Comments Submitted by National Heat Safety Coalition (heatsafetycoalition.com) at the Korey Stringer Institute (ksi.uconn.edu), University of Connecticut

Docket No. OSHA-2021-0009
Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings
January 14th, 2022

INTRODUCTION

The National Heat Safety Coalition (NHSC), a branch of the Korey Stringer Institute (KSI) housed at the University of Connecticut, is pleased to submit the enclosed comments on the U.S. Department of Labor, Occupational Health and Safety Administration (OSHA) Advance Notice of Proposed Rulemaking (ANPRM), Heat Injury and Illness Prevention in Outdoor and Indoor Settings.

The KSIwas founded in 2010 in legacy of Korey Stringer, a Minnesota Vikings football player who tragically died from the consequences of exertional heat stroke suffered in pre-season practice. The mission of the KSI is to provide research, education, advocacy, and consultation to maximize performance, optimize safety and prevent sudden death for the athlete, warfighter, and laborer (https://ksi.uconn.edu/annual-report/).

In June 2021, the KSI officially launched NHSC with two key industry partners: Magid (leading personal protective equipment manufacturer) and MISSION (leading cooling gear developer). NHSC is entirely focused on preventing heat-related injuries and fatalities of indoor and outdoor laborers. The new branch of KSI provides heat safety education, research, resources, and heat safety services to businesses to protect their workers from extreme heat. Since NHSC was founded, we have achieved the following key items:

- Published a peer-reviewed, heat safety best practice document entitled, "Heat Safety in the Workplace: Modified Delphi Consensus to Establish Strategies and Resources at the Organizational Level to Protect U.S Workers" in the journal, GeoHealth. Fifty-one heat safety experts and key stakeholders worked together to systematically create 40 recommendations to protect workers from heat-related injuries and illnesses.

- Heat safety assessment conducted for one of the largest appliance manufacturers in the USA
- Serving on the American Society of Safety Professionals (ASSP) subcommittee for the A10.50 Proposed Standard on Heat Stress (Margaret Morrissey)
- Appointed as secretary of the newly created thermal stress working group at American Industrial Hygienist Association (AIHA) (Margaret Morrissey).
- Awarded Harvard-NIOSH Education and Research Center pilot grant (Margaret Morrissey & Douglas Casa).
- Served as expert panelists for Gatorade Sports Science Institute expert panel for physically demanding occupations (Margaret Morrissey & Douglas Casa)
- Assisted Amnesty International in the recent report, "In the prime of their lives: Qatar's failure to investigate, remedy, and prevent migrant workers' deaths". Amnesty International. Retrieved from: https://www.amnesty.org/en/documents/mde22/4614/2021/en/

We sincerely hope our comments will be helpful to OSHA and look forward to continuing to identify strategies to better protect workers from the dangers of heat.

Attachments:

- Occupational Heat Safety Consensus Document
- Effects of Heat on Productivity (Commentary)

Sincerely,

Margaret Morrissey

MARGARET C. MORRISSEY, MS
President, **National Heat Safety Coalition**
Director of Occupational & Military Safety,
Korey Stringer Institute

Douglas J Casa

DOUGLAS J. CASA, PhD, ATC, FNAK, FACSM, FNATA
Chief Executive Officer, **Korey Stringer Institute**
Director, **Athletic Training Education**
Professor, **Department of Kinesiology**
Research Associate, **Human Performance Laboratory**
College of Agriculture, Health & Natural Resources

Responses to ANPRM Proposed Questions

(1) What are the occupational health or safety impacts of hazardous heat exposure?

A. *Heat illness*
   (Casa et al. 2015)
B. *Impaired cognitive, neurological, psychological performance*
   (Hasegawa and Cheung 2013; Gaoua et al. 2018; Piil et al. 2018; Adan 2012; Cian et al. 2001; Calkins et al. 2019; Morrissey, Brewer, et al. 2021)
C. *Kidney injury*
   (Glaser et al. 2016; Hansson et al. 2020; Johnson n.d.; Mix et al. 2018; Nerbass et al. 2017; Yang, Wu, and Li 2020; Butler-Dawson et al. 2019; Aguilar and Madero 2019)
D. *Cardiac strain*
   (Donaldson, Keatinge, and Saunders 2003; González-Alonso, Crandall, and Johnson 2008; Montain and Coyle 1992)
E. *Dehydration*
   (Piil et al. 2018; Cheuvront and Kenefick 2014a; Schlader et al. 2015)
F. *Increased fall, accident, injury risk*
   (Spector et al. 2016; 2019; Calkins et al. 2019; McInnes et al. 2018; Calkins et al. 2019)
G. *Fatigue*
   (Nybo, Rasmussen, and Sawka 2014)

Many of the adverse health and safety outcomes are exacerbated by dehydration, workload and individual characteristics. Figure 4 and Figure 5 in Morrissey, Brewer, et al. 2021) reports worker and work characteristics in combination with heat stress, that can result in physiological, cognitive/psychological, and physical strain (Figure 4). Implementing a heat safety plan can reduce the negative influence of the work environment (and potentially individual characteristics) to result in positive health and safety outcomes while working in the heat.

It is also important to note that various medical conditions are associated with increased risk of heat-related illness fatality. This includes obesity, hypertension, diabetes, cardiac disease, kidney disease (Morrissey et al., 2021; Tustin, Cannon, et al. 2018; Tustin, Lamson, et al. 2018). We recommend reviewing Table 3 and Table 4 in the heat safety in the workplace consensus document (Morrissey et al., 2021) for conditions that increase risk of heat intolerance and indications that place workers at greater risk of heat-related illness.

(2) What sources of data are important to consider when evaluating occupational heat-related illnesses, injuries, and fatalities?

It is important to consider EMS data as many severe injuries and fatalities require the assistance of emergency medical services. NEMSIS (the National Emergency Medical

Services Information System) is a database that collects EMS data from the US and other territories (https://nemsis.org).

Self-reported injury data are important to consider As well. However, the likelihood of workers reporting injuries is dependent on the safety climate within the organization and their commitment to safety, return to work policies, and safety training (Huang et al. 2006).

(3) Beyond the studies discussed in this ANPRM, are there other data that provide more information about the scope and magnitude of injuries, illnesses, and fatalities related to occupational heat exposure?

There are limited studies that share the magnitude of injuries, illnesses and fatalities related to occupational heat exposure.

The article in Washington Center for Equitable Growth, entitled Temperature, Workplace Safety, and Labor Market Inequality (authors: R. Jisung Park, Nora Pankratz, A. Patrick Behrer), reported that approximately 20,000 heat-related injuries were undercounted according to California worker compensation claims ("Temperature, Workplace Safety, and Labor Market Inequality" n.d.; https://www.nytimes.com/2021/07/15/climate/heat-injuries.html).

Other articles regarding heat-related injuries, illnesses, and fatalities include (Calkins et al. 2019; Spector et al. 2016; 2018; Lee et al. 2019; McInnes et al. 2018; Butler-Dawson et al. 2019).

(4) Are there quantitative estimates of the magnitude of occupational illnesses, injuries, and fatalities related to hazardous heat, beyond what is described in this ANPRM?

See articles included in question 3.

(5) Are there quantitative estimates or other quantitative or non-quantitative examinations of the magnitude of underreporting of occupational illnesses, injuries, and fatalities related to hazardous heat?

To our knowledge, there are very few research articles that provide information on underreporting of occupational heat-related illnesses injuries, and fatalities. One article, as mentioned previously, is the article described in question three: .

Temperature, Workplace Safety, and Labor Market Inequality." n.d. *Equitable Growth* (blog). Accessed October 29, 2021. https://equitablegrowth.org/working-papers/temperature-workplace-safety-and-labor-market-inequality/.

Importantly, there are recent reports through Human Rights Watch, FairSquare and Amnesty International advocating for better protection of vulnerable workers due to devastating heat-related fatalities that occur(ed) in migrant workers and extremely high heat stress exposure levels in the Arabian Gulf peninsula. Specifically, the report by Amnesty International (https://www.amnesty.org/en/latest/news/2021/08/qatar-failure-to-investigate-migrant-worker-deaths-leaves-families-in-despair/), reveals the exploitation that the Qatar government has had over migrant workers after announcing that Qatar won their bid to become the 2022 World Cup host. This bid requires significant physical labor in extremely hot conditions to build the world cup facilities (resulting in the recruitment many migrant workers to work in Qatar as construction workers). It is also extremely difficult to precisely quantify how many deaths in Qatar result from heat as Qatar does not adequately investigation and certify deaths. Many of the young migrant men that died on the construction site had death certificates that state, "natural causes". Moreover, the ILO estimated that most deaths from work-related accidents and diseases occur not from industrial accidents (14%) but from diseases or illnesses contracted as a result of exposure to risk factors arising from work (86%). KSI has had the opportunity to collaborated with Human Rights Watch, FairSquare and Amnesty International to support migrant workers and advocate for better protection of worker at risk of intense heat and humidity and lack of heat safety regulations.

Human Rights Watch Report:
https://www.hrw.org/sites/default/files/media_2021/01/2021_hrw_world_report.pdf

There is also a publication in Cardiology in June 2019 looking specifically at the impact of heat stress on mortality statistics in Nepali migrant workers in Qatar. There was a strong correlations between monthly WBGTmax and death rate due to cardiovascular causes (42% of Nepali workers in Qatar) and the death rate in to 58% (from 22%) in the hot months of the year.

(5) What factors lead to the underreporting of occupational heat related illness, injuries, and fatalities of which OSHA should be aware?

As described in question 4, exploitation of labor contributes to underreporting of occupational heat related injuries, illnesses, and fatalities.

Absence of trained medical professionals on-site may lead to underreporting. Although there are several big corporations that have medical centers on site, many outdoor settings or small businesses do not have access to medical professionals. Moreover, medical professionals must be appropriately trained to recognize the signs and symptoms of all heat-related illnesses. There must be a clear distinction between heat exhaustion and heat stroke (heat stroke being a life-threatening medical emergency). Medical professionals can also distinguish over differential diagnoses such as rhabdomyolysis, orthostatic hypotension, vasovagal reflex, traumatic head injury, hyponatremia, diabetic emergency, or hemorrhage.

The description of categories for severe injuries related to heat from the Bureau of Labor Statistics are listed below (Table 2) . If medical professionals, safety managers, and/or industrial hygienists do not clearly understand the distinction between heat stroke, heat syncope, heat fatigue, heat exhaustion, the injury or death could be coded incorrectly. To appropriately code the condition, the narrative descriptions of the event must be described in detail and reviewed by a medical professional.

Table 2. Definitions for Heat-related Severe Injury Categories*

Definition	**Description**	
	Includes	**Excludes**
Effects of Heat and Light Heat Stroke Heat Syncope Heat fatigue Heat exhaustion Multiple effects of heat and light Effects of heat and light, n.e.c	heat stroke (1721); heat apoplexy (1721); heat exhaustion (1725); heat pyrexia (1721); ictus solaris (1721); fainting and loss of consciousness associated with heat (1722); siriasis (1721); sunstroke (1721); thermoplegia (1721); heat fatigue including transient (1723); fatal hyperthermia (1721); dehydration resulting from heat exposure (1729)	fainting and loss of consciousness without reference to heat (5111); sunburn—first degree or degree unspecified (1591); heat burns (152); prickly heat (2893); heat rash (2893); miliaria rubra (2893)

Athletic trainers are important medical professionals to consider when integrating a medical professional into the business. These healthcare professionals are extensively trained in acute and chronic injury, rehabilitation, and can create emergency action plans related to medical emergencies.

Lastly, employees are significantly less likely to report occupational injuries if they are being paid based on a piece-pay structure(Davis 2016). Employees are less likely to report signs and symptoms of heat-related injuries and illnesses if they are getting paid based on the amount they produce. Reporting an injury or illness may remove them from the job and impact their pay.

(6) What datasets are available to address some of the limitations associated with the underreporting of occupational heat-related illnesses, injuries, and fatalities?

To our knowledge, there are no databases that address limitations associated with underreporting.

Resources that can be used include the Amnesty International report. Moreover, educational materials such as https://ksi.uconn.edu/emergency-conditions/heat-illnesses/exertional-heat-stroke/heat-stroke-resources/, can provide insight on the differences among heat-related illnesses to allow for better characterization of each injury/death.

(7) Are there industries, occupations, or job tasks that should be considered when evaluating the health and safety impacts of hazardous heat exposure in indoor and outdoor work environments? Please provide examples and data.

There is a significant gap in knowledge regarding specific industries, occupations, or job tasks that experience high levels of heat stress.

Any occupation that is required to perform physical activity in the heat and/or in heavy/insulating personal protective equipment should be considered. Many indoor occupations or jobs such as steel workers, factory workers, jobs near radiant heat sources (i.e., furnaces) are often overlooked since they are not directly exposed to solar radiation. Equipment within a manufacturing facility and produce significant heat and many of the huge plants cannot provide adequate cooling solutions for their workers given the size of the facility. It is important to also recognize that there are typically specific sections within the indoor work setting, that experience more heat strain than others. For examples, areas with furnaces are more likely to experience heat stress than ones that do not (or have significant air movement)("Heat - Overview: Working in Outdoor and Indoor Heat Environments | Occupational Safety and Health Administration" n.d.).

Moreover, although physical exertion is critically important when characterizing level of exposure to heat stress, the work intensity categories created by governing bodies are often difficult to interpret and assess(Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner 2016). Especially for safety personnel who may not have been trained in thermal physiology. Also, the physical demands of many occupations and jobs task have not been adequately defined. This is a huge limitation for heat safety stakeholders as there could be many industries, occupations, and job tasks overlooked simply because they were not evaluated.

Research initiatives must quantity the physical demands of the job, the level of environmental heat stress (through environmental monitoring metrics such as ambient temperature, humidity, WBGT, wind speed) and influence of personal protective equipment.

8) Are there any industries, occupations, or job tasks that are facing changes in the rate or frequency of occupational heat-related illness? Please provide examples and data.

Unfortunately, due to lack of funding, there are no studies that allow for evaluation of rate or frequency of occupational-heat-related illnesses over time. There must be a large initiative to collect this data in order to make the comparisons among industries, occupations, or job tasks.

(9) In addition to traditional work arrangements, are there specific types of work arrangements or multi-employer work arrangements that should be considered when evaluating the health and safety impacts of hazardous heat exposure in indoor and outdoor work environments?

Work arrangements that require workers to be in the heat for prolonged periods (>5 hours) should be considered(Tustin, Cannon, et al. 2018; Notley, Flouris, and Kenny 2019). Many workers are required to work for 8 hours a day for multiple consecutive days, which increases their risk of heat-related injury and illness(Notley et al. 2018). Work arrangements where workers are required to perform unaccustomed, heavy physical work in the heat or in personal protective gear should be considered. Lastly, work arrangements that allow for job rotation (ex. Working in fields or groves and rotating into processing area) must be considered as they often allow for reduced exposure to heat stress.

Comparisons between different work arrangements or multi-employer work arrangements have not been specifically studied.

(10) What are current and best practices for protecting workers in various types of work arrangements, including temporary and multiemployer work arrangements, from hazardous heat exposure?

