacy regarding HRI and first aid, perceived barriers to hydration and rest breaks, attitudes and desires related to training and educational materials, and demographics).

2.2.1. Employment information

The Employment Information section consisted of five items: (1) occupational role (safety and health professional, employer, or worker); (2) years of employment in the oil spill cleanup industry; (3) state within which they currently worked; (4) whether they respond to oil spill cleanups in other states/countries; and (5) size of company.

2.2.2. Heat-related experiences at work

The Heat-Related Experiences at Work section requested participants to report the number of oil spill cleanups in a year; shift length; number of breaks during a shift and whether they experienced a list of heat-related situations. There was also a question that requested participants to report the level of activities that a shift might consist of, as a way to estimate the level of physical exertion experienced. The section ended with a checkbox list of possible heat stress preventive initiatives a workplace may have in place.

2.2.3. Knowledge of heat stress

The Knowledge of Heat Stress section consisted of eight items. Participants answered each item by checking "True," "False," or "Unsure." Statements chosen for this section were common topics and concepts that should be addressed in a quality occupational heat stress training program. Participants received one point for each correct answer, resulting in a potential range of 0–8.

2.2.4. Health belief model constructs

A series of 5-point Likert scales were used to measure Perceived Severity of heat stress; Self-Efficacy related to identifying a HRI and effectively responding with first aid; and Perceived Barriers to taking hydration and rest breaks during oil spill cleanup activities (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree; except when reverse order coding was necessary). Statements were based on previously used heat-related survey instruments as well as items identified in the professional literature.

2.2.5. Demographics

The Demographics section consisted of items assessing age (five categories, starting with age 18 years), sex (male, female), level of education (nine categories, including GED, trade/vocational school, and various levels of college), and race/ethnicity (seven categories).

2.3. Data analysis

Data were exported from SurveyMonkey into Microsoft Excel spreadsheets and recoded, as necessary. All data were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) statistical software package (Version 24). Frequencies, ranges, and percentages were used to describe demographics, employment information, and knowledge levels. Means and standard deviations were used to describe heat stress-related perceived severity, self-efficacy, and barriers. As this was a pilot study, the sample size was small, thus the independent variables were dichotomized into the following categories: number of years of experience (24 years or less; 25 years or more), company size (1–19 individuals; 20 or more individuals), employment classification (non-safety and health professional; safety and health professional), highest education achieved (Associate's degree or less; Bachelor's degree or higher), and current climate region (north/central; south/west). Subscale scores were computed for each of the dependent variables: heat stress knowledge, perceived severity, perceived self-efficacy, and perceived barriers. T-tests were used to determine whether heat stress knowledge, perceived severity, self-efficacy, and perceived barriers differed significantly based on demographic variables (number of years of experience, company size, employment classification, highest education achieved, and current climate region).

3. Results

3.1. Demographics and work information

A total of 65 oil spill cleanup responders participated in the survey (Jacklitsch et al., 2018). Participants were mostly male, Caucasian, and 40 years or older. Of these participants, the mean years of experience was 22 years, and company size varied with slightly more than half having 19 or fewer employees. Approximately two in three respondents reported that they were not safety and health professionals (e.g., employers, supervisors, employees, scientific support). Regarding education, most (73.3%) had a Bachelor's degree or higher. And half reported working in the northern or central region of the US. Additional details on demographics and work information can be found in Table 1.

