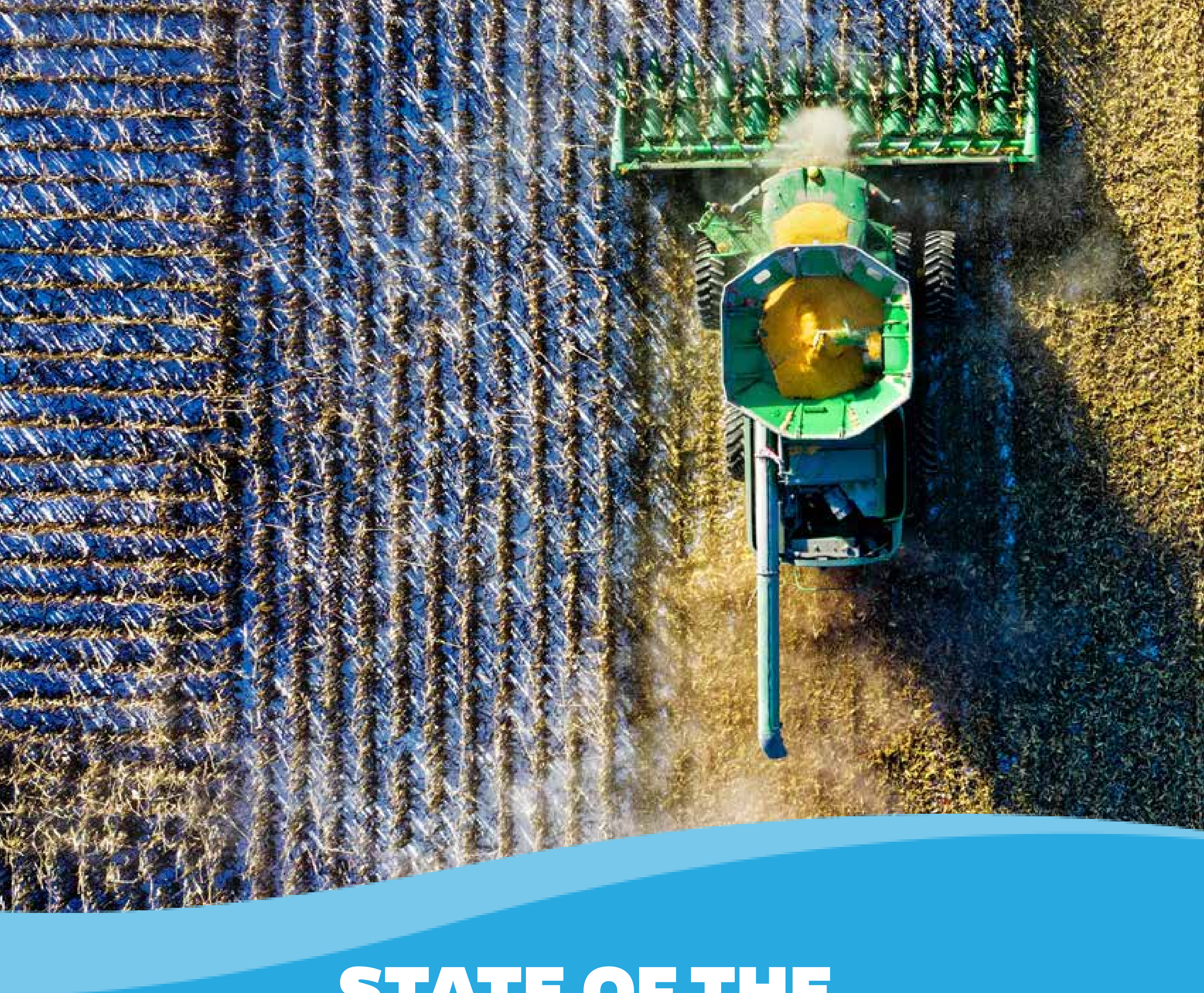

STATE OF THE SCIENCE MEETING

State of the Science White Paper: Interdisciplinary Perspectives on Heat Related Illness Prevention