Current best practices for protecting workers in various work arrangements can be found in Morrissey et al. (2021) Heat Safety in the Workplace: Modified Delphi Consensus to Establish Strategies and Resources to Protect US Workers. GeoHealth https://doi.org/10.1029/2021GH000443. This document is an open access, consensus document created to develop feasible, evidence-based, occupational heat safety recommendations to protect US workers that experience heat stress. An interdisciplinary roundtable comprised of 51 experts (scientists, representatives from governing bodies, worker health and safety advocate, safety managers, and clinicians) united to form 40 recommendations related to heat hygiene (methods to improve heat tolerance), hydration, heat acclimatization, environmental monitoring, physiological monitoring, body cooling, textiles and personal protective gear, and emergency action plan implementation. Each of the 40 recommendations were scored using a rigorous, systematic method called the Delphi method. Each recommendation was accepted into the final manuscript if they met the threshold for feasibility, clarity, and scientific evidence (Morrissey et al., 2021).

Table 2 from this document describes each recommendation.

(11) What are current challenges in and limitations of protecting workers in various types of work arrangements, including temporary and multiemployer work arrangements, from hazardous heat exposure?

One major limitation of protecting workers in various types of work arrangements is that they do not always perform the same work every day. These workers wear “different hats “depending on the objectives of the project they are working on and are required to perform work they are not accustomed to. Performing unaccustomed work in the heat can increase risk of heat-related injuries and illnesses(Casa et al. 2015). The degree to which their work changes is dependent on the size of their corporation. Workers in small corporations may be more likely to change job tasks frequently compared to larger corporations.

(12) How are employers in businesses of various sizes currently preventing heat-related injury and illness in workers?

We are not aware of any systematic research studies that evaluate how employers of various sized companies currently prevent heat-related injuries and illnesses in workers.

However, based on our extensive interactions with corporate businesses, there is little being done to address heat-related injury and illness. There also appears to be a gap in education of heat-related illness signs and symptoms.

(13) Are there limitations or concerns in preventing heat-related injury and illness in workers that vary among businesses of various sizes?

Concerns related to preventing heat-related injury and illness in small businesses is that many small businesses do not have the resources to provide heat safety training or implement heat stress mitigation strategies. Moreover, many do not have access to medical professionals who are trained to treat heat-related injuries and illnesses.

(14) How does geographic region contribute to occupational heat hazards and the outcomes experienced by workers? Please provide examples and data.

Risk of heat-related *occupational* injuries and illnesses across different geographic regions of the US has not been fully examined. There has been research within specific regions on the US examining symptoms of occupational heat illness (Mirabelli et al. 2010; Culp and Tonelli 2019; Kearney et al. 2016) and physiological responses in US workers, but not regional comparisons of outcomes experienced by workers. It is very important to recognized that current work to rest ratios based on WBGT (ACGIH, NIOSH) do not have regionally specific heat safety thresholds. We should not be taking a “one size fits all” approach for activity modification across the US as it does not account for regional variations in acclimatization to heat(Grundstein et al. 2015). For example, physiological responses such as sweat rate are different in those who are acclimatized to hot-humid climates compared to hot-dry climates.(Grundstein et al. 2015; Fox et al. 1963). Outdoor workers in northern states will be less acclimatized to the same WBGT as workers in southern states (as southern states likely exposed to heat more frequency for longer durations). Outdoor workers in northern states would therefore be at more at risk for exertional heat illnesses compared to southern states(Carter et al. 2005).

It is important to recognize that indoor environments that experience heat stress may or may not be seasonal. Therefore, heat stress mitigation must be considered through out the year.

Moreover, Vanos & Grundstein (2020) revealed that a human heat stress model from 15-year hourly WBGT dataset from 217 stations across the contiguous United States reported differences in potential heat loss between hot-dry vs. warm-humid environments. Specially, potential heat loss was consistently greater in hot-dry than warm-humid despite equal WBGTs(Vanos and Grundstein 2020).

Grundstein et al. (2015) identified 3 different regions of the contiguous US that experiences regional differences in heat exposure. Categories were identified based on the extreme WBGT within the location. Categories can be found in Grundstein et al. (2015) figure 2.

Category 1: Pacific Coast, New England, the northern tier of the country
Category 2: extends in an arc from the interior Northwest through Nevada, portions of the Midwest, northern Ohio valley and the northeast.
Category 3: Much of the southeastern quadrant of the US with portions of New Mexico, Arizona, and central valley California.

(Grundstein et al. 2015)
Grundstein et al. (2015) revised American College of Sports Medicine (ACSM) heat safety threshold guidelines based on the extreme WBGT located within each region.

(15) Are there regions with improving or worsening occupational heat hazards and associated outcomes? Please provide examples and data.

Although climate change projections reveal that heat exposure will increase across the globe (Gao et al. 2018; Hayhoe et al. 2008; Gubernot, Anderson, and Hunting 2014; Day et al. 2019), Weatherly & Rosenhaum (2017) reported that the greatest increase across the contiguous US was in the southern United States for both maximum and minimum daily WBGT. Changes in relative humidity also have a substantial impact on WBGT, which results in approximately 2.5 additional days with high WBGT for each 1% increase in RH.(Weatherly and Rosenbaum 2017).

Importantly, regions with non-US citizens are more likely to experience heat-related deaths than US citizens(“Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed” n.d.; Vega-Arroyo et al. 2019; Mitchell et al. 2017; S. C. Moyce and Schenker 2017; S. Moyce et al. 2016; Sugg, Fuhrmann, and Runkle 2018). Taylor et al. (2018) reported that heat-related deaths accounted for 2.23% (n = 999) of deaths among non-US citizens and 0.02% (n = 4196) of deaths among US citizens. The age-adjusted standardized mortality ratio for non-US citizens compared with US citizens was 3.4 (95% confidence ratio [CI] = 3.2, 3.6). This risk was higher for Hispanic non-US citizens (risk ratio [RR] = 3.6; 95% CI = 3.2, 3.9) and non-US citizens aged 18 to 24 years (RR = 20.6; 95% CI = 16.5, 25.7) (“Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed” n.d.).

(16) Do regions with traditional and pervasive heat hazards address the hazard differently than regions with more episodic exposures (e.g., heat waves in a normally temperate region)?

(17) What regional differences should be considered or accounted for when determining the appropriate interventions and practices to prevent heat-related injuries and illnesses among workers?

Differences in the climate and the nature of work (ex. outdoor, indoor, industry, duration of work must be considered. Also, workers who are vulnerable (i.e., low economic status, social vulnerability, diseased workers, migrant workers, women, disparities in access to health care, unknown personal health status) and cultural differences across regions must be considered (S. Moyce et al. 2016; S. C. Moyce and Schenker 2017; "Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed" n.d.). In summary, "prevention strategies for heat stress much consider local and global climate disparities, community and stakeholder participation, and tailoring of prevention approaches to specific local work settings" (Spector et al. 2019).

(18) Are there specific populations facing disproportionate exposure to or outcomes from hazardous heat in indoor or outdoor work settings? Please provide examples and data.

Non-US citizens are more likely to experience heat-related deaths than US citizens("Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed" n.d.; Vega-Arroyo et al. 2019; Mitchell et al. 2017; S. C. Moyce and Schenker 2017; S. Moyce et al. 2016; Sugg, Fuhrmann, and Runkle 2018).

The age-adjusted standardized mortality ratio for non-US citizens compared with US citizens was 3.4 (95% confidence ratio [CI] = 3.2, 3.6). This risk was higher for Hispanic non-US citizens (risk ratio [RR] = 3.6; 95% CI = 3.2, 3.9) and non-US citizens aged 18 to 24 years (RR = 20.6; 95% CI = 16.5, 25.7)("Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed" n.d.).

Union status should also be considered as those that are non-unionized are at greater risk than unionized workers("Employee and Union Inputs into Occupational Health and Safety Measures in Chinese Factories - ScienceDirect" n.d.). To our knowledge, there no epidemiological studies that examine union status and impact of heat related injury, illness, and fatality.

(19) Are there data sources available to assess inequalities in exposure to or outcomes from hazardous heat in indoor or outdoor work settings?

Non-US citizens are more likely to experience heat-related deaths than US citizens(“Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed” n.d.; Vega-Arroyo et al. 2019; Mitchell et al. 2017; S. C. Moyce and Schenker 2017; S. Moyce et al. 2016; Sugg, Fuhrmann, and Runkle 2018).

However, to our knowledge, there are no research on the distinction between indoor or outdoor work settings and inequalities.

(20) Are there industries or employers who are addressing occupational heatrelated illness with an environmental justice approach (i.e., with a focus on fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income) to appropriately address the disproportionate exposures and outcomes faced by workers of color, low-wage workers, immigrant workers, or pregnant workers (NIOSH, April 20, 2017)? Please provide examples and data

We are not aware of industries or employers addressing occupational heat-related illness with an environmental justice approach.

However, based on our extensive interactions with corporate businesses, there appears to be limited work being done to address heat-related injury and illness with an environmental approach.

(21) Are there data sources available to assess how climate change is altering hazardous heat exposure in outdoor and indoor work environments?

The following citations can be utilized to see how climate change can increase risk to heat-related injuries and illnesses:

(Gao et al. 2018; Glaser et al. 2016; Day et al. 2019; Hayhoe et al. 2008; Josh Foster et al. 2021; Heidari et al. 2019; Tord Kjellstrom et al., n.d.; T. Kjellstrom et al. 2014).

(22) How will climate change affect existing inequities in occupational heat exposure and related health outcomes? Please provide relevant data.

Climate change will have a disproportionate impact on different groups within the US. Those that experience social inequality (low income, few assets) and spatial inequality will be at greater risk for the adverse effects of climate change. The October 2017 DESA Working Paper No. 152 provides a summary of climate change and social inequality(“Climate Change and Social Inequality | UN Department of Economic and Social Affairs (DESA) Working Papers | OECD ILibrary” n.d.)**.**

(23) How will climate change affect the risk of occupational heat-related illness and mortality in the different regions of the United States?

As our changing climate continues to get hotter, the number of heat-related injuries, illnesses, and fatalities are projected to increase if no effective heat safety mitigation plans are set in place(“Climate Change, Health and Safety of Workers in Developing Economies: A Scoping Review - ScienceDirect” n.d.; T. Kjellstrom et al. 2016; Flouris et al. 2018; Tord Kjellstrom, Holmer, and Lemke 2009; Tord Kjellstrom et al. 2018). Ansah et al. (2021) reported in a review of 334 studies that there is a link between climate change and injuries, fatigue, exhaustion, psycho-logical stress, cardiovascular and respiratory issues, chronic illnesses including cancer and kidney diseases and in extreme cases, death to workers.

(24) How should climate change be factored into an OSHA heat illness and injury prevention standard?

Policy makers and employers implementing prevention strategies to reduce risk of heat stress must be aware that as the climate continues to change, our policies and procedures must change along with it. Therefore, thresholds chosen to initiate heat safety programs may change.

(25) What efforts are employers currently taking to prepare for and respond to the ways that climate change is altering hazardous heat exposure in their workplaces?

We are not aware of industry or employer efforts to prepare for. And respond to ways climate change is altering hazardous heat exposure in their workplace.

However, based on our extensive interactions with corporate businesses, these efforts appear to be limited.

(26) Are OSHA’s existing efforts and authorities adequate or effective in protecting workers from hazardous heat in indoor and outdoor work settings?

OSHA’s current efforts to protect workers from the dangers of heat stress are not adequate and too general to provide effective (and feasible) solutions across all industries that experience heat stress. Utilizing the General Duty Clause as a protective measure against heat stress promotes ambiguity and hinges on the employer’s interpretation of providing “a place of employment which are free from recognized hazards”. In some cases, employers may not see heat stress as a hazard. Moreover, we do not have adequate evidence to determine the level of heat exposure of each industry. To provide effective solutions, the physical demands of the work must be quantified (i.e., OSHA and employers must know what recognized heat hazards they are up against), extensive environmental monitoring must occur, and workers at greater risk of heat-related injuries and illnesses must be identified. Morrissey et al. (2021) serves as a foundation to build best practice recommendations that are evidence-based and feasible. Specific best practices for each occupation and corresponding industry must be created to better protect all workers(Morrissey et al., 2021).

(27) What additional efforts or improvements should be undertaken by OSHA to protect workers from hazardous heat in indoor and outdoor work settings?

A. Acknowledgement of Athletic Trainers as health care provider in OSHA standard

29 CFR 825.125 does not explicitly state athletic trainers as healthcare providers. OSHA must consider explicitly stating athletic trainers as medical professionals given their expertise in:

1. Injury and Illness Prevention and Wellness Promotion
    - Can identify risk factors for injury and illness through assessments, pre-work participation examinations, other screening instruments, and reviewing injury surveillance data or individual medical histories.
    - Ability to implement risk management and reduction plans based on applicable guidelines
    - Provide education of risk factors for heat-related injuries and illnesses (along with other injuries/illnesses)
    - Provide safety (injury and illness) monitoring in various environmental conditions
    - Optimize wellness through wellness program

2. Physical Examination, Assessment and Diagnosis

    - Collect workers' history through interview, observation, or relevant records
    - Perform physical examinations which includes diagnostic testing
    - Formulate a clinical diagnosis through interpretation of medical history, physical exam, and signs/symptoms of injures, illnesses or other conditions.
    - Educate workers or appropriate personnel on clinical findings, prognosis, and plan of care

3. Immediate and Emergency Care
    - Establish emergency action plans to guide response to catastrophic events and increase likelihood of positive outcome
    - Implement emergency and immediate care to reduce risk of death
    - Implement referral strategies to facilitate timely transfer of care
    -
4. Therapeutic Intervention
    - Optimize worker clinical outcomes by developing, evaluating, and updating plan of care
    - Educate workers on information to optimize treatment and rehab
    - Administer therapeutic devices using appropriate techniques and procedures to aid recovery
    - Administer therapeutic interventions for general medical conditions

- Determine workers' function state and time frame when they can return to work
- Create return to work plans for each injured worker

5. Health Care Administration and Professional Responsibility
    - Develop policies, procedures, and strategies to address risk and organizational needs
    - Use established documentation procedures to ensure best practice

B. Revision of body cooling from first aid to medical treatment

According to 1904.7(b)(5)(ii)(E), using hot or cold therapy is considered first aid, and therefore, not reportable. The gold standard treatment for exertional heat stroke is cold water immersion, which is a form of body cooling. According to this regulation, cold water immersion would not be considered medical treatment when it is in fact the gold standard medical treatment.

C. Heat Safety Onboarding Training

Employees should be extensively educated on the signs/symptoms of heat-related illnesses, prevention strategies, and exertional heat stroke treatment during the on-boarding process. This will also inform employees that heat safety is a priority for the employer.

D. Use Physical Exam or Medical Screening for Education.

Biometric screening and/or physical examinations should be performed to assess the risk factors that increase risk of heat-related injuries and illnesses. Healthcare providers should use the employee's screening to educate them if they have any risk factors associated with their ability to tolerate heat.

E. Checklists, Surveys, Signage to Check Health Status.

There should be health status checks that assess whether the worker is at risk of heat-related illness. Some indications may increase risk but may not require consultation from a medical professional. However, there are some indications that should be recognized AND require workers to consult with a medical professional as it would be dangerous to partake in the work shift with the conditions. The table below, [Table 4 in (Morrissey et al., 2021)] highlights indications that are at greater risk of heat-related illness as well as indications that require consultation with a medical professional.

NHSC recommended daily heat readiness checklist*

The presence of any of the following indications may place you at greater risk of heat-related illness:

- **Dehydration**
- **Lack of sleep**
- **Fatigue or lack of recovery from the previous day**
- **Gastrointestinal discomfort**
- **Not recently eaten or in a fasting state**
- **Psychological stress**

The presence of any of the following indications may place you at greater risk of heat-related illness AND require consultation with medical supervisor before partaking in the work shift:

- **Signs and symptoms of infection/illness (e.g., common cold, flu, sinusitis)**
- **Fever**
- **Diarrhea**
- **Vomiting**
- **Medications that affect thermoregulation, central nervous system function, sodium balance**

*Table 4 from (Morrissey et al., 2021)

D. **Consider Language Barriers.**
As many workers do not speak English (or English is not their first language), it's important to have strategies for these individuals to communicate with supervisors during an emergency. All resources should be translated into workers' primary languages or OSHA should provide services to do so.