Table 1
Demographics and work information.

	n	%
Age		
18–29	3	5.8
30–39	8	15.4
40–49	16	30.8
50–59	25	48.1
60 +	0	0.0
Sex		
Male	51	86.4
Female	8	13.6
Highest level of education		
Some high school	1	1.7
High school diploma	0	0.0
GED	0	0.0
Trade/vocational school	2	3.3
Some college	9	15.0
Associate's degree	3	5.0
Bachelor's degree	24	40.0
Graduate or professional	20	33.3
Other	1	1.7
Race/Ethnicity		
African American/Black	1	1.7
Asian/Pacific Islander	1	1.7
Caucasian	56	93.3
Hispanic/Latino	1	1.7
American Indian/Alaska Native	0	0.0
Other	1	1.7
Employment classification		
Safety and health professional	21	32.3
Employer	18	27.7
Supervisor	19	29.2
Employee/worker	4	6.2
Scientific support/consultant	3	4.6
Company size		
1–9	11	25.6
10–19	12	27.9
20–49	13	30.2
50–99	7	16.3
100 +	0	0.0
Years of experience		
24 years or less	30	47.6
25 years or more	33	52.4
Mean	22.25	
Range	1 – 69	
Current climate region		
Northern or central	33	50.8
Southern or western	32	49.2

Note: N = 65; Percents refer to valid percents; Missing values excluded.

3.2. Heat stress knowledge

Nearly all respondents correctly responded to knowledge statements related to symptoms of dehydration (98.4% percent correct), high humidity as a risk factor (96.8%), medications as a risk factor (95.3%), and recognizing that heat stroke is a medical emergency (92.2%) (Supplementary Table 1). Items that had the lowest percent of respondents answering correctly were identifying the difference between heat exhaustion and heat stroke (12.5% percent correct), the appropriate use of salt tablets (62.5%), the effects of air conditioning on acclimatization (70.3%), and previous HRI as a risk factor (73.4). Results revealed that safety and health professionals had a significantly higher heat stress knowledge score. For knowledge of heat stress, there was a significant difference in the employment classification scores as safety and health professionals ($M = 6.62$, $SD = 1.024$) were significantly more knowledgeable than non-safety and health professionals ($M = 5.70$, $SD = 1.081$, $t = 3.257$, $p = .002$). Knowledge of heat stress did not differ significantly based on number of years of experience, company size, highest education achieved, and current climate region in which individuals worked (n = 65).

3.3. Perceived severity of heat stress

Respondents reported they perceived that heat stress can be severe, such as leading to death ($M = 4.45$, $SD = 0.711$) and that HRI's may affect workers as the jobs are hot and hard ($M = 4.03$, $SD = 0.712$) (Supplementary Table 2). Perceived severity of heat stress did not differ based on number of years of experience, company size, whether or not employees were safety and health professionals, highest education achieved, and current climate region in which individuals worked (n = 65).

3.4. Self-efficacy related to recognizing HRI and performing first aid

In general, most respondents felt confident in contacting emergency medical services for HRI ($M = 4.45$, $SD = 0.589$), recognizing signs and symptoms of HRI ($M = 4.27$, $SD = 0.623$), and knowing what to do if a coworker became ill ($M = 4.06$, $SD = 1.037$) (Supplementary Table 3). Self-efficacy did not differ based on number of years of experience, company size, whether or not employees were safety and health professionals, highest education achieved, and current climate region in which individuals worked (n = 65).

3.5. Perceived barriers to hydration and rest breaks

The majority of respondents felt that there were few barriers to taking rest and hydration breaks (Supplementary Table 4). Perceived barriers did not differ significantly based on number of years of experience, company size, whether or not employees were safety and health professionals, highest education achieved, and current climate region in which individuals worked (n = 65).

4. Discussion

The present study examined emergency oil spill cleanup responders' perceptions and self-efficacy related to their work in hot environments and exposure to heat stress. Results indicated that additional emphasis on heat stress basics is warranted for training and prevention plans to deter misconceptions and better inform oil spill responders.