Southeastern Coastal Center for Agricultural Health and Safety

Rachel Claire Mitchell, Tracy A. Irani, Farah A. Arosemena, Thomas E. Bernard, Joseph G. Grzywacz, Linda A. McCauley, Valerie Mac, Eric Coris, Rebecca M. Lopez, Candi D. Ashley, Michael N. Sawka, Vasubandhu Misra, Beatrice Pierre, and J. Glenn Morris

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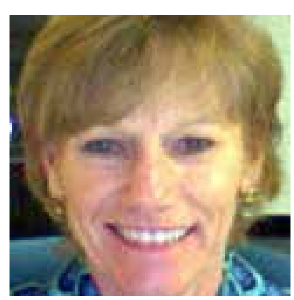

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For More Information Contact the Southeastern Coastal Center for Agricultural Health and Safety at http://sccahs.org/contact/

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Contents

Executive Summary

Background

Between 2000-2010, 28.6% of deaths due to heat related illness (HRI) in occupational settings occurred in six states in the Southeast. HRI is and will continue to be a major issue affecting outdoor workers. Climate models predict a 2.2°F (1.2°C) rise in temperatures in the continental United States, and that the number of days per year that achieve temperatures above 95 degrees will increase in Florida and the Southeast from 15 days per year from 1971-2000, to over 75 days per year 2041-2070. Additionally, HRI will take a toll on industry in the Southeast, with annual losses in productivity equivalent to $47 billion predicted by 2090. There is a need for collaborative, multi-disciplinary research to protect worker health and mitigate productivity losses in outdoor industries. The issue of HRI among outdoor workers, including agricultural workers, athletes, and military personnel, will continue to become more prominent. Farmworkers are particularly vulnerable, and are 20 more times more at risk of death due to HRI than other American workers. Farmworkers work long hours outdoors, are paid based on productivity rather than hourly wages, and have low political capital and fewer worker protections than many sectors of the US workforce. There is therefore a need for collaborative, multi-disciplinary research and education approach to protect worker health and mitigate productivity losses in outdoor industries.

Meeting Summary

To address this need, the Southeastern Coastal Center for Agricultural Health and Safety (SCCAHS) organized the HRI State of the Science meeting, held October 25-26, 2018. The meeting was held in St. Petersburg, Florida. The focus of the meeting was to bring together a slate of eight esteemed presenters on this topic, showcasing research at the intersections of heat related illness and climate as they relate to the health and safety of outdoor workers and farmworkers, as well as athletes and military personnel. This crosscutting, one day meeting brought together researchers from various fields to present current findings and begin the process of developing future research collaborations on this topic. Meeting attendees represented four universities, federal agencies, medical institutions, and consulting organizations.

Key Findings

Preventing HRI

The responsibility for preventing HRI lies both with organizations that employ workers, as well as with workers themselves. Many risk factors can be mitigated on both the organizational and individual level to decrease worker susceptibility to HRI.

Organizational Level

On the organizational level, employers can provide appropriate acclimatization periods, work to rest ratio, access to fluid and rehydration, and recognize, treat and manage HRI. Acclimatization refers to the period of time needed for the body to adjust to working in the heat. According to National Institute of Occupational Safety and

Health (NIOSH) and Occupational Safety and Health Administration (OSHA) recommendations, workers should begin with a decreased workload, as low as 20% of a normal workload, and slowly increase the workload over a period of five to six days. Dehydration affects many outdoor workers. In one SCCAHS study, almost all farmworkers were found to be dehydrated at the end of the workday, and half of them reported HRI symptoms (McCauley, 2018). In the athletics world, studies find that dehydration decreases athletic performance and psychomotor function. Football players lose 9.4 liters of water through daily sweat loss, and 12.2 liters of water consumption is needed to compensate. The Centers for Disease Control and Prevention (CDC) recommends that people working the heat should hydrate before, during, and after work, drinking a cup of water every 20 minutes, taking care to not drink more than one quart per hour to prevent hyperhydration.