E. Mandate Environmental Monitoring

OSHA should require that all workplaces perform environmental monitoring. Environmental measurements for heat stress assessment should account for the influences of air temperature, humidity, wind speed, and radiant heat. Indices that incorporate or integrate the individual measurements can be used for heat stress assessment (e.g., wet bulb globe temperature, WBGT).

As the environmental conditions within the worksite differ based on the location, it is critically important to measure all locations. WBGT monitors should be placed (on a stand or attached to the wall) at all the heat vulnerable locations so that continuous monitoring can occur throughout the day. For example, WBGT monitoring can be sent to another device such as an IPad through Bluetooth, which can then alert the employer when there are unsafe working conditions.

Moreover, to ensure the accuracy of measurements from portable environmental sensors (i.e., portable WBGT monitors), employers MUST follow manufacturer specifications for set up, equilibration (i.e., time for the sensor to adjust to ambient conditions), and calibration. If this is not performed, you will have little confidence in the integrity of the data.

F. Weather Forecasting for Heat Stress Preparation.

To effectively prepare for the environmental conditions, it is important for safety personnel to monitor projected extreme temperatures and heat waves. Identifying extreme heat events in advance will allow for better preparation of heat mitigation strategies to improve health, safety, and productivity outcomes. www.weather.com is a popular website that can be utilized for weather forecasting. Weather forecasting does NOT replace environmental monitoring that must occur on site (as close to the site as possible).

G. Mandate Accessibility and Availability to Hydration Solutions

Employers should be required to provide cool, potable water to prevent dehydration. To effectively do so, employers should develop fluid replacement strategies that account for individuals needs of the worker and the conditions of the workplace. The intensity of work, duration of work, environmental conditions and frequency of rest breaks must be considered. Hydration education should also be included in onboarding and annual training.

H. **Promote "Field" Assessment of Hydration Status Before, During, and After Work. Recommend Validated Urine Color Chart and Other Methods of Assessment.**

Simple and Practical Hydration Assessment Techniques

Body Weight: Acute changes in hydration can be calculated by the difference in pre- and post-physical activity body weight. For example, if a worker steps on the scale before the work shift and steps on the scale again following the work shift (or break), he or she will be able to calculate how many kilograms of body water was lost to sweating. They should step on the scale immediately following activity as fluid intake and urine/fecal losses will alter this measure. One kilogram of body weight lost (or gained) equates to one liter of fluid. The greater the difference between pre- and post-values, the greater the level of dehydration. The level of dehydration can be described as a percent of the pre-body weight value (Percent of body weight lost= pre-weight / post-weight).

For work conditions that require PPE that have high sweat saturation within the fabric (i.e., the fabrics cause heavy absorption of sweat), differences in pre-shift weight and next pre-shift weight should be considered as well.

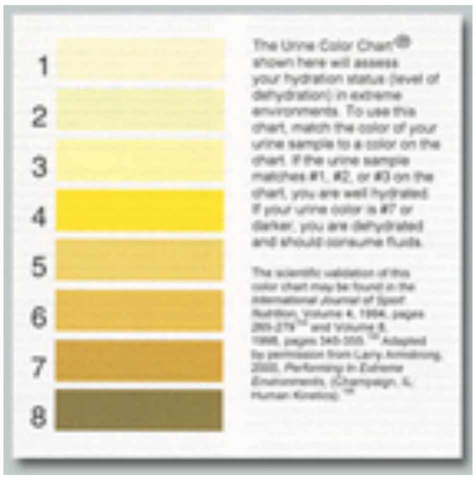
<u>Example of Body Weight Loss Calculations for pre-post calculation</u>

72.90 kg before first rest break
71.80 kg after first rest break

72.90-71.80kg= 1.1kg = 1.1 liters lost
72.90/71.80kg = 1.01% body weight lost

Pound (lbs) to kilogram (kg) conversion: 1 lbs / 2.2 kg = X kg

Urine Color: A the urine color chart can be used to estimate hydration status. Dr. Lawrence Armstrong created a validated, 8-point urine color scale to estimate hydration levels (picture below). Pale yellow or "straw-colored" urine indicates that you are adequately hydrated. The darker the urine, the more at risk you are for dehydration.



Urine Color Chart (found at www.hydrationcheck.com)

How to Use the Urine Color Chart

Scores	Indication
1,2,3	Well hydrated
4	Normally hydrated or slightly dehydrated
5,6	You are dehydrated
7, 8	You are extremely dehydrated

Employers should hang urine color charts in each restroom stall for workers to assess their urine color and increase (or decrease) fluid intake depending on the score.

Urine Output: More urine is typically produced when adequately hydrated and less urine is produced when dehydrated. Therefore, a reduction in daily urine frequency (how often you urinate) may be an indicator of dehydration (at least 5 voids a day).

Thirst: When in a dehydrated state and body water content is low, fluid regulatory mechanisms in the body will initiate sensation of thirst as a signal to consume more fluids. If you are thirsty, you are ALREADY dehydrated!! It is important to note that the absence of thirst does not indicate the absence of dehydration.

I. Mandate Heat Acclimatization Program

Heat Acclimatization is defined as repeated bouts of physical activity in a hot environment that induce physiological adaptations that reduce strain and improve thermal tolerance during physical activity (Périard, Racinais, and Sawka 2015; L. E. Armstrong and Maresh 1991). As heat-related injuries and illnesses typically occur within the first three days of work(Tustin, Cannon, et al. 2018; Tustin, Lamson, et al. 2018). Employers should create and implement a gradual, progressive heat acclimatization program to minimize the effects of heat stress (programs must be tailored to the demands of the work, environmental conditions, and occupation). Any worker returning to work following a prolonged absence must perform heat acclimatization prior to returning to normal working hours (and working procedures)(Morrissey et al., 2021).

J. Mandate Emergency Action Plan and Emergency Procedures for Exertional Heat Stroke and Exertional Heat Illnesses

Employers must have a written emergency action plan in place to treat an exertional heat stroke patient. This emergency action plan must be created with a healthcare professional, provided to all workers, and rehearsed.

For the emergency procedures for exertional heat stroke, the only way to **accurately** diagnose EHS is through internal core temperature (core temperature greater than or equal to 104-105°F)(Casa et al. 2015). It is important to distinguish whether it is an exertional heat stroke since when a patient collapses, the clinician's differential diagnoses may include several different injuries including traumatic heat injury, hyponatremia, diabetic emergency, exertional sickling, hemorrhage or EHS. To effectively treat a EHS patient, they MUST have their body temperature down to normal values within 30 mins. The gold standard treatment for EHS is whole-body cold water immersion. OSHA must require employers to have equipment required for recognition and treatment of EHS to ensure they are prepared for this heat emergency. The equipment includes a rectal thermometer, 100-gallon industrial tub, ice, bed sheet or large towel for privacy, and towels for placement over the heat and neck.

OSHA and employers should consider athletic trainers as medical professionals for recognition and treatment of exertional heat stroke and all other medical emergencies. Athletic trainers are trained to not only use best practices to treat patients, but they are trained to create, implement, review, and educate on emergency action plans, implement return-to-work protocols, perform therapeutic interventions, physical exam, assessments, and diagnoses and injury and illness prevention and wellness promotion (review question 28).

K. Recommend Body Cooling Strategies

OSHA should recommend the use of body cooling strategies to reduce the risk of heat-related injuries and illnesses(Adams et al. 2016; DeMartini et al. 2011; McDermott et al. 2009; Hosokawa et al. 2017; Bongers, Hopman, and Eijsvogels 2017; M. Brearley 2016; Chicas et al. 2020).

Table 6, Table 7, and Figure 3 in Morrissey et al. (2021) GeoHealth illustrates what body cooling strategies can be used (cost, effectiveness, and special considerations) and what equipment may be required to implement certain body cooling strategies.

(28) What are the gaps and limitations of existing applicable OSHA standards, as well as existing campaign, guidance, enforcement, and other efforts for preventing occupational heat-related illness in indoor and outdoor work settings?

Please review all recommendations listed in questions 28. There are also several gaps/limitations that must be reiterated:

A. Best practice recognition and treatment of exertional heat stroke (core temperature assessment, whole body cold water immersion, cool first, transport second)
B. Cold water immersion is not considered a medical treatment according to 1904.7(b)(5)(ii)(e). It must be considered a reportable medical treatment.
C. Recommendation for medical staff (such as athletic trainers) to be on site to treat and recognize medical emergencies
D. Recommendations for how to appropriately implement a heat acclimatization program
E. Effectiveness of body cooling strategies to reduce risk of heat-related injuries and illnesses
F. Industry and Occupation specific recommendations to reduce risk of heat-related injuries and illnesses. It is extremely important to note that we need more research to quantify the level of heat strain experienced by workers in various occupations and need to assess their current strategies (if any) to implement an effective heat safety plan.
G. Recommendation for medical staff such as athletic trainers to be on site or accessible via telehealth or provide consultation regarding environmental conditions, assess symptoms, and to make appropriate referrals as necessary.

(29) What are the most effective aspects of existing state standards aimed at preventing occupational heat-related illness?

Any heat stress management program that utilizes environmental monitoring to define work to rest ratios, has hydration strategies, a heat acclimatization program, body cooling strategies, medical professionals on site or nearby (that can perform emergency care of exertional heat stroke), has heat stress PPE, and emergency action plans in place are the most effective(Morrissey et al., 2021).

(30) What are the challenges with the implementation of existing state standards aimed at preventing occupational heat-related illness?

A major challenge is that there is little research that identifies the effectiveness of existing state standards and their ability to prevent occupational heat-related illness.

(31) Of the existing state standards, have any been more effective or challenging in their implementation than others? Why?

(32) What components of a state standard or program should be included in Federal guidance or regulatory efforts on heat-related illness prevention?

(33) Would any of the elements of the state standards not be feasible to include at the Federal level?

(34) Do any of these existing standards contain elements that should be considered for a Federal standard?

(35) Are there other industry standards that contain elements that should be considered for a Federal standard?

(36) Are there elements of these standards that would not be appropriate or feasible for a Federal heat standard?

(37) What efforts are employers currently taking to prevent occupational heat-related illness in their workplace? Please provide examples and data.

Information regarding the efforts of employers to prevent occupational heat-related illnesses are limited and/or anecdotal-there are currently no research initiatives that focus on quantifying this. Some employers have performed environmental monitoring on-site (best practice), provided hydration solutions, body cooling, and/or extended rest breaks (however, we do not know how many across the US).

.

(38) How effective have employers been in preventing occupational heatrelated illness in their workplaces, and how are employer-driven heat injury and illness prevention programs being evaluated?

There is limited to no research on the effectiveness of employer-driven heat injury and illness prevention programs. Here is one reference: (McCarthy, Shofer, and Green-McKenzie 2019).

(39) What metrics are currently being used to monitor and assess hazardous heat exposure in the workplace (e.g., heat index, ambient temperature, WBGT)?

Although there are no large-scale investigations that quantify which environmental monitoring metric is being utilized to assess heat stress, heat index, ambient temperature, and WBGT are the most common. We must perform large scale survey-based research to determine what metrics industries are currently using and what would be the most effective metric dependent on the industry and environmental conditions.WBGT is considered the industrial standard for environmental monitoring(Bernard et al. 2005; 2008; Budd 2008). The table below is from Morrissey et al. (2021) GeoHealth, which provides the advantages or disadvantages of heat stress metrics.

*basic rational index simplified from its original version (apparent temperature) and derived from only air temperature and humidity in its current form

(40) What are the advantages and disadvantages of using each of these metrics (e.g., heat index, ambient temperature, WBGT) in indoor and outdoor work settings? Are there any

Monitoring Weather Variables		Advantages	Disadvantages	
Location	On-site with portable weather sensor at 1.1m height	Best represents workers' environmental conditions; provides accurate classification of heat exposure	Cost of portable sensor, maintenance, ease of use	
	Off-site weather station observations or model output	Low-cost/free, ease of use via apps	May not be representative of local conditions, leading to misclassification of heat exposure	Interpolate values
Indices calculated from environmental measures	WBGT **Industry Standard**	Combines multiple meteorological variables for a more comprehensive heat stress measure	Monitoring equipment costs; lower-cost equipment may be less accurate.	Must account for acclimatization; r
Indices calculated from heat balance models	Heat Index*	Simple to determine; widely available; widely used unit; broadly known	Solar, clothing, and activity assumptions not representative of most working conditions; does not work in very dry climates (avoid use).	Add solar factor a rate and clothing
	UTCI	Publicly available version (regressions) simple to determine, widely used unit (°C). Accounts for the full environment	Built to assess thermal stress in average person; not developed for working population; does not yet have adjustments for metabolic rate.	Clothing is adapte (0.30–2.6clo rang
	PET	Publicly available software easy to us, widely used unit (°C). Accounts for the full environment Use mPET if making calculations for workers.	Built to assess thermal comfort for average person; assumes "light activity" and not moving with constant clothing (0.9clo). cannot modifying clothing or MET	

challenges associated with training employers and employees on these different metrics?

Question 39 includes table 5 from Morrissey et al. (2021) GeoHealth. This table describes the advantages and disadvantages of various environmental monitoring metrics. (Morrissey et al., 2021)

(41) Are there other metrics used to assess hazardous heat exposure in the workplace that are not discussed here?

There are other metrics that are calculated from heat balance models. There is UTCI (universal thermal climate index) and PET (physiological equivalent temperature) as examples (see table 5 above). These metrics account for nonenvironmental factors such as metabolic demands and clothing. UTCI is a human model that predicts thermoregulatory responses involved in heat balance under different environmental conditions (Blazejczyk et al. 2013) Similarly, PET uses an energy balance model to predict thermoregulatory responses("The Physiological Equivalent Temperature – a Universal Index for the Biometeorological Assessment of the Thermal Environment | SpringerLink" n.d.)

(42) What are current and best practices in defining hazardous heat exposure in outdoor and indoor workplaces, and what are the limitations or challenges associated with those practices?

ENVIRONMENTAL MONITORING (Morrissey at al. 2021 GeoHealth)
#1: Environmental measurements should be taken on-site—as close to the individual work site as possible—to best represent environmental heat stress.
#2: Comprehensive heat stress assessment and associated interventions should include information on ambient environmental conditions, work demands, clothing, personal protective equipment, and worker heat acclimatization status.
#3: Environmental measurements for heat stress assessment should account for the influences of air temperature, humidity, wind speed, and radiant heat. Indices that incorporate or integrate the individual measurements can be used for heat stress assessment (e.g., Wet Bulb Globe Temperature).
#4: When using portable environmental sensors, employers should follow manufacturer specifications for set up, equilibration (i.e., time for the sensor to adjust to ambient conditions), and calibration.
#5: Employers should incorporate environment-based work modifications (e.g., change in number of rest breaks) into workplace policies and procedures.

Current best practice guidelines for activity modification in the occupational sector is presented in NIOSH recommendations (2016) and created by ACGIH (Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner 2016; ACGIH 2017).

Limitations:

1) We don't know what most industries use for environmental monitoring (if any)
2) The intervention thresholds currently recommended by NIOSH and ACGIH do not account for worker characteristics (age, body fat, physical fitness level, etc).
3) More research needs to be implemented to determine whether the activity modification threshold is adequate for shorter (<1 hr) versus longer (>1 hr) heat exposures (or multiple days).