4.1. Knowledge of heat stress

This study found that while most participants were knowledgeable regarding heat stress with a few exceptions regarding heat stroke classification, salt intake, and acclimatization. The item least understood was identifying the difference between heat exhaustion and heat stroke. Occupational heat stress experts anecdotally concur with this area being an area for needed improvement. The low level of knowledge regarding the differences between heat exhaustion and heat stroke may be due to insufficient and unclear classification and confusion about the differentiation between not only these two types of HRI, but also the two classifications of heat stroke. Widely unrecognized in public health, there are actually two classifications of heat stroke: classic and exertional heat stroke (NIOSH, 2016). The characteristics of the individual (age and health status), type of activity (sedentary versus strenuous exertion), and symptoms (sweating versus dry skin) vary between the classic and exertional classifications (Department of Defense [DOD], 2003). Some of the commonly heard public health messaging focuses only on classic heat stroke, despite workers being at higher risk for exertional heat stroke.

A lack of knowledge about acclimatization, might lead to a lack of acclimatization being implemented in any heat stress prevention plans. Acclimatization consists of the physiological changes that occur in response to a succession of days of exposure to environmental heat stress and reduce the strain caused by the heat stress of the environment; and enable a person to work with greater effectiveness and with less chance of heat injury (NIOSH, 2016). When workers are not acclimatized they may readily show signs of heat stress when exposed to hot environments, and have difficulty replacing all of the water lost in sweat (DOD, 2003; NIOSH, 2016). Arbury et al. (2014) presented cases of HRI or death among workers, in which most of the employers had no program to prevent HRI, or the program was deficient. Acclimatization was the program element most commonly absent and clearly associated with worker death.

Misunderstandings about salt intake were apparent based on the results of this study, as 30% of participants thought salt tablets could restore electrolytes lost. An increase in salt intake is probably not justified, unless recommended by a physician, as the average United States diet contains a relatively high salt content, more than 3440 mg per day (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). Additionally, salt tablets can irritate the stomach and should not be used; instead, salt losses are best replaced by the ingestion of normal salted foods or fluids over many hours (DOD, 2003). Increased clarity and understanding of these areas is warranted among employees in the field to deter unhealthy prevention habits.

4.2. Years of experience

It is often reasonable to assume that with increased years of experience, knowledge increases. However, in this study no significant difference was noted. This may be related to other factors, such as, that most respondents perceived heat stress as severe and could affect responders at their worksites. If something is a known danger, then a person may be more knowledgeable about the risks and how to prevent becoming ill or injured and more motivated to take action to prevent a detrimental outcome (Rosenstock, 1960). This acknowledgement about the perceived severity of heat stress and the increased knowledge, could also affect self-efficacy and the perception of barriers.

4.3. Company size

Interestingly, knowledge, perceived severity, perceived self-efficacy, and perceived barriers did not differ significantly based on company size. Oftentimes, small businesses are most susceptible to workplace illness and injury, as they tend to have limited resources, greater time demands on managers, poor manager attitudes about safety, and fewer employees to engage in activities such as safety committees (De Kok, 2005; Hasle and Limborg, 2006; Lentz and Wenzl, 2006; Parker et al., 2007; Sinclair and Cunningham, 2014). As definitions of small businesses by size can vary, it may be that not enough of the smallest businesses participated for a significant difference to be realized. A larger sampling of small businesses is recommended in future studies.

4.4. Safety and health professionals

Not surprisingly, safety and health professionals were significantly more knowledgeable than non-safety and health professionals regarding heat stress knowledge. Such a finding may be due to the increased amount of workplace training and education they receive regarding workplace safety in general, and heat stress specifically. However, perceived severity, perceived self-efficacy, and perceived barriers did not differ significantly based on employment classification. The findings indicated that both types of employees recognized the severity of heat stress, felt confident in addressing the issue, and perceived there to be few barriers. While overall knowledge differed, it appears that all employees recognize that heat stress is an important and critical issue in workplace safety. Additionally, this pilot sample did not include some of the most often cited vulnerable populations of workers (e.g., immigrant, young, and/or temporary workers) (NIOSH and ASSE, 2015). Future studies are therefore needed to examine whether knowledge and attitudes differ based on such variables.