The most common HRI conditions, from least severe to most severe, include heat cramps, heat exhaustion and heat stroke. Heat stroke is a medical emergency requiring medical attention, so recognition of the symptoms distinguishing HRI conditions is recommended among both employers and workers. While there are conflicting recommendations about how to administer heat stroke first aid, State of the Science meeting presenters recommended that victims be cooled with ice baths to lower core body temperatures. In the athletic setting, when heat stroke has been recognized promptly and the victim has been cooled aggressively on-site, there is a 100% survival rate (Korey Stringer Institute, 2019). After a worker is affected by HRI, they should be reintroduced to work activities with caution. Sports associations recommend a seven- to 21-day rest period for athletes with slow progression of intensity of work activity.

Individual Factors Influencing HRI

Medications that workers take for chronic diseases have been found to increase risk for HRI. These medications include anticoagulants, cardiovascular medicines, antipsychotics, antidepressants and anticholinergic agents (skeletal muscle relaxants). Alcohol can increase risk for HRI as well. Chronic diseases like cardiovascular diseases, skin disorders, viral infections can be HRI risk factors, along with physical fitness and obesity. Finally, individual behaviors can lead to HRI, like lack of hydration, sleep deprivation and alcohol use.

Research Recommendations

Research recommendations for further study of HRI include dissemination of consistent recommendations for heat stroke first aid, intervention testing, medical analysis, and economic analysis. At the HRI State of the Science meeting, multiple presenters recommended that ice baths are so important in medical response to heat

stroke that ice water and tarps should be included in farm first aid kits. However, some top internet searches and CDC resources recommend cooling victims of heat stroke with cool, not ice, water. Consistent recommendations could save lives during heat stroke first aid. Intervention testing is also a research need to address HRI. While SCCAHS has funded two research and two pilot projects that evaluate HRI interventions, more intervention testing is needed, especially technological interventions to measure worker body temperature to alert them when they are in danger, as well as clothing that protects against pesticide exposure while also keeping workers cool. From a medical perspective, there are interesting research possibilities involving the relationship between gut bacteria, heat stress and inflammation. Finally, research is needed to explore HRI prevention among farmworkers makes them more productive. The practical recommendations in this white paper are not mandated by law, resulting in both employers and workers ignoring HRI symptoms in some cases. Economic analysis would investigate if acclimatized, well-rested, hydrated workers were more productive, giving workers and employers both health and financial incentives to protect workers from HRI. Conversely, it is also important to conduct research to determine the extent to which possible productivity loss and workmen's compensation claims related to HRI episodes affect profitability.

Background

Heat Related Illness in the Southeast

The occupational risks for farmworkers, fishers and forestry workers in the coastal Southeast arenumerous. These individuals work outdoors in all kinds of weather, leading to major concerns in Florida, other Southern states and the Caribbean about the impact of heat stress on workers, particularly in light of increases in the number of days annually with temperatures above 90 degrees F in the Southeast (USGCRP, 2017). Climate models predict that annual average temperatures in the lower 48 states will rise by about 2.2°F (1.2°C) over the next few decades (USGCRP, 2017). Of the ten states with the highest rate of deaths due to heat related illness, six are located in the Southeast, and between 2000 and 2010, 28.6% of deaths due to HRI in occupational settings occurred in these six Southeastern states. The Southeast is predicted to incur the largest HRI-related productivity losses in the country, with annual losses in over 570 million labor hours (equal to $47 billion dollars) by 2090 (USGCRP, 2017). Although a baseline temperature shift would affect all populations, vulnerable populations most adversely affected by HRI include the elderly, the poor, and individuals who work outdoors, including agricultural workers, construction workers, military personnel, and firefighters (Balbus & Malina, 2009). To address these occupational risks, government agencies issue guidelines on exposure limits to heat to protect these workers, as well as recommendations for periods of acclimatization and reacclimatization for workers exposed and re-exposed to high temperatures. Similarly, sports federations have issued recommendations for competition at high temperature thresholds, which include breaks for athletes and suspension of play (Racinais, Alonso, Coutts, Flouris, Girard, González-Alonso, ... & Nassis, 2015).