(43) Are there industries implementing exposure monitoring for heat? Please provide examples and data.

To our knowledge, there are currently no studies that evaluate whether industries are implementing exposure monitoring for heat.

(44) What thresholds are utilized for various metrics implemented in existing occupational heat prevention plans or activities? Are these thresholds effective for preventing heat-related illness and fatalities?

To our knowledge, there are currently no studies that evaluate the effectiveness of various thresholds (for different metrics) in occupational heat prevention plans.

(45) Which metrics and accompanying thresholds are both feasible and health-protective in both indoor and outdoor occupational settings?

Please see response to questions 41,42, and 43. Environmental monitoring recommendations from Morrissey et al. (2021) were accepted into the final manuscript if it was considered a feasible recommendation.

(46) Does application of certain heat metrics require more training than the use of other heat metrics?

Using activity modification guidelines by ACGIH require an estimation of the metabolic demands of the work performed, which may require more training than metrics that focus only on the environment. In many cases, the physical demands of the occupation or industry has not been extensively evaluated, which makes it difficult to assess what activity modification guidelines to follow (according to WBGT and metabolic rate). Additionally, the use of the adjusted heat index is comprehensive and may require more training than other indexes such as heat index or WBGT.

(47) What factors, beyond those discussed above, contribute to heat stress in outdoor and/or indoor occupational settings?

The following conditions (beyond those discussed above) may contribute to heat stress in occupational settings:

1) **Motivation/Behavioral:** Although individuals are typically able to modify their physical work intensity as a protective mechanism to prevent dangerously high core temperatures, motivation or certain behaviors may hinder their ability to do so. When workers are paid based on piece-pay system, the likelihood of self-pacing reduces. Moreover, employers may not be promoting a working culture that encourages self-pacing when workers experience heat stress (Tigchelaar, Battisti, and Spector 2020).

2) **Previous illness (pre-existing inflammatory state)**

The pathology of exertional heat stroke includes an inflammatory response driven by endotoxemia (elevated level of gram-negative bacteria, LPS). Heat stroke victims have elevated inflammatory biomarkers (Lim et al. 2007). Individuals in a pre-existing inflammatory state (i.e., have an illness or infection) are predisposed to exertional heat stroke. King et al. (2019) reported that 30% of 179 documented cases of exertional heat stroke had a previous illness (but had only minimal effects on severity) (King et al. 2019).

3) **Heat Acclimatization**

Exertional heat illnesses are more like to occur in the first three days of work when workers may not be acclimatized to heat (Tustin, Cannon, et al. 2018; Tustin, Lamson, et al. 2018). Heat acclimatization has been shown to improve thermoregulatory and cardiovascular responses to physical work such as increase sweat rate, lower heart rate and core temperature(Périard, Racinais, and Sawka 2015; Tustin, Lamson, et al. 2018; L. E. Armstrong and Maresh 1991; Lawrence E. Armstrong and Stoppani 2002; Daanen et al. 2011). For heat acclimatized workers, future heat exposures will result in a decrease in physiological strain to the same thermal stimulus.

4) **Fitness**

Fitness is sometimes referred to as "partial" heat acclimatization as it produces physiological adaptations that decrease physiological strain. This includes sweat and cardiovascular adaptations(J. Foster et al. 2020). Therefore , individuals with low fitness levels may be at greater risk than physically fit individuals(Hosokawa n.d.; Casa et al. 2015).

5) **Hydration**
   Piil et al. (2018) reported that 70% of 139 workers arrived at work dehydrated(Piil et al. 2018). Dehydration can exacerbate physiological strain resulting in increased core temperature and heart rate response(Cian et al. 2001; Chapman et al. 2020), which could increase risk of exertional heat illness or injury. Caution is warranted to use of diuretics. Alcohol may increase risk of hydration(ROBERTS 1963).

6) **Anthropometric Characteristics**

Body Mass

At the same fixed metabolic rate, larger people (higher body mass) are at an advantageous compared to smaller people since it results more energy to raise the core temperature of larger individuals (change in core temperature is negatively correlated with body mass at the same absolute metabolic rate). It is important to recognize that body mass has this effect during heavy weight bearing exercises.(J. Foster et al. 2020; Cramer and Jay 2015; 2019)

Body Surface Area to Body Mass Ratio
Smaller individuals tend to have higher body surface area to body mass ratios than larger people. Having a higher body surface area to mass ratio is associated with a faster rise in core temperature(J. Foster et al. 2020).

(48) Is air conditioning provided in employer-provided or sponsored housing?

Our extensive interactions with corporate businesses have us to believe there are little employers who provide air conditioning in large facilities due to the overwhelming cost. This statement excludes smaller facilities where air conditioning is more feasible.

(49) Are there existing employer efforts or programs to ensure that employees have the ability to adequately cool at night in order to recover from occupational heat exposure?

We are unaware of existing employer efforts or programs to ensure that employees have the ability to adequately cool at night.

(50) What factors are the most important contributors to heat-related illness risk?

In this order:

A. Physical Work Intensity
B. Environmental Conditions
C. Clothing
D. Individual Characteristics

(51) Are there other individual risk factors that contribute to the risk of heat-related illness?

Factors (also listed in Question 47) include:

-Fitness Level
-Prior Illness or Infection

-Previous heat complication
-Heat acclimatization status
-Body Mass
-Body surface area to mass ratio
-Body fat
-Medications
-Health Status
-Hydration

(52) What individual risk factors are the most important contributors to heat related illness risk?

Heat Acclimatization Status
Fitness
Previous heat injury or illness
Health Status
Body Mass
Hydration
Healthy Diet (indirect)

Please see response in question 47.

(53) Are there existing employer-led heat prevention programs that consider individual-level risk factors in their prevention guidance? If so, how are they implemented? What are the challenges associated with this?

We are unaware of employer-led heat prevention programs that consider individual-level risk factors.

(54) What are the elements of a successful employer-led heat injury and illness prevention program? How are these programs implemented? What are the challenges associated with them? Please provide examples and data.

Employers should include the following in their heat injury and illness prevention program(Morrissey et al., 2021):

- Emergency Action plans for exertional heat illness (heat stroke)
- Heat acclimatization program
- Hydration strategies
- Environmental Monitoring
- Heat hygiene practices (wellness programs, identifying workers at risk for heat injury/illness, physical exams)
- Physiological monitoring (measuring actual responses of workers during heat stress)
- Heat stress textiles and personal protective equipment
- Body cooling
- Onboarding and annual training on 8 topics above

All examples and data to support the elements listed are provided in Morrissey et al. (2021) GeoHealth. Table 1 describes barriers to implementation (below).

Table 1: Examples of barriers to implementing effective heat safety in the workplace

- Worker Culture and Habits
- Emphasis on Productivity
- Legal Implications*
- Fixed Work Hours and Schedule
- Cost and Feasibility of Heat Safety Best-Practices
- Lack of heat safety training
- Logistical issues (ex: time to water source, remote setting)

*Legal implications may include screening procedures that identify high risk individuals and physiological data collection (e.g., Americans with disabilities act, HIPAA)

(55) Are there other elements of a heat injury and illness prevention program that are important to consider?

It is important to consider groups of workers that may be more vulnerable to heat stress due to social vulnerability. For example, this would include workers such as agriculture workers (Tigchelaar, Battisti, and Spector 2020; Spector et al. 2016; Mix et al. 2018). Workers of low economic status or migrant workers are more likely to be paid on a piece pay structure, travel far distances for work, have limited resources, food insecurity, decreased affordability and availability of healthy food choices, limited access to restrooms during work (which can limit fluid consumption for hydration).

(56) Are there limitations associated with implementing a heat injury and illness prevention program across indoor or outdoor work settings, or across businesses of various sizes? If so, what are they?

Anecdotally, large corporations have greater resources to provide their employees, are more likely to have wellness program, and can provide their employees with food/beverage choices that can limit fatigue and improve performance in the heat.

(57) Are there demonstrated evaluations on the successes or limitations of various components of any existing state or employer heat injury and illness prevention program, including quantitative or qualitative evaluations?

We are unaware of any demonstrated evaluations on the successes or limitations of various components of existing state or employer heat injury and illness programs.

(58) What engineering controls, administrative controls, or PPE can be used to prevent heat-related illness in indoor and outdoor work settings? Have the qualitative or quantitative effectiveness of these controls been evaluated?

Engineering Controls: Air conditioning, ventilation (air movement, fans) (Morris et al. 2020; Morrissey et al., 2021; Hospers et al. 2020; Jay et al. 2015; Morris et al. 2019)

Administrative Controls: Work to rest ratios based on WBGT, job rotation, training (onboarding and annual training), hydration, heat acclimatization, physiological monitoring, emergency action plans.

(Morrissey et al., 2021; Hostler et al. 2016; Maresh et al. 2014; Cheung and McLellan 1997; Cheuvront and Kenefick 2014b; Clapp et al. 2000; Kenefick and Sawka 2007; Benjamin et al. 2019; Casa and Csillan 2009; M. B. Brearley, Norton, and Trewin 2017; Chong et al. 2020; James et al. 2017; Bongers, Hopman, and Eijsvogels 2017; Kiely et al. 2019; Courson 2007)

PPE: Body cooling PPE, body cooling strategies, ventilated PPE (to promote heat dissipation) (Adams et al. 2016; Choi, Kim, and Lee 2008; DeMartini et al. 2011; Smolander et al. 2004; Bach et al. 2019; Morrissey et al., 2021)

NOTE: Most studies are performed in military and sports settings. More research is warranted to determine the effectiveness in various occupational settings.

(59) Are there data that demonstrate the role of facility energy efficiency in maintaining optimal thermal conditions, optimizing worker performance, and cost-effectiveness of cooling strategies?

To our knowledge, there are no data that demonstrated the role of facility energy efficiency on maintaining optimal thermal conditions, optimizing worker performance and cost-effectiveness of cooling strategy.

(60) Are certain controls that are more effective or more feasible than others? If so, which ones? Do effectiveness and feasibility of controls differ due to setting (indoor/outdoor, business size, arrangement of work, etc.)?

Reducing the physical intensity of work in the heat is one of the most effective strategies to limit heat-related injuries and illnesses (Casa et al. 2015). Heat generated from physical work increases one's metabolism 15-20 times their resting metabolic rate. The body will continue to generate heat until physical work decreases or a rest break occurs ("Sport and Physical Activity in the Heat - Maximizing Performance and Safety | Douglas J. Casa | Springer" n.d.). Moreover, as stated in previous questions, heat acclimatization is critically important as worker may not be accustomed to working in the heat if they are new or returning from a prolonged absence.

(61) What are the limitations associated with implementing water, rest, and shade effectively in indoor and outdoor work settings?

There are many limitations to the phrase, “water,rest, shade”. First, not only should water be provided, but it must be potable and cool (water temperature). Workers must also have access to water throughout their work shift and should be educated on how to properly assess their hydration status. They should also be advised to arrive to work hydrated. The term “shade” also ignores indoor work, which often does not have shade and/or does not have solar radiation that contributes to heat stress.

(62) How are work-rest cycles currently implemented in indoor and outdoor work settings? What are the limitations for implementation?

There are no current investigations that specifically evaluate how work-rest cycles are being implemented in both indoor and outdoor work settings. It appears that at certain heat index or WBGT thresholds, rest breaks are increasing in duration (with no specific pattern). Limitations to the implementation of work-rest cycles is potential “push back” from employers who believe increasing rest breaks with disrupt productivity. However, in fact, increasing work to rest cycles can increase productivity due to better quality work and ability to perform in the heat following adequate rest(Morrissey, Brewer, et al. 2021).

(63) Are there additional sources of data or evidence that describe the quantitative or qualitative impacts of work-rest cycles on productivity?

We are unaware of additional sources of data or evidence that describes quantitative or qualitative impacts of work to rest cycles on productivity.

There are many investigations that suggest labor loss and productivity losses that occur due to occupational heat stress (Flouris et al. 2018; Morrissey, Brewer, et al. 2021; Tord Kjellstrom et al., n.d.; GUN and BUDD 1995; Mattke et al. 2007; Axelson 1974).

(64) How do productivity or output based payment schemes affect the ability of workers to follow heat illness and injury prevention training, guidance or requirements?

Piece pay systems of work (paid per product) limit the worker’s incentive to self-pace in hot conditions and are often accompanied by exploitation of the workers. They tend to be less likely to voice their concerns regarding their health and safety. This also applies to non-unionized workers(Davis 2016).

(65) How do productivity or output based payment schemes affect employer implementation of heat illness and injury prevention training, guidance or requirements?

Productivity-based payment scheme have been shown to marginalize workers and cause them to not be forthcoming about their health and safety and create an environment where heat-related injuries, illnesses, and fatalities are underreported.

(66) Are there additional sources of data or evidence that describe the quantitative or qualitative impacts of self-pacing as an alternative to work-rest cycles to prevent occupational heat-related illness?

Although self-pacing is considered a behavioral strategy to reduce risk of exertional heat illness, it should not be considered an alternative to work-rest cycle as some workers will not have the ability to self-pace if paid on a “piece-pay” structure.

(67) What are current and best practices for implementing acclimatization in various industries and across businesses of various sizes?

There are no current best practices that quantify specific acclimatization strategies with specific industries. Morrissey et al. (2021) presents the following recommendations for heat acclimatization based on scientific evidence and feasibility:

Employers/supervisors should create and implement a gradual, progressive heat acclimatization program (5-7 days) to minimize the effects of heat stress
Employer-initiated heat acclimatization programs that are tailored to the demands of the job, environmental conditions, clothing and personal protective equipment should be applied to all workers new to the job (day 1 to day 7) and workers returning from an extended absence (e.g., injury, medical leave).
Workers should be acclimatized to the heat by gradually increasing their exposure to heat over a 5-7-day period. When possible or feasible, employers should also reduce new or returning workers’ exposure time and/or physical demands (i.e., lower the intensity of work compared to normal work conditions) and modify work to rest ratios for the first 5-7 days.

(68) What are the challenges with acclimatizing workers, including workers in non-traditional/multiemployer work arrangements (e.g., temporary workers)?

The major challenge with acclimatizing workers is that there is little research on what heat acclimatization protocols work best in the occupational sector. There are currently guidelines in sport and in the military, however, the recommended protocols stem from original research investigations.

(69) Are there different challenges and best practices for acclimatization in indoor work settings versus outdoor work settings?

There are limited challenges between indoor and outdoor settings for acclimatization.

(70) Are there unique concerns or approaches for implementing acclimatization for a small versus large business?

We are not aware of any unique concern or approach for implementing acclimatization for a small versos large business. Larger businesses may be able to perform group-based heat acclimatization where many new or returning workers are able to acclimatize together, where small businesses may not have this opportunity.

(71) Are there additional sources of data or evidence that describe the quantitative or qualitative impacts of acclimatization schedules on productivity?

To our knowledge there is no research on heat acclimatization and productivity in occupational settings.

(72) Are there industries or individual employers implementing exposure, medical, and/or physiological monitoring to assess workers' health and safety during hazardous heat events?

We are unaware of specific industries or individual employers implementing exposure, medical and physiological monitoring for worker health and safety assessment.

(73) What are the best practices for implementing a monitoring program? How effective are the monitoring activities in preventing heat-related illness in workers?

There is little to no research of physiological monitoring in the occupational sector. Current devices that are often used to assess heat-related illness such as body temperature with infrared aural thermometry or oral thermometry are invalid and should not be used to estimate core temperature(Morrissey, Scarneo-Miller, et al. 2021).