4.5. Education

Nearly three-fourths of respondents had a Bachelor's degree or higher which may have impacted the overall knowledge score of heat stress. Studies have shown that those with higher education are able to think more critically, problem solve, and understand while retaining important information (Gyekye and Salminen, 2009). This study failed to show any significant differences based on education. Therefore, it may well be the case, that companies overall education level does not impact knowledge and attitudes of heat stress, but rather on-the-job training and education at the workplace may have more of a profound impact on oil spill cleanup responders.

4.6. Climate regions

Climate region was hypothesized to have an impact on knowledge, perceptions, self-efficacy, and barriers. Previous studies have shown that those working in certain regions of the United States experience more HRI and fatalities (Hyatt et al., 2010; Schulte et al., 2016) The present study indicated that knowledge, perceived severity, perceived self-efficacy, and perceived barriers did not differ based on the climate region in which individuals worked. Perhaps, respondents had experienced similar incidents of heat stress and such incidents were not dependent on climate region. Due to the limited sample size, this study dichotomized climate region into two different regions, and therefore the extremes in any climatic differences may have been muddied by including states with more moderate or varying temperatures. Follow up studies that are larger in scope and use the nine NOAA climate regions, as was originally planned in this study, may show different results (Karl and Koss, 1984; NOAA, 2017).

4.7. Limitations

The limitations of this study should be noted. First, the present study was a pilot study consisting of a small sample size. Therefore, results may not be generalizable to all populations. In addition, because of the smaller and less robust and diverse sample, this may have led to no differences being observed for the previously mentioned variables based on demographic variables. Second, as this was an unmonitored, online survey, knowledge items may have been searched for online before answering. Third, some individuals may have answered in a socially desirable manner. Fourth, dichotomizing the variables may have affected findings by diluting the extremes. Future studies are needed which specifically recruit workers with different backgrounds and vulnerabilities (e.g., immigrant, young, and/or those working for small businesses).

5. Conclusion

This study provides some insight into heat-related knowledge and perceptions among oil spill cleanup responders. While acknowledging the small sample size of this pilot study, it can still be inferred that oil spill cleanup responders who are considered safety and health professionals are quite knowledgeable about heat stress and more knowledgeable than those in the industry without this designation. For those with or without this professional designation, other constructs such as perceived severity of heat stress, self-efficacy related to recognition of HRI and performing first aid, and perceived barriers to hydration and rest breaks all lead to the potential effectiveness of heat stress prevention plan being put in place or currently in use. Even if all the constructs are in place, for training and a prevention plan to be well received, more emphasis on some heat stress basics are needed to efficiently increase general knowledge and ensure the correct information is being presented at the workplace.

Despite intervention efforts to prevent heat-related deaths and illnesses, such deaths and illnesses continue to plague workplaces. Extreme environmental heat combined with the metabolic heat of person working can result in illness, injury, and death. Knowledge about heat stress, perceiving the level of danger, recognizing HRI and performing first aid, and removing barriers to taking needed rest and hydration breaks are important elements for a safer work environment for employees. An abundance of research-based knowledge is available for training improvements, but safety and health professionals, employers, and educators must know where to obtain information and guidance, how to implement evidence-based practices into workplaces, and how to most effectively educate employees to successfully deter death and illness.

The findings from this study may be beneficial to safety and health professionals and health educators, particularly those interested in assisting oil spill cleanup responders regarding their knowledge and perceptions in handling heat stress while on the job. More emphasis on certain knowledge-related issues is needed, such as acclimatization, use of salt tablets, and differentiating between heat exhaustion and heat stroke. More research is needed to determine knowledge gaps, perceptions, keys to increasing self-efficacy, and barriers at the non-safety and health professional worker level. Workers, particularly those with limited educational backgrounds, and additional vulnerabilities (e.g., immigrant, young, and/or those working for small businesses) may have more deficiencies and variability related to knowledge, perceptions, and barriers of occupational heat stress.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2019.08.002.

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