Risk to Farmworkers

The most recent estimates from the National Agricultural Workers Survey (NAWS) survey estimate approximately 2.4 million farmworkers are employed in the production of plant and animal commodities. This workforce is made up primarily of Latino workers, who have migrated from areas of Mexico and Central America. Currently 82% of farmworkers in the U.S. are Latino, and just over 50% of farmworkers lack legal authorization to work in the U.S. Farmworkers are a vulnerable, medically underserved and health disparate population (Arcury & Quandt, 2007; Villarejo, 2003; Villarejo & Baron, 1999).

The combination of ethnic minority, foreign-born status and legal liminality conspire with occupational marginality to create a "perfect storm" of vulnerability and poor health outcomes. The U.S. Centers for Disease Control and Prevention (CDC) suggests the death rate for heat illness is 20-times greater for farmworkers in crop production than the general U.S. worker (Luginbuhl et al., 2008). Farmworkers have been identified as a vulnerable occupational group that is at 20 times higher risk for heat related deaths compared to other occupational groups (May, 2009). The Occupational Safety and Health Administration (OSHA) outlined HRI prevention strategies for workers, but the lack of occupational control and bargaining power impedes farmworkers' ability to implement recommended strategies despite consistent occupational disparities in heat-related mortality (Arcury, et al., 2010). Farmworkers often lack the ability to modify their work environments, may not have access to shade or adequate drinking water in the fields, and are typically paid according to volume harvested, with little incentive to take frequent work breaks (Flocks et al., 2013; Runkle et al., 2013; Zierden & Griffin, 2014).

Background on the Southeastern Coastal Center for Agricultural Health and Safety (SCCAHS)

SCCAHS was established in 2016 as part of a Centers for Disease Control and Prevention (CDC) / National Institute for Occupational Safety and Health (NIOSH) Agricultural Health and Safety Initiative. SCCAHS explores and addresses the occupational safety and health needs of people working in agriculture, fishing, and forestry in Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Puerto Rico, and the U.S. Virgin Islands. SCCAHS focuses specifically on the unique environments and occupational communities of this region (e.g., hot, humid climate and coastal/coastal plains with farming andfishing and timber). SCCAHS is a multidisciplinary partnership of academic institutions, community organizations, and industry representatives that brings together individuals and organizations that are already pursuing academic and applied basic research, intervention, translational, and outreach solutions for occupational illness and injuries. SCCAHS provides centralized regional infrastructure where these individuals, organizations and companies can engage in mutual learning, leverage resources, build on previous efforts of colleagues, and promote new research.

Meeting Objectives

SCCAHS organized the HRI State of the Science meeting, held October 25-26, 2018, in St. Petersburg, Florida. The focus of the meeting was to bring together a slate of esteemed presenters on this topic, showcasing research at the intersections of heat related illness and climate change as they relate to the health and safety of outdoor workers and farmworkers, as well as athletes and military personnel. This crosscutting, one day meeting brought together researchers from various fields to present current findings and begin the process of developing future research collaborations on this topic. This white paper is based on a summary analysis of the meeting's findings, the audience for which includes meeting attendees, SCCAHS stakeholders, scientists, public agencies and policymakers.