Gastrointestinal core temperature pills can be utilized for workers under extreme heat stress and would be considered the "gold standard" core temperature assessment in the field(Bongers, Hopman, and Eijsvogels 2015; Hosokawa et al. 2016).

Heart rate is also another metric that can be utilized to assess safety. However, there is little research on what heart rate thresholds should be used to determine when the worker is at a greater risk for exertional heat illness.

(74) If physiological and medical monitoring programs are used, who implements these programs? Does that individual(s) have specialized training or experience?

It is our recommendation to have a trained medical professional or safety manager implement a physiological/medical monitoring program. A medical professional will be able to distinguish physiological abnormalities that may put the worker at risk for heat-related injury and illness.

(75) If physiological and medical monitoring programs are used, are data protected by confidentiality or privacy requirements? Please describe how data are maintained to ensure employee privacy and to meet any confidentiality or privacy requirements.

There are many electronic applications and programs available such as Redcap or EPIC, that comply with HIPAA requirements. Utilizing the electronic applications compliant with HIPAA can be used to track body weight changes (i.e., to measure hydration status changes).

(76) How is exposure, medical, or physiological monitoring currently implemented or tracked across various time scales (e.g., hourly, daily) in an occupational setting?

Electronic medical records are available for this purpose per employer demands. Most are customizable to address various time scales.

(77) What are the risks or challenges with this type of medical or physiological monitoring in a workplace?
Risks include, accurate data collected, what health care professional is reviewing and analyzing data, establish methods to address concerns from collected data, confidentiality, and security of data.

(78) Do you use physiological or medical monitoring to assist in identifying high risk employees?

(79) How do you use physiological monitoring data (e.g., as a short term response to heat stress conditions, to address long term examination in protecting employees, to identify high risk categories of workers)?

It is important to recognize that physiological monitoring should not be performed in isolation, but rather with other preventative strategies such as environmental monitoring, heat acclimatization, body cooling, etc. At this time, indirect methods of core temperature assessment are limited and caution is warranted when interpreting core temperature responses to work in the heat with these methods. The gold standard for core temperature monitoring is rectal thermometry (also esophageal, pulmonary artery), however, gastrointestinal thermometry (using a telemetric pill) is strongly correlated with the gold standard assessments(Byrne and Lim 2007; Casa, Becker, et al. 2007; Gant, Atkinson, and Williams 2006; Ganio et al. 2009). Other metrics such as heart rate can be used to identify activity thresholds performed by the workers, however, to our knowledge, activity modification guidelines using heart rate during occupational work in the heat has not been fully developed.

(80) Do you require that notification of monitoring results be provided to employees?

(81) Do you use physiological monitoring to validate the effectiveness of recommended controls?

There is little data on utilizing physiological monitoring to validate the effectiveness of recommended controls.

(82) Are there unique concerns or approaches in developing a monitoring program for small versus large businesses?

As mentioned previously, resources may be a unique concern for small vs. large businesses**.**

(83) How do organizations in both indoor and outdoor work environments currently deal with heat-illness emergencies if they arise?

Based on our extensive interactions with businesses, it appears that little is being done when heat- illness emergencies arise with the exception of first aid and calling 911.

(84) What are current best practices in workplace response to occupational heat-illness emergencies?

Best practice guidelines for occupational heat illnesses emergencies, exertional heat stroke, has been extensively identified in athletic and military populations. This also applies to the occupational sector. First, I will outline the treatment for all heat-related illnesses.

Recognition and Treatment of Heat-related Illnesses (Casa et al. 2015; Casa and Stearns 2016)

1. **Heat Syncope**
   Fainting episode, normal body temperatures
   Signs and Symptoms: dizziness, weakness, tunnel vision, decreased or weak pulse, pale or sweaty skin, loss of consciousness
   Treatment: move patient to shade, sit or lie down patient when symptoms occur, monitor vital signs, elevate legs to promote blood returning to heart, rehydrate

2. **Exercise-induced Muscle Cramps**
   Painful, involuntary muscle spasms (usually occurring in legs) in the heat
   Prevention/Treatment: Adequate fluid and electrolyte replacement, stretching of the muscle, rest

3. **Exertional Heat Exhaustion**
   Signs/symptoms: fatigue, nausea, fainting, weakness, vomiting, dizziness, pale, chills, diarrhea, irritability, headache, decreased muscle coordination,
   Core temperature: Usually between 102-105°F
   Treatment: move to shaded area, cool patient (ice bags, ice towels, cooling vests, etc.), remove excess clothing, elevate legs to promote venous return, provide fluids and rehydrate

4. **Exertional Heat Stroke (MEDICAL EMERGENCY)**
   The two main diagnostic criteria for EHS are:

1. Core temperature greater than 104-105°F (or 40-40.5°C)
2. Central nervous system dysfunction (altered consciousness)

Exertional Heat Stroke Recognition

The only way to **accurately** diagnose EHS is through internal core temperature (core temperature greater than or equal to 104-105°F)(Casa et al. 2015; Morrissey, Scarneo-Miller, et al. 2021).

When a patient collapses, the clinician's differential diagnoses may include several different injuries including traumatic heat injury, hyponatremia, diabetic emergency, hemorrhage or EHS(Casa and Stearns 2016).

This means having an accurate and valid temperature method to ensure proper diagnosis and subsequent treatment.

If an inaccurate or invalid temperature is obtained, it is impossible for a clinician to know if they are treating the correct injury or illness.

In the case of EHS, this means that an invalid internal temperature measurement of below 104/105ºF, when actual temperature is >104/105ºF, may mean that the patient is not being aggressively cooled when rapid cooling is indicated.

Death from EHS is 100% preventable with proper recognition and care. As such, if clinicians are not obtaining an accurate and valid internal temperature to aid in the differential diagnosis of a patient, catastrophic outcomes are likely.

Steps to obtain a rectal temperature (medical professionals only):

a. Remove the worker from immediate worksite (to the medical center if possible)

b. Drape the patient accordingly (with towels and sheets) for privacy.

c. Position the patient on their side with their top knee and hip flexed forward.

d. Make sure the thermometer is cleaned with isopropyl alcohol.

e. Make sure the probe is plugged into the thermometer (when applicable).

f. Turn the thermometer on.

g. Insert the probe 10-15cm past the anal sphincter.

h. If you meet resistance while inserting, stop and remove the probe and then try again.

i. Replace the patients clothing.

j. Temperature duration

i. If temperature is at or above 104°F, initiate treatment protocol. See below regarding EHS treatment.

2. After the treatment has ended, remove the probe gently (should be a flexible probe for continuous monitoring during treatment)

Treatment

To effectively treat a EHS patient, they MUST have their body temperature down to normal values within 30 mins. The gold standard treatment for EHS is whole body cold water immersion(Casa et al. 2015; Casa, McDermott, et al. 2007).

If body temperature is NOT down to normal values within 30 mins, they are at significant risk of long term or permanent complications or death.

Whole body cold water immersion is considered the gold standard treatment because it has the highest cooling rates (ability to cool the body quickly)(Casa et al. 2015; DeMartini et al. 2011; Demartini et al. 2015; Casa, McDermott, et al. 2007).

Whole body cold water immersion is performed in a cold water immersion tub. If the workers are in a remote location, ice, water, and a tarp can be utilized for the TACO (tarp assisted cooling with oscillation) method (Hosokawa et al. 2017).

If there is a circumstance where a medical professional is not available to appropriately diagnose EHS, but EHS is suspected, the patient should be cooled as fast as possible.

DO NOT wait for EMS to arrive. You should practice "Cool first, transport second". Everything should be done to appropriately reduce their body temperature before transport (where they will not be appropriately cooled).

Procedures for whole body cold water immersion:

1. Excess clothing shall be removed to aid cooling.

a. If removal of clothing and/or equipment would cause delays of 5+ minutes, do not remove and initiate cooling.

2. Place patient in a cold-water (35-59°F) tub (or middle of tarp if remote setting) up to the neck.

a. Wrap a towel across the chest and beneath both arms to prevent the patient from sliding into the tub.

b. Ice shall cover the surface of the water at all times.

c. Water shall be continuously stirred to maximize cooling. If you are performing the TACO method, the tarp should be oscillated to facilitate water movement.

d. An ice-cold towel will be placed over the head and re-wet and replaced every 2 minutes.

e. Cooling shall cease when body temperature reaches 102°F.

(85) What are the challenges with responding to a heat-illness emergency in various work environments (e.g., indoor settings, outdoor settings, remote locations)?

There are two big challenges in responding to exertional heat stroke in work environment

(1) If there is no medical staff on site (therefore cannot assess core temperature to determine if it is EHS).
(2) Absence of a cold water immersion tub because of remote setting. A tarp (ice and water) can be used (TACO method) if a cold water immersion tub is not feasible.

Review Question 84 for procedures if medical professional is not on-site and if a cold water immersion tub is not feasible.

(86) What should be included in an employer's heat emergency response plan?

In Morrissey et al. (2021) GeoHealth, an example of an emergency action plan template for exertional heat stroke is included (Appendix D). (Morrissey et al., 2021). The emergency action plan includes the following:

(3) Personnel involved in Development
    - Should be collaborative effort between safety manager, industrial hygienist, medical professional (athletic trainer, physician, PA, etc.)
(4) Introduction to the Medical Emergency and Staff Education
    - Includes brief statement on why it is being included and how each employee will be educated
(5) Chain of Command
    - This will be organization wide and will include who will be contacted when a heat illness occurs, who will record and document event
(6) Emergency Telephone numbers and Emergency Situation Contact Tree
    - This includes a list of all emergency numbers and who should be contacted for the exertional heat illness
(7) Emergency Equipment Locations
    - Detailed outline (map should be included) of where the exertional heat stroke emergency equipment is located, who will set it up, etc
(8) Cold water tub or tarp location
    - Description of where the cold water tub for EHS treatment will be (if in a remote setting, where the trap, water, and ice will be)
(9) General Plan of Action and Emergency Procedures
    - All emergency procedures for exertional heat stroke are listed in question 85. A General plan of action should also be included.
(10) Rehearsal Strategy
    - All emergency action plans must be shared and rehearsed by all employees. A strategy must be included to determine how often the rehearsal is performed
(11) Page for Updates to Emergency Action Plan

- When the emergency action plan is updated, a page should be included in the front of the document.

(12) Documentation of Employee Education, emergency equipment maintenance and approval signature from personnel who created document and CEO of company

(87) What materials or supplies should employers have on-site to respond to a heat emergency?

Equipment Required to Use Best Practices to Treatment EHS (set up is approx. 5 mins)

- Rectal Thermometer
- 100-150-gallon industrial tub filled with water
- Two chests filled with ice next to the tub ready for treatment.
- Available bed sheet or large towels for privacy (pull curtain if in medical center)
- Towels for placement over the head and neck

<u>**Appendix C from Morrissey et al. (2021) GeoHealth:**</u>

Table S3. Recognition and Treatment of Exertional Heat Illnesses and Emergency Medical Supplies Required Based on Work Setting

Tier I: Indoor setting or outdoor setting with close access to a facility that has power, storage capabilities for materials, etc.					
Tier II: Remote setting with a temporary facility with large group of workers (e.g., a trailer)					
Tier III: Remote Settings with Small Group of Workers (e.g., setting with no facility)					
EHI	**Recognition**	**Treatment Standard**	**Tier I Equipment**	**Tier II Equipment**	**Tier III Equipment**
Heat Syncope (fainting)	Brief episode of fainting, must rule out cardiac event; decreased pulse rate; collapse due to prolonged standing in the heat	• Remove the individual from the heat source, move to a shaded area • Elevate lower extremities • Remove excess clothing • Assess heart rate, breath rate, blood pressure	Water Ice Cooler WBGT Device Fan Fan with mist Towels for cooling Electrolyte drink* Pulse oximeter Smartwatch*	Water Ice Cooler Battery-operated fan WBGT Device Tarp (to use for shade if no shade available) Pulse oximeter	Water Ice Cooler Light Tarp/pop up tent (to use for shade if no shade available) WBGT Device Ice Towels Pulse oximeter

		• Superficial cooling		Smartwatch*	Smartwatch*
Exertional Heat Exhaustion	Inability to complete tasks, fainting, extreme fatigue, headache, dizziness, low blood pressure, vomiting,	• Obtain rectal temperature to rule out EHS (<40.5°C/105°F) • Remove individual from the heat source, move to a shaded area • Remove excess clothing, expose as much skin to promote evaporative cooling • Superficial cooling (Provide ice towels, fanning) • Assess heart rate, breath rate, blood pressure	Rectal Thermometer Pulse oximeter Portable tub/Tarp Water Ice Cooler Fan Fan with mist Ice towels Electrolyte drink Smartwatch*	Rectal Thermometer Pulse oximeter Portable tub/Tarp Water Ice Cooler Fan Fan with mist Ice towels Electrolyte drink* Smartwatch*	Rectal Thermometer Water Ice Cooler Light Tarp/pop up tent (to use for shade if no shade available) Ice Towels Electrolyte drink Pulse oximeter Smartwatch*
Exertional Heat Stroke (EHS)	Severely impaired cognitive function Core body temperature >40.5C/105F, Disorientation, bizarre behavior, emotional responses, weakness, nausea, fainting, vomiting,	• Obtain rectal temperature to confirm EHS (>40.5° C/105°F) • · Activate Emergency Action Plan/Advanced Medical Care	Rectal Thermometer WBGT Device Pulse oximeter Portable tub/Tarp Water Ice Cooler	Rectal Thermometer WBGT Device Pulse oximeter Portable tub/Tarp Water Ice Cooler	Rectal Thermometer WBGT Device Pulse oximeter Portable tub/Tarp Water Ice Cooler

	dizziness, light-headedness, irrational behavior, headache, hyperventilation, diarrhea, collapse, staggered movement, and altered consciousness	• Lower body temperature as quickly as possible, within 30 minutes of recognition • Whole-body Cold-water Immersion • Water temperature should be 35-59°F • Continuous stirring/agitation of water • **Do not remove person from active cooling until core temperature reaches 102.5°F**			
Exertional Hyponatremia	Weight gain, Severely impaired cognitive function, Core body temperature < 40.5C/105F, disorientation, intense headache, vomiting, nausea, bizarre behavior, emotional responses, possible puffy fingers and toes	• Remove individual from heat source • · Activate Emergency Action Plan/Advanced Medical Care • Obtain rectal temperature to rule out EHS (<40.5/105F)	Rectal Thermometer Salty foods (pickles, mustard, chips, pretzels, bouillon cubes) Pulse oximeter Smartwatch*	Rectal Thermometer Salty foods (pickles, mustard, chips, pretzels, bouillon cubes) Light Tarp/pop up tent (to use for shade if no shade available)	Rectal Thermometer Salty foods (pickles, mustard, chips, pretzels, bouillon cubes) Light Tarp/pop up tent (to use for shade if no shade available)

		• Serum sodium levels <129-135 mEq/L** • Asymptomatic and mild symptomatic hyponatremia symptoms should be treated with ***fluid RESTRICTION*** and salty foods • Severe cases require immediate activation of advanced medical care • Assess heart rate, breath rate, blood pressure		Pulse oximeter Smartwatch*	Pulse oximeter Smartwatch*

Note: *Not required but useful; **If a serum electrolyte analyzer device is available (eg., ISAT)

(88) When should employers refer employees for medical treatment or seek medical treatment for an employee who is experiencing a heat-illness emergency?