Four objectives guided the development of the State of the Science meeting. The first was to bring together researchers from different academic backgrounds to share scientific information and research strategies about HRI prevention, detection, treatment, effects and education. The second was to determine future directions for heat related illness research in the Southeast. The third was to discuss potential for collaborations across disciplines. The fourth was to determine successful strategies for communicating scientific findings on HRI with researchers, educators, and agricultural workers.

Meeting Summary

Methods

The HRI State of the Science Meeting consisted of a poster session on the evening of October 25, followed by a full day on site meeting on October 26. Eight presenters, drawn from the fields of agricultural safety and health, sports medicine and defense/ military presented their work to an invited audience of research colleagues, center stakeholders and students. Presentations are described below.

After each presentation, participants were given the opportunity to ask questions. Dr. Glenn Morris then facilitated a panel discussion which consisted of the eight presenters. Finally, Dr. Lisa Lundy, a University of Florida faculty member and a communication researcher with SCCAHS, facilitated a focus group discussion about science communication in the context of HRI.

All of the presentations were recorded and transcribed. Data was collected from a variety of sources, including online sign-in sheets, meeting presentations, participant observation, presentation abstracts, notes from presentation question and answer sessions, and notes from the panel discussion. These data were organized according to theme and category and details are summarized below.

Attendees

After a date for the State of the Science meeting was decided, the Outreach Core sent invitations to researchers who were solicited to submit SCCAHS pilot projects, University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) administration, NIOSH Education and Research Centers, IFAS researchers, NIOSH Ag Center Directors, and other occupational medicine researchers. Meeting presenters were also encouraged to invite students and researchers. Participants included students and faculty from the University of South Florida, Florida Department of Health, Occupational Safety and Health Administration, medical institutions, consulting organizations and SCCAHS staff, including members of the Research, Outreach and Planning and Evaluation Cores.

Presentation and Discussion Summary

Desribing HRI

Heat stress is based on environmental conditions, metabolic rate, and clothing (Ashley, 2018.) The three main types of HRI are heat exhaustion, heat injury, and heat stroke (Sawka, 2018). Heat exhaustion is the inability to sustain adequate cardiac output with moderate to high body temperature, and heat injury describes injuries to the liver, kidneys, muscle tissue and gut tissue with high body temperature. Heat stroke is the most dangerous (often fatal) condition, involving central nervous system dysfunction along with organ and tissue injury with high body temperatures above 40.5oC. There are two main types of heat stress (Table 1). Classic heat stroke is described as "passive", meaning HRI is caused by heat in the environment, while exertional heat stroke is cause by physical activity, often occurring in a hot environment.

Table 1: Classic vs. Exertional Heat Stroke (Sawka & O'Connor, 2016).

Patient Characteristics	Classic	Exertional
Age	Young & Elderly	15-55 years
Health	Chronic Illness	Usually Healthy
Weather	Heat Waves	Variable
Activity	Sedentary	Strenuous Activity
Drug Use	Diuretics, Antidepressants, Anticholingergics, Antipsychotics	Ergogenic Stimulants, Cocaine
Sweating	Often Absent	Common
Fever	Unusual	Common
Acute Renal Failure	Uncommon	Common (15%)
Rhabdomyolsis	Uncommon	Common (25%)
DIC	Mild	Marked

Scope of the Problem of Heat Related Illness

Between 2000-2010, there were 359 heat related deaths in the U.S, accounting for .22 per 1 million workers. The greatest period of risk for HRI is May to September, with the majority of these deaths occurring between June-August during the hours of noon and 6 p.m. (Lopez, 2018). Construction workers are at 13 times the risk from HRI than other American workers, while agricultural workers face 35 times the risk of heat-related death. (Gubernot et al., 2015). Between 2007and 2011, there were 8,315 heat-related emergency department visits and inpatient hospitalizations in the Southeast U.S., and in Florida, there were 8.5 emergency department visits, 1.1 hospitalizations, and 0.1 deaths per 100,000 workers (approximately 3 deaths) between 2005-2012 (Bernard, 2018). Some of these injuries and deaths could be explained by the fact that out-of-state workers are not well acclimated to heat and humidity in the Southeast, and many cases occur on the first few days of heat exposure. Additionally, those with co-morbidities are at more risk for HRI. Despite this, many employers had no heat illness prevention program (Morano, Bunn, Lackovic, Lavender, Dang, Chalmers, Li Y, & Flammia, 2015).