Employees should be referred for medical treatment if the employee is experiencing any of the signs and symptoms of EHS (This is a MEDICAL EMERGENCY and must be cooled to normal body temperature within 30 mins)(Casa et al. 2015):

Signs	**Symptoms**
Extreme Hyperthermia (greater 104-105°F)	Dizziness
Altered Consciousness	Headache
Disorientation	Nausea
Confusion; Look "out of it"	Muscle Cramps
Vomiting	Dehydration
Staggering	Irrational Behavior
Decreased Performance	Muscle Weakness
Profuse Sweating	Irritability/Combative

(89) When and how do employers refer employees for medical treatment or seek medical treatment for them when experiencing a heat-illness emergency?

Employers refer employees for medical treatment based on the individual company's emergency action plan.

(90) How do employers currently involve workers in heat injury and illness prevention?

(91) What types of occupational heat injury and illness prevention training programs have been implemented and how effective are they? What is the scope and format of these training programs? Are workers in nontraditional/multi-employer work arrangements included in these training programs?

(92) What are best practices in worker training and engagement in heat injury and illness prevention?

We'd like to comment that worker training and engagement for heat injury and illness prevention should be performed at onboarding and annually(Morrissey et al., 2021).

(95) How do employers involve workers in the design and implementation of heat injury and illness prevention activities?

(96) What challenges are there with worker training and engagement for heat injury and illness prevention?

There appears to be limited education across the occupational setting regarding heat injury and illness (prevention, recognition, and treatment).

(97) OSHA requests any workers' compensation data related to heatrelated injury and illness. Any other information on your workplace's experience would also be appreciated.

(98) Are there additional data (other than workers' compensation data) from published or unpublished sources that describe or inform about the incidence or prevalence of heat-related injuries, illness, or fatalities in particular occupations and industries?

Question 2 provides the additional data that may provide some information on the incidence or prevalence of heat-related injuries, illnesses, and fatalities in particular occupations (farm workers). Most of the published research is related to worker compensation claims.

(99) What are the potential economic impacts associated with the promulgation of a standard specific to the risk of heat-related injury and illness? Describe these impacts in terms of benefits, including reduction of incidents; effects on costs, revenue, and profit; and any other relevant impact measurements.

Morrissey et al. (2021) American Journal of Industrial Medicine shares the economic burden of heat stress on productivity in the workplace(Morrissey, Brewer, et al. 2021).

(100) If you utilize the WBGT method when making your work determinations, what were the costs of any associated equipment and/or training to implement this measurement method?

WBGT monitors are relatively inexpensive (approximately $100-150).

(101) If you utilize a temperature metric other than WBGT when making work determinations, what were the costs associated with measurement and/ or training to implement this measurement method?

(102) Have you instituted programs or policies directed at mitigating heat related injury and illness at your worksite? If so, what were the resulting benefits?

(103) If you have implemented a heat injury and illness program or policy, what was the cost of implementing the program or policy, in terms of both time and expenditures for supplies and equipment? Please describe in detail the resource requirements and associated costs expended to initiate the program(s) and to conduct the program(s) annually. If you have any other estimates of the costs of preventing or mitigating heat-related injury and illness, please provide them. It would be helpful to OSHA to learn both overall totals and specific components of the program (e.g., cost of equipment, equipment installation, equipment maintenance, training programs, staff time, facility redesign). a. What are the ongoing operating and maintenance costs for the program? b. Has your program reduced incidents of heat-related injury and illness and by how much? Can you identify which elements of your program most reduced incidents? Which elements did not seem effective? c. Has your program reduced direct costs for your facility (e.g., workers' compensation costs, fewer lost workdays)? Please quantify these reductions, if applicable. d. Has your program reduced indirect costs for your facility (e.g., reductions in absenteeism and worker turnover; increases in reported productivity, satisfaction, and level of safety in the workplace)?

Costs associated with heat-related fatalities far exceed the cost of implementation of heat safety best practices. A heat-related fatality can cost the business around $53,000 (OSHA).

(104) Do you provide wearable devices (specific to heat) to workers? Does each worker get a device or only specific members of the crew? a. If wearables are provided, what were the associated upfront costs of the equipment and how often do they need to be replaced? b. Which specific wearable did you choose? What were your deciding factors (i.e., price, ease of use)?

If wearables are provided to workers, employers must ensure they are validated in the occupation and environment their workers are in.

(105) If you are in a state with standards requiring programs and/or policies to reduce heat stress, how did implementing the program and/or policy affect the facility's budget and finances?

(106) What changes, if any, in market conditions would reasonably be expected to result from issuing a standard on heat stress prevention? Describe any changes in market structure or concentration, and any effects on the prices of products and services to consumers, that would reasonably be expected from issuing such a standard.

(107) If you have implemented acclimatization practices in your workplace, were there any associated costs?

(108) How does your workplace address the costs of any rest breaks necessary to prevent heat-related injury and illness?

(109) How many, and what type of small firms, or other small entities, have heat-related injury and illness training, or a heat injury and illness program, and what percentage of their industry (NAICS code) do these entities comprise? Please specify the types of heat stress risks employees in these firms face.

We are unaware of how many and what types of small firms have heat-related injury and illness training and programs.

(110) How, and to what extent, would small entities in your industry be affected by a potential OSHA standard to prevent heat stress? Do special circumstances exist that make preventing heat stress more difficult or more costly for small entities than for large entities? Please describe these circumstances.

Small entities typically have less resources than larger entities. However, it is important to note that the cost of a heat-related fatality far exceeds the cost of implementing a heat safety program.

(111) How many, and in what type of small entities, is heat-related injury and illness a threat, and what percentage of their industry (by NAICS codes) do these entities comprise?

To our knowledge, this information is unknown.

(112) Are there alternative regulatory or non-regulatory approaches OSHA could use to mitigate possible impacts on small entities?

Provide resources to small entities to develop heat safety programs.

(113) For very small entities (historically defined by OSHA as those with fewer than 20 employees), what types of heat-related injury and illness threats are faced by workers? Does your experience with heat-related injury and illness reflect the lower rates reported by BLS?

There is no research to suggest that small business experience different heat-related injury and illness threats than larger entities.

(114) For very small entities, what are the unique challenges establishments face in addressing heat-related injury and illness?

As mentioned previously, a major limitation is resources they are able to allocate for heat safety.

(115) If you are in a jurisdiction with standards requiring programs and/or policies to reduce heat stress, how did implementing the program and/or policy affect your small entity or other small entities in your jurisdiction?

REFERENCES.

ACGIH. 2017. "TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices."

Adams, William M., Yuri Hosokawa, Elizabeth L. Adams, Luke N. Belval, Robert A. Huggins, and Douglas J. Casa. 2016. "Reduction in Body Temperature Using Hand Cooling versus Passive Rest after Exercise in the Heat." *Journal of Science and Medicine in Sport* 19 (11): 936–40. https://doi.org/10.1016/j.jsams.2016.02.006.

Adan, Ana. 2012. "Cognitive Performance and Dehydration." *Journal of the American College of Nutrition* 31 (2): 71–78. https://doi.org/10.1080/07315724.2012.10720011.

Aguilar, Diego J., and Magdalena Madero. 2019. "Other Potential CKD Hotspots in the World: The Cases of Mexico and the United States." *Seminars in Nephrology* 39 (3): 300–307. https://doi.org/10.1016/j.semnephrol.2019.02.008.

Armstrong, L. E., and C. M. Maresh. 1991. "The Induction and Decay of Heat Acclimatisation in Trained Athletes." *Sports Medicine (Auckland, N.Z.)* 12 (5): 302–12. https://doi.org/10.2165/00007256-199112050-00003.

Armstrong, Lawrence E., and James Stoppani. 2002. "Central Nervous System Control of Heat Acclimation Adaptations: An Emerging Paradigm." *Reviews in the Neurosciences* 13 (3): 271–85. https://doi.org/10.1515/revneuro.2002.13.3.271.

Axelson, O. 1974. "Influence of Heat Exposure on Productivity." *WK.ENVIRON.HLTH* 11 (2): 94–99.

Bach, Aaron J. E., Matthew J. Maley, Geoffrey M. Minett, Stephanie A. Zietek, Kelly L. Stewart, and Ian B. Stewart. 2019. "An Evaluation of Personal Cooling Systems for Reducing Thermal Strain Whilst Working in Chemical/Biological Protective Clothing." *Frontiers in Physiology* 10. https://doi.org/10.3389/fphys.2019.00424.

Benjamin, Courteney Leigh, Yasuki Sekiguchi, Lauren Amanda Fry, and Douglas James Casa. 2019. "Performance Changes Following Heat Acclimation and the Factors That Influence These Changes: Meta-Analysis and Meta-Regression." *Frontiers in Physiology* 10: 1448. https://doi.org/10.3389/fphys.2019.01448.

Bernard, Thomas E., Victor Caravello, Skai W. Schwartz, and Candi D. Ashley. 2008. "WBGT Clothing Adjustment Factors for Four Clothing Ensembles and the Effects of Metabolic Demands." *Journal of Occupational and Environmental Hygiene* 5 (1): 1–5; quiz d21-23. https://doi.org/10.1080/15459620701732355.

Bernard, Thomas E., Christina L. Luecke, Skai K. Schwartz, K. Scott Kirkland, and Candi D. Ashley. 2005. "WBGT Clothing Adjustments for Four Clothing Ensembles Under Three Relative Humidity Levels." *Journal of Occupational and Environmental Hygiene* 2 (5): 251–56. https://doi.org/10.1080/15459620590934224.

Blazejczyk, Krzysztof, Gerd Jendritzky, Peter Broede, Dusan Fiala, George Havenith, Yoram Epstein, Agnes Psikuta, and Bernhardt Kampmann. 2013. "An Introduction to the Universal Thermal Climate Index (UTCI)," January. https://doi.org/10.7163/GPol.2013.1'].

Bongers, Coen C. W. G., Maria T. E. Hopman, and Thijs M. H. Eijsvogels. 2017. "Cooling Interventions for Athletes: An Overview of Effectiveness, Physiological Mechanisms, and Practical Considerations." *Temperature: Multidisciplinary Biomedical Journal* 4 (1): 60–78. https://doi.org/10.1080/23328940.2016.1277003.

Bongers, Coen C.W.G., Maria T.E. Hopman, and Thijs M.H. Eijsvogels. 2015. "Using an Ingestible Telemetric Temperature Pill to Assess Gastrointestinal Temperature During Exercise." *Journal of Visualized Experiments : JoVE*, no. 104 (October). https://doi.org/10.3791/53258.

Brearley, Matt. 2016. "Cooling Methods to Prevent Heat-Related Illness in the Workplace." *Workplace Health & Safety* 64 (2): 80–80. https://doi.org/10.1177/2165079915613353.

Brearley, Matt B., Ian N. Norton, and Abigail S. Trewin. 2017. "The Case for Heat Acclimatization of Disaster Responders—An Australian Perspective." *Frontiers in Public Health* 5 (April). https://doi.org/10.3389/fpubh.2017.00098.

Budd, Grahame M. 2008. "Wet-Bulb Globe Temperature (WBGT)—Its History and Its Limitations." *Journal of Science and Medicine in Sport* 11 (1): 20–32. https://doi.org/10.1016/j.jsams.2007.07.003.

Butler-Dawson, Jaime, Lyndsay Krisher, Hillary Yoder, Miranda Dally, Cecilia Sorensen, Richard J. Johnson, Claudia Asensio, et al. 2019. "Evaluation of Heat Stress and Cumulative Incidence of Acute Kidney Injury in Sugarcane Workers in Guatemala." *International Archives of Occupational and Environmental Health* 92 (7): 977–90. https://doi.org/10.1007/s00420-019-01426-3.

Byrne, Christopher, and Chin Leong Lim. 2007. "The Ingestible Telemetric Body Core Temperature Sensor: A Review of Validity and Exercise Applications." *British Journal of Sports Medicine* 41 (3): 126–33. https://doi.org/10.1136/bjsm.2006.026344.

Calkins, Miriam, David Bonauto, Anjum Hajat, Max Lieblich, Noah Seixas, Lianne Sheppard, and June Spector. 2019. "A Case-Crossover Study of Heat Exposure and Injury Risk among Outdoor Construction Workers in Washington State." *Scandinavian Journal of Work, Environment & Health* 45 (March). https://doi.org/10.5271/sjweh.3814.

Carter, Robert, Samuel N. Cheuvront, Jeffrey O. Williams, Margaret A. Kolka, Lou A. Stephenson, Michael N. Sawka, and Paul J. Amoroso. 2005. "Epidemiology of Hospitalizations and Deaths from Heat Illness in Soldiers." *Medicine and Science in Sports and Exercise* 37 (8): 1338–44. https://doi.org/10.1249/01.mss.0000174895.19639.ed.

Casa, Douglas J, Shannon M Becker, Matthew S Ganio, Christopher M Brown, Susan W Yeargin, Melissa W Roti, Jason Siegler, et al. 2007. "Validity of Devices That Assess Body Temperature During Outdoor Exercise in the Heat." *Journal of Athletic Training* 42 (3): 333–42.

Casa, Douglas J, and David Csillan. 2009. "Preseason Heat-Acclimatization Guidelines for Secondary School Athletics." *Journal of Athletic Training* 44 (3): 332–33.

Casa, Douglas J., Julie K. DeMartini, Michael F. Bergeron, Dave Csillan, E. Randy Eichner, Rebecca M. Lopez, Michael S. Ferrara, et al. 2015. "National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses." *Journal of Athletic Training* 50 (9): 986–1000. https://doi.org/10.4085/1062-6050-50.9.07.

Casa, Douglas J., Brendon P. McDermott, Elaine C. Lee, Susan W. Yeargin, Lawrence E. Armstrong, and Carl M. Maresh. 2007. "Cold Water Immersion: The Gold Standard for Exertional Heatstroke Treatment." *Exercise and Sport Sciences Reviews* 35 (3): 141–49. https://doi.org/10.1097/jes.0b013e3180a02bec.

Casa, Douglas J., and Rebecca L. Stearns. 2016. *Preventing Sudden Death in Sport & Physical Activity*. Jones & Bartlett Publishers.

Chapman, Christopher L., Blair D. Johnson, Nicole T. Vargas, David Hostler, Mark D. Parker, and Zachary J. Schlader. 2020. "Both Hyperthermia and Dehydration during Physical Work in the Heat Contribute to the Risk of Acute Kidney Injury." *Journal of Applied Physiology* 128 (4): 715–28. https://doi.org/10.1152/japplphysiol.00787.2019.

Cheung, S.S., and T.M. McLellan. 1997. "Influence of Hydration Status and Fluid Replacement on Heat Tolerance While Wearing NBC Protective Clothing." *European Journal of Applied Physiology and Occupational Physiology* 77 (1–2): 139–48. https://doi.org/10.1007/s004210050312.

Cheuvront, Samuel N., and Robert W. Kenefick. 2014a. "Dehydration: Physiology, Assessment, and Performance Effects." *Comprehensive Physiology* 4 (1): 257–85. https://doi.org/10.1002/cphy.c130017.

———. 2014b. "Dehydration: Physiology, Assessment, and Performance Effects." *Comprehensive Physiology* 4 (1): 257–85. https://doi.org/10.1002/cphy.c130017.

Chicas, Roxana, Nezahualcoyotl Xiuhtecutli, Nathan E. Dickman, Madeleine L. Scammell, Kyle Steenland, Vicki S. Hertzberg, and Linda McCauley. 2020. "Cooling Intervention Studies among Outdoor Occupational Groups: A Review of the Literature." *American Journal of Industrial Medicine* 63 (11): 988–1007. https://doi.org/10.1002/ajim.23175.

Choi, Jeong-Wha, Myung-Ju Kim, and Joo-Young Lee. 2008. "Alleviation of Heat Strain by Cooling Different Body Areas during Red Pepper Harvest Work at WBGT 33 Degrees C." *Industrial Health* 46 (6): 620–28. https://doi.org/10.2486/indhealth.46.620.

Chong, D., N. Zhu, W. Luo, Z. Zhang, and X. Pan. 2020. "Effects of Heat Acclimation on Individual Safety Performance in Hyperthermal Indoor Environments." *Building and Environment* 168. https://doi.org/10.1016/j.buildenv.2019.106537.

Cian, C., P. A. Barraud, B. Melin, and C. Raphel. 2001. "Effects of Fluid Ingestion on Cognitive Function after Heat Stress or Exercise-Induced Dehydration." *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology* 42 (3): 243–51.

Clapp, A. J., P. A. Bishop, J. F. Smith, and E. R. Mansfield. 2000. "Effects of Carbohydrate-Electrolyte Content of Beverages on Voluntary Hydration in a Simulated Industrial Environment." *AIHAJ: A Journal for the Science of Occupational and Environmental Health and Safety* 61 (5): 692–99. https://doi.org/10.1080/15298660008984579.

"Climate Change and Social Inequality | UN Department of Economic and Social Affairs (DESA) Working Papers | OECD ILibrary." n.d. Accessed December 21, 2021. https://www.oecd-ilibrary.org/content/paper/2c62335d-en.

"Climate Change, Health and Safety of Workers in Developing Economies: A Scoping Review - ScienceDirect." n.d. Accessed December 21, 2021. https://www.sciencedirect.com/science/article/pii/S2667278221000316.

Courson, Ron. 2007. "Preventing Sudden Death on the Athletic Field: The Emergency Action Plan." *Current Sports Medicine Reports* 6 (2): 93–100. https://doi.org/10.1007/BF02941149.

Cramer, Matthew N., and Ollie Jay. 2015. "Explained Variance in the Thermoregulatory Responses to Exercise: The Independent Roles of Biophysical and Fitness/Fatness-Related Factors." *Journal of Applied Physiology (Bethesda, Md.: 1985)* 119 (9): 982–89. https://doi.org/10.1152/japplphysiol.00281.2015.

———. 2019. "Partitional Calorimetry." *Journal of Applied Physiology (Bethesda, Md.: 1985)* 126 (2): 267–77. https://doi.org/10.1152/japplphysiol.00191.2018.

Culp, Kennith, and Shalome Tonelli. 2019. “Heat-Related Illness in Midwestern Hispanic Farmworkers: A Descriptive Analysis of Hydration Status and Reported Symptoms.” *Workplace Health & Safety* 67 (4): 168–78. https://doi.org/10.1177/2165079918813380.

Daanen, H. a. M., A. G. Jonkman, J. D. Layden, D. M. Linnane, and A. S. Weller. 2011. “Optimising the Acquisition and Retention of Heat Acclimation.” *International Journal of Sports Medicine* 32 (11): 822–28. https://doi.org/10.1055/s-0031-1279767.

Davis, Mary E. 2016. “Pay Matters: The Piece Rate and Health in the Developing World.” *Annals of Global Health*, Current Topics in Global Health, 82 (5): 858-865.e6. https://doi.org/10.1016/j.aogh.2016.05.005.

Day, Ed, Sam Fankhauser, Nick Kingsmill, Hélia Costa, and Anna Mavrogianni. 2019. “Upholding Labour Productivity under Climate Change: An Assessment of Adaptation Options.” *Climate Policy* 19 (3): 367–85. https://doi.org/10.1080/14693062.2018.1517640.

Demartini, Julie K., Douglas J. Casa, Rebecca Stearns, Luke Belval, Arthur Crago, Rob Davis, and John Jardine. 2015. “Effectiveness of Cold Water Immersion in the Treatment of Exertional Heat Stroke at the Falmouth Road Race.” *Medicine and Science in Sports and Exercise* 47 (2): 240–45. https://doi.org/10.1249/MSS.0000000000000409.

DeMartini, Julie K., Gregory F. Ranalli, Douglas J. Casa, Rebecca M. Lopez, Matthew S. Ganio, Rebecca L. Stearns, Brendon P. McDermott, Lawrence E. Armstrong, and Carl M. Maresh. 2011. “Comparison of Body Cooling Methods on Physiological and Perceptual Measures of Mildly Hyperthermic Athletes.” *Journal of Strength and Conditioning Research* 25 (8): 2065–74. https://doi.org/10.1519/JSC.0b013e3182259b1d.

“Differences in Heat-Related Mortality by Citizenship Status: United States, 2005-2014 - PubMed.” n.d. Accessed December 21, 2021. https://pubmed.ncbi.nlm.nih.gov/29072944/.

Donaldson, G.C., W.R. Keatinge, and R.D. Saunders. 2003. “Cardiovascular Responses to Heat Stress and Their Adverse Consequences in Healthy and Vulnerable Human Populations.” *International Journal of Hyperthermia* 19 (3): 225–35. https://doi.org/10.1080/0265673021000058357.

“Employee and Union Inputs into Occupational Health and Safety Measures in Chinese Factories - ScienceDirect.” n.d. Accessed December 21, 2021. https://www-sciencedirect-com.ezproxy.lib.uconn.edu/science/article/pii/S0277953603003150?casa_token=oHBRUvazQaEAAAAA:dc7kgkqEieHW6KJy5VJARYGOM3J-UZ-0ajeHMqju6bggnON9dExxv8l1G5hP2BzB2RvUOtFW.

Flouris, Andreas D., Petros C. Dinas, Leonidas G. Ioannou, Lars Nybo, George Havenith, Glen P. Kenny, and Tord Kjellstrom. 2018. “Workers’ Health and Productivity under Occupational Heat Strain: A Systematic Review and Meta-Analysis.” *The Lancet Planetary Health* 2 (12): e521–31. https://doi.org/10.1016/S2542-5196(18)30237-7.

Foster, J., S.G. Hodder, A.B. Lloyd, and G. Havenith. 2020. “Individual Responses to Heat Stress: Implications for Hyperthermia and Physical Work Capacity.” *Frontiers in Physiology* 11. https://doi.org/10.3389/fphys.2020.541483.

Foster, Josh, James Smallcombe, Simon Hodder, Ollie Jay, Andreas Flouris, Lars Nybo, and George Havenith. 2021. “An Advanced Empirical Model for Quantifying the Impact of Heat and Climate Change on Human Physical Work Capacity.” *International Journal of Biometeorology*, March, 1–15. https://doi.org/10.1007/s00484-021-02105-0.

Fox, R. H., R. Goldsmith, D. J. Kidd, and H. E. Lewis. 1963. “Acclimatization to Heat in Man by Controlled Elevation of Body Temperature.” *The Journal of Physiology* 166 (May): 530–47. https://doi.org/10.1113/jphysiol.1963.sp007121.

Ganio, Matthew S, Christopher M Brown, Douglas J Casa, Shannon M Becker, Susan W Yeargin, Brendon P McDermott, Lindsay M Boots, Paul W Boyd, Lawrence E Armstrong, and Carl M Maresh. 2009. “Validity and Reliability of Devices That Assess Body Temperature During Indoor Exercise in the Heat.” *Journal of Athletic Training* 44 (2): 124–35.

Gant, Nicholas, Greg Atkinson, and Clyde Williams. 2006. “The Validity and Reliability of Intestinal Temperature during Intermittent Running.” *Medicine and Science in Sports and Exercise* 38 (11): 1926–31. https://doi.org/10.1249/01.mss.0000233800.69776.ef.

Gao, Chuansi, Kalev Kuklane, Per-Olof Östergren, and Tord Kjellstrom. 2018. “Occupational Heat Stress Assessment and Protective Strategies in the Context of Climate Change.” *International Journal of Biometeorology* 62 (3): 359–71. https://doi.org/10.1007/s00484-017-1352-y.

Gaoua, Nadia, Christopher P. Herrera, Julien D. Périard, Farid El Massioui, and Sebastien Racinais. 2018. “Effect of Passive Hyperthermia on Working Memory Resources during Simple and Complex Cognitive Tasks.” *Frontiers in Psychology* 8 (January). https://doi.org/10.3389/fpsyg.2017.02290.

Glaser, Jason, Jay Lemery, Balaji Rajagopalan, Henry F. Diaz, Ramón García-Trabanino, Gangadhar Taduri, Magdalena Madero, et al. 2016. “Climate Change and the Emergent Epidemic of CKD from Heat Stress in Rural Communities: The Case for Heat Stress Nephropathy.” *Clinical Journal of the American Society of Nephrology: CJASN* 11 (8): 1472–83. https://doi.org/10.2215/CJN.13841215.

González-Alonso, José, Craig G. Crandall, and John M. Johnson. 2008. “The Cardiovascular Challenge of Exercising in the Heat.” *The Journal of Physiology* 586 (1): 45–53. https://doi.org/10.1113/jphysiol.2007.142158.

Grundstein, Andrew, Castle Williams, Minh Phan, and Earl Cooper. 2015. “Regional Heat Safety Thresholds for Athletics in the Contiguous United States.” *Applied Geography* 56 (January): 55–60. https://doi.org/10.1016/j.apgeog.2014.10.014.

Gubernot, Diane M., G. Brooke Anderson, and Katherine L. Hunting. 2014. “The Epidemiology of Occupational Heat Exposure in the United States: A Review of the Literature and Assessment of Research Needs in a Changing Climate.” *International Journal of Biometeorology* 58 (8): 1779–88. https://doi.org/10.1007/s00484-013-0752-x.

GUN, R. T., and G. M. BUDD. 1995. “Effects of Thermal, Personal and Behavioural Factors on the Physiological Strain, Thermal Comfort and Productivity of Australian Shearers in Hot Weather.” *Ergonomics* 38 (7): 1368–84. https://doi.org/10.1080/00140139508925195.

Hansson, Erik, Jason Glaser, Kristina Jakobsson, Ilana Weiss, Catarina Wesseling, Rebekah A. I. Lucas, Jason Lee Kai Wei, et al. 2020. “Pathophysiological Mechanisms by Which Heat Stress Potentially Induces Kidney Inflammation and Chronic Kidney Disease in Sugarcane Workers.” *Nutrients* 12 (6). https://doi.org/10.3390/nu12061639.

Hasegawa, Hiroshi, and Stephen S Cheung. 2013. “Hyperthermia Effects on Brain Function and Exercise Capacity.” *The Journal of Physical Fitness and Sports Medicine* 2 (4): 429–38. https://doi.org/10.7600/jpfsm.2.429.

Hayhoe, Katharine, Cameron Wake, Bruce Anderson, Xin-Zhong Liang, Edwin Maurer, Jinhong Zhu, James Bradbury, Art DeGaetano, Anne Stoner, and Donald Wuebbles. 2008.

"Regional Climate Change Projections for the Northeast USA." *Civil, Environmental and Sustainable Engineering*, June. https://scholarcommons.scu.edu/ceng/49.

"Heat - Overview: Working in Outdoor and Indoor Heat Environments | Occupational Safety and Health Administration." n.d. Accessed December 21, 2021. https://www.osha.gov/heat-exposure.

Heidari, H., F. Golbabaei, A. Shamsipour, and A.R. Forushani. 2019. "Occupational Heat Stress in Outdoor Settings Considering the Regional Climate Change in the Future Decades in Iran." *Iran Occupational Health* 16 (2): 33–47.

Hosokawa, Yuri. n.d. "Activity Modification in Heat: Critical Assessment of Guidelines across Athletic, Occupational, and Military Settings in the USA | SpringerLink." Accessed September 15, 2019. https://link-springer-com.ezproxy.lib.uconn.edu/article/10.1007/s00484-019-01673-6.

Hosokawa, Yuri, William M. Adams, Luke N. Belval, Lesley W. Vandermark, and Douglas J. Casa. 2017. "Tarp-Assisted Cooling as a Method of Whole-Body Cooling in Hyperthermic Individuals." *Annals of Emergency Medicine* 69 (3): 347–52. https://doi.org/10.1016/j.annemergmed.2016.08.428.

Hosokawa, Yuri, William M. Adams, Rebecca L. Stearns, and Douglas J. Casa. 2016. "Comparison of Gastrointestinal and Rectal Temperatures During Recovery After a Warm-Weather Road Race." *Journal of Athletic Training* 51 (5): 382–88. https://doi.org/10.4085/1062-6050-51.7.02.

Hospers, Lily, James W. Smallcombe, Nathan B. Morris, Anthony Capon, and Ollie Jay. 2020. "Electric Fans: A Potential Stay-at-Home Cooling Strategy during the COVID-19 Pandemic This Summer?" *The Science of the Total Environment* 747 (December): 141180. https://doi.org/10.1016/j.scitotenv.2020.141180.

Hostler, D., D. Colburn, J.C. Rittenberger, and S.E. Reis. 2016. "Effect of Two Work-to-Rest Ratios on Cardiovascular, Thermal, and Perceptual Responses During Fire Suppression and Recovery." *Prehospital Emergency Care* 20 (6): 681–87. https://doi.org/10.3109/10903127.2016.1168890.

Huang, Yueng-Hsiang, Michael Ho, Gordon S. Smith, and Peter Y. Chen. 2006. "Safety Climate and Self-Reported Injury: Assessing the Mediating Role of Employee Safety Control." *Accident; Analysis and Prevention* 38 (3): 425–33. https://doi.org/10.1016/j.aap.2005.07.002.

Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner. 2016. "Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments - Revised Criteria 2016." https://doi.org/10.26616/NIOSHPUB2016106.

James, C.A., A.J. Richardson, P.W. Watt, A.G.B. Willmott, O.R. Gibson, and N.S. Maxwell. 2017. "Short-Term Heat Acclimation Improves the Determinants of Endurance Performance and 5-Km Running Performance in the Heat." *Applied Physiology, Nutrition and Metabolism* 42 (3): 285–94. https://doi.org/10.1139/apnm-2016-0349.

Jay, Ollie, Matthew N. Cramer, Nicholas M. Ravanelli, and Simon G. Hodder. 2015. "Should Electric Fans Be Used during a Heat Wave?" *Applied Ergonomics* 46 (January): 137–43. https://doi.org/10.1016/j.apergo.2014.07.013.

Johnson, Richard J. n.d. "Fructokinase Activity Mediates Dehydration-Induced Renal Injury." Accessed March 18, 2021. https://core.ac.uk/reader/82660560.

Kearney, Gregory D., Hui Hu, Xiaohui Xu, Marla B. Hall, and Jo Anne G. Balanay. 2016. "Estimating the Prevalence of Heat-Related Symptoms and Sun Safety-Related Behavior among Latino Farmworkers in Eastern North Carolina.” *Journal of Agromedicine* 21 (1): 15–23. https://doi.org/10.1080/1059924X.2015.1106377.

Kenefick, Robert W., and Michael N. Sawka. 2007. “Hydration at the Work Site.” *Journal of the American College of Nutrition* 26 (5 Suppl): 597S-603S. https://doi.org/10.1080/07315724.2007.10719665.

Kiely, Michael, Giles Warrington, Adrian McGoldrick, and SarahJane Cullen. 2019. “Physiological and Performance Monitoring in Competitive Sporting Environments: A Review for Elite Individual Sports.” *Strength & Conditioning Journal* 41 (6): 62–74. https://doi.org/10.1519/SSC.0000000000000493.

King, Michelle A., Matthew D. Ward, Thomas A. Mayer, Mark L. Plamper, Clifford M. Madsen, Samuel N. Cheuvront, Robert W. Kenefick, and Lisa R. Leon. 2019. “Influence of Prior Illness on Exertional Heat Stroke Presentation and Outcome.” *PloS One* 14 (8): e0221329. https://doi.org/10.1371/journal.pone.0221329.

Kjellstrom, T., D. Briggs, Chris Freyberg, B. Lemke, M. Otto, and O. Hyatt. 2016. “Heat, Human Performance, and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts.” https://doi.org/10.1146/annurev-publhealth-032315-021740.

Kjellstrom, T., B. Lemke, M. Otto, O. Hyatt, and K. Dear. 2014. “Occupational Heat Stress Contribution to WHO Project on ‘Global Assessment of the Health Impacts of Climate Change’, Which Started in 2009.” https://www.semanticscholar.org/paper/31803cda808fb9cddf931380833b48abd6d6298a.

Kjellstrom, Tord, Chris Freyberg, Bruno Lemke, Matthias Otto, and David Briggs. 2018. “Estimating Population Heat Exposure and Impacts on Working People in Conjunction with Climate Change.” *International Journal of Biometeorology* 62 (3): 291–306. https://doi.org/10.1007/s00484-017-1407-0.

Kjellstrom, Tord, Ingvar Holmer, and Bruno Lemke. 2009. “Workplace Heat Stress, Health and Productivity – an Increasing Challenge for Low and Middle-Income Countries during Climate Change.” *Global Health Action* 2 (November). https://doi.org/10.3402/gha.v2i0.2047.

Kjellstrom, Tord, Bruno Lemke, Matthias Otto, Olivia Hyatt, Dave Briggs, and Chris Freyberg. n.d. “Threats to Occupational Health, Labor Productivity and the Economy from Increasing Heat during Climate Change:,” 8.

Lee, Junhyeong, Wanhyung Lee, Won-Jun Choi, Seong-Kyu Kang, and Seunghon Ham. 2019. “Association between Exposure to Extreme Temperature and Injury at the Workplace.” *International Journal of Environmental Research and Public Health* 16 (24). https://doi.org/10.3390/ijerph16244955.

Lim, Chin Leong, Gary Wilson, Lindsay Brown, Jeff S. Coombes, and Laurel T. Mackinnon. 2007. “Pre-Existing Inflammatory State Compromises Heat Tolerance in Rats Exposed to Heat Stress.” *American Journal of Physiology. Regulatory, Integrative and Comparative Physiology* 292 (1): R186-194. https://doi.org/10.1152/ajpregu.00921.2005.

Maresh, Carl M., Bulent Sökmen, Lawrence E. Armstrong, Joao C. Dias, J. Luke Pryor, Brent C. Creighton, Colleen X. Muñoz, et al. 2014. “Repetitive Box Lifting Performance Is Impaired in a Hot Environment: Implications for Altered Work-Rest Cycles.” *Journal of Occupational and Environmental Hygiene* 11 (7): 460–68. https://doi.org/10.1080/15459624.2013.875185.

Mattke, Soeren, Aruna Balakrishnan, Giacomo Bergamo, and Sydne J. Newberry. 2007. "A Review of Methods to Measure Health-Related Productivity Loss." *The American Journal of Managed Care* 13 (4): 211–17.

McCarthy, Ronda B., Frances S. Shofer, and Judith Green-McKenzie. 2019. "Outcomes of a Heat Stress Awareness Program on Heat-Related Illness in Municipal Outdoor Workers." *Journal of Occupational and Environmental Medicine* 61 (9): 724–28. https://doi.org/10.1097/JOM.0000000000001639.

McDermott, Brendon P, Douglas J Casa, Matthew S Ganio, Rebecca M Lopez, Susan W Yeargin, Lawrence E Armstrong, and Carl M Maresh. 2009. "Acute Whole-Body Cooling for Exercise-Induced Hyperthermia: A Systematic Review." *Journal of Athletic Training* 44 (1): 84–93.

McInnes, Judith Anne, Ewan M. MacFarlane, Malcolm R. Sim, and Peter Smith. 2018. "The Impact of Sustained Hot Weather on Risk of Acute Work-Related Injury in Melbourne, Australia." *International Journal of Biometeorology* 62 (2): 153–63. https://doi.org/10.1007/s00484-017-1435-9.

Mirabelli, Maria C., Sara A. Quandt, Rebecca Crain, Joseph G. Grzywacz, Erin N. Robinson, Quirina M. Vallejos, and Thomas A. Arcury. 2010. "Symptoms of Heat Illness among Latino Farm Workers in North Carolina." *American Journal of Preventive Medicine* 39 (5): 468–71. https://doi.org/10.1016/j.amepre.2010.07.008.

Mitchell, Diane C., Javier Castro, Tracey L. Armitage, Alondra J. Vega-Arroyo, Sally C. Moyce, Daniel J. Tancredi, Deborah H. Bennett, James H. Jones, Tord Kjellstrom, and Marc B. Schenker. 2017. "Recruitment, Methods, and Descriptive Results of a Physiologic Assessment of Latino Farmworkers: The California Heat Illness Prevention Study." *Journal of Occupational and Environmental Medicine* 59 (7): 649–58. https://doi.org/10.1097/JOM.0000000000000988.

Mix, Jacqueline, Lisa Elon, Valerie Vi Thien Mac, Joan Flocks, Eugenia Economos, Antonio J. Tovar-Aguilar, Vicki Stover Hertzberg, and Linda A. McCauley. 2018. "Hydration Status, Kidney Function, and Kidney Injury in Florida Agricultural Workers." *Journal of Occupational and Environmental Medicine* 60 (5): e253–60. https://doi.org/10.1097/JOM.0000000000001261.

Montain, S. J., and E. F. Coyle. 1992. "Influence of Graded Dehydration on Hyperthermia and Cardiovascular Drift during Exercise." *Journal of Applied Physiology (Bethesda, Md.: 1985)* 73 (4): 1340–50. https://doi.org/10.1152/jappl.1992.73.4.1340.

Morris, Nathan B., Timothy English, Lily Hospers, Anthony Capon, and Ollie Jay. 2019. "The Effects of Electric Fan Use Under Differing Resting Heat Index Conditions: A Clinical Trial." *Annals of Internal Medicine* 171 (9): 675–77. https://doi.org/10.7326/M19-0512.

Morris, Nathan B., Ollie Jay, Andreas D. Flouris, Ana Casanueva, Chuansi Gao, Josh Foster, George Havenith, and Lars Nybo. 2020. "Sustainable Solutions to Mitigate Occupational Heat Strain – an Umbrella Review of Physiological Effects and Global Health Perspectives." *Environmental Health* 19 (September). https://doi.org/10.1186/s12940-020-00641-7.

Morrissey et al.,. 2021. "Heat Safety in the Workplace: Modified Delphi Consensus to Establish Strategies and Resources to Protect U.S Workers." *GeoHealth*.

Morrissey, Margaret C., Gabrielle J. Brewer, Warren Jon Williams, Tyler Quinn, and Douglas J. Casa. 2021. "Impact of Occupational Heat Stress on Worker Productivity and Economic

Cost." *American Journal of Industrial Medicine*, September. https://doi.org/10.1002/ajim.23297.
Morrissey, Margaret C., Samantha E. Scarneo-Miller, Gabrielle E. W. Giersch, John F. Jardine, and Douglas J. Casa. 2021. "Assessing the Validity of Aural Thermometry for Measuring Internal Temperature in Patients With Exertional Heat Stroke." *Journal of Athletic Training*, January. https://doi.org/10.4085/1062-6050-0449.19.
Moyce, Sally C., and Marc Schenker. 2017. "Occupational Exposures and Health Outcomes Among Immigrants in the USA." *Current Environmental Health Reports* 4 (3): 349–54. https://doi.org/10.1007/s40572-017-0152-1.
Moyce, Sally, Jill Joseph, Daniel Tancredi, Diane Mitchell, and Marc Schenker. 2016. "Cumulative Incidence of Acute Kidney Injury in California's Agricultural Workers." *Journal of Occupational and Environmental Medicine* 58 (4): 391–97. https://doi.org/10.1097/JOM.0000000000000668.
Nerbass, Fabiana B., Roberto Pecoits-Filho, William F. Clark, Jessica M. Sontrop, Christopher W. McIntyre, and Louise Moist. 2017. "Occupational Heat Stress and Kidney Health: From Farms to Factories." *Kidney International Reports* 2 (6): 998–1008. https://doi.org/10.1016/j.ekir.2017.08.012.
Notley, Sean R., Andreas D. Flouris, and Glen P. Kenny. 2019. "Occupational Heat Stress Management: Does One Size Fit All?" *American Journal of Industrial Medicine* 62 (12): 1017–23. https://doi.org/10.1002/ajim.22961.
Notley, Sean R., Robert D. Meade, Andrew W. D'Souza, Gregory W. McGarr, and Glen P. Kenny. 2018. "Cumulative Effects of Successive Workdays in the Heat on Thermoregulatory Function in the Aging Worker." *Temperature: Multidisciplinary Biomedical Journal* 5 (4): 293–95. https://doi.org/10.1080/23328940.2018.1512830.
Nybo, Lars, Peter Rasmussen, and Michael N. Sawka. 2014. "Performance in the Heat-Physiological Factors of Importance for Hyperthermia-Induced Fatigue." *Comprehensive Physiology* 4 (2): 657–89. https://doi.org/10.1002/cphy.c130012.
Périard, J. D., S. Racinais, and M. N. Sawka. 2015. "Adaptations and Mechanisms of Human Heat Acclimation: Applications for Competitive Athletes and Sports." *Scandinavian Journal of Medicine & Science in Sports* 25 Suppl 1 (June): 20–38. https://doi.org/10.1111/sms.12408.
Piil, Jacob F., Jesper Lundbye-Jensen, Lasse Christiansen, Leonidas Ioannou, Lydia Tsoutsoubi, Constantinos N. Dallas, Konstantinos Mantzios, Andreas D. Flouris, and Lars Nybo. 2018. "High Prevalence of Hypohydration in Occupations with Heat Stress-Perspectives for Performance in Combined Cognitive and Motor Tasks." *PloS One* 13 (10): e0205321. https://doi.org/10.1371/journal.pone.0205321.
ROBERTS, KATHLEEN E. 1963. "Mechanism of Dehydration Following Alcohol Ingestion." *Archives of Internal Medicine* 112 (2): 154–57. https://doi.org/10.1001/archinte.1963.03860020052002.
Schlader, Zachary J., Daniel Gagnon, Eric Rivas, Victor A. Convertino, and Craig G. Crandall. 2015. "Fluid Restriction during Exercise in the Heat Reduces Tolerance to Progressive Central Hypovolaemia." *Experimental Physiology* 100 (8): 926–34. https://doi.org/10.1113/EP085280.
Smolander, J., K. Kuklane, I. Holmér, D. Gavhed, and H. Nilsson. 2004. "Effectiveness of a Light-Weight Ice-Vest for Body Cooling While Wearing Fire Fighter's Protective

Clothing in the Heat." *International Journal of Occupational Safety and Ergonomics* 10 (2): 111–17. https://doi.org/10.1080/10803548.2004.11076599.
Spector, June T., David K. Bonauto, Lianne Sheppard, Tania Busch-Isaksen, Miriam Calkins, Darrin Adams, Max Lieblich, and Richard A. Fenske. 2016. "A Case-Crossover Study of Heat Exposure and Injury Risk in Outdoor Agricultural Workers." *PloS One* 11 (10): e0164498. https://doi.org/10.1371/journal.pone.0164498.
Spector, June T., Jennifer Krenz, Miriam Calkins, Dawn Ryan, Jose Carmona, Mengjie Pan, Anna Zemke, and Paul D. Sampson. 2018. "Associations between Heat Exposure, Vigilance, and Balance Performance in Summer Tree Fruit Harvesters." *Applied Ergonomics* 67 (February): 1–8. https://doi.org/10.1016/j.apergo.2017.09.002.
Spector, June T., Yuta J. Masuda, Nicholas H. Wolff, Miriam Calkins, and Noah Seixas. 2019. "Heat Exposure and Occupational Injuries: Review of the Literature and Implications." *Current Environmental Health Reports* 6 (4): 286–96. https://doi.org/10.1007/s40572-019-00250-8.
"Sport and Physical Activity in the Heat - Maximizing Performance and Safety | Douglas J. Casa | Springer." n.d. Accessed March 19, 2021. https://www.springer.com/gp/book/9783319702162.
Sugg, Margaret M., Christopher M. Fuhrmann, and Jennifer D. Runkle. 2018. "Temporal and Spatial Variation in Personal Ambient Temperatures for Outdoor Working Populations in the Southeastern USA." *International Journal of Biometeorology* 62 (August): 1521–34. https://doi.org/10.1007/s00484-018-1553-z.
"Temperature, Workplace Safety, and Labor Market Inequality." n.d. *Equitable Growth* (blog). Accessed October 29, 2021. https://equitablegrowth.org/working-papers/temperature-workplace-safety-and-labor-market-inequality/.
"The Physiological Equivalent Temperature – a Universal Index for the Biometeorological Assessment of the Thermal Environment | SpringerLink." n.d. Accessed March 19, 2021. https://link.springer.com/article/10.1007/s004840050118.
Tigchelaar, Michelle, David S Battisti, and June T Spector. 2020. "Work Adaptations Insufficient to Address Growing Heat Risk for U.S. Agricultural Workers." *Environmental Research Letters* 15 (9): 094035. https://doi.org/10.1088/1748-9326/ab86f4.
Tustin, Aaron W., Dawn L. Cannon, Sheila B. Arbury, Richard J. Thomas, and Michael J. Hodgson. 2018. "Risk Factors for Heat-Related Illness in U.S. Workers: An OSHA Case Series." *Journal of Occupational and Environmental Medicine* 60 (8): e383–89. https://doi.org/10.1097/JOM.0000000000001365.
Tustin, Aaron W., Glenn E. Lamson, Brenda L. Jacklitsch, Richard J. Thomas, Sheila B. Arbury, Dawn L. Cannon, Richard G. Gonzales, and Michael J. Hodgson. 2018. "Evaluation of Occupational Exposure Limits for Heat Stress in Outdoor Workers - United States, 2011-2016." *MMWR. Morbidity and Mortality Weekly Report* 67 (26): 733–37. https://doi.org/10.15585/mmwr.mm6726a1.
Vanos, Jennifer K., and Andrew J. Grundstein. 2020. "Variations in Athlete Heat-Loss Potential Between Hot-Dry and Warm-Humid Environments at Equivalent Wet-Bulb Globe Temperature Thresholds." *Journal of Athletic Training* 55 (11): 1190–98. https://doi.org/10.4085/1062-6050-313-19.
Vega-Arroyo, Alondra J., Diane C. Mitchell, Javier R. Castro, Tracey L. Armitage, Daniel J. Tancredi, Deborah H. Bennett, and Marc B. Schenker. 2019. "Impacts of Weather, Work

Rate, Hydration, and Clothing in Heat-Related Illness in California Farmworkers." *American Journal of Industrial Medicine* 62 (12): 1038–46. https://doi.org/10.1002/ajim.22973.
Weatherly, John W., and Mattson A. Rosenbaum. 2017. "Future Projections of Heat and Fire-Risk Indices for the Contiguous United States." *Journal of Applied Meteorology and Climatology* 56 (4): 863–76. https://doi.org/10.1175/JAMC-D-16-0068.1.
Yang, Xinglin, Haiting Wu, and Hang Li. 2020. "Dehydration-Associated Chronic Kidney Disease: A Novel Case of Kidney Failure in China." *BMC Nephrology* 21 (1): 159. https://doi.org/10.1186/s12882-020-01804-x.