Climate Implications

Dr. Vasu Misra's presentation, entitled Heat Related Illness in a Changing Climate and Demography of Florida, explained Florida's unique situation as a state with a booming population, that has increasing odds of experiencing extreme weather events, including storms, droughts, and flooding due to climate change. The Social Vulnerability Index (SoVI) shows that populations in Florida experience a combination of high exposure and high sensitivity to the effects of climate change and low capacity to deal with them (Misra, 2018). Models predict that the number of days per year that achieve temperatures above 95 degrees will increase in Florida and the Southeast from 15 days per year from 1971-2000, to over 75 days per year 2041-2070 (Ingram, Dow, Carter, & Anderson, 2013; Carter, Terando, Dow, Hiers, Kunkel, Lascurain, Marcy, Osland, & Schramm, 2014). Models also predict drier and hotter inland climates and more storms in coastal climates.

Affected Populations

The effects of heat exposure in outdoor workers can have adverse health consequences when untrained and unprepared. There is ample evidence for the increase in heat related illness related to ambient conditions of temperature and humidity. A plethora of research states that the physiological strain associated with work in elevated temperatures can cause fatigue, weakness, dizziness, fainting and cognitive impairment; all symptoms of heat exhaustion. Studies investigating instances of delivering first aid, hospital treatments and fatalities have all found that heat and humidity are directly related to these situations. Among farmworkers in Florida, studies have reported repeated observations of high and excessive heat strain, and there is strong evidence that heat stress occurring one day can carry over consequences to the following day. Additionally, there is evidence that heat and humidity can cause an increase in acute injuries caused by accidents, and these accidents can affect not just human safety, but have environmental and economic implications pertaining to toxins in the environment and equipment damage.

Farmworkers

Agricultural workers are 20 times more at risk for heat related death than other American workers. The majority of agricultural work in fruit, vegetable, and dairy production is done by farmworkers.

Farmworkers are individuals involved in agricultural production, including planting, cultivating, harvesting, and processing crops for sale, and caring for animals (Arcury & Quandt, 2009). The vast majority, 82%, of farmworkers are Latino, from Mexico and Central America. Despite this, however, not all farmworkers are the same. Some workers have settled in the U.S., with and without legal status. Some of these domestic workers have established permanent homes in one place and work in agriculture on a seasonal basis. Some domestic workers are migrants and follow the harvests with their families as the season progresses beginning, in Southern states and working their way north. Other workers obtain legal H2A guest visas to work on a contractual basis with producers for up to nine months out of the year, after which they return to their home country.

Dr. Linda McCauley's studies profiling HRI in farmworkers found that nearly all of the workers who participated had progressive dehydration over a day. Whether workers arrived at their job well-hydrated or dehydrated, almost all of them were at least mildly dehydrated – with over 10% severely dehydrated - when they were finished for the day. Half of the workers reported symptoms of heat disorder, and a quarter of the workers had body core temperatures over 38.5 degrees C for 22 minutes of the day and many much longer. A body temperature of 38.5 degrees C is on the tipping point of crossing into temperatures in which dangerous heat illnesses occur—it shows that workers are under heat stress and it is at this point that work activities must stop in order to avoid HRI. that could turn dangerous with small environmental or personal changes. Additionally, one fifth of the workers had high sustained heart rates, indicating high work demands plus heat stress. There was no association between the level of activity during the workday and heat index, indicating that the participants work just as intensely on hotter days.

McCauley's current research focuses on Chronic Kidney Disease of Unknown Etiology (CKDu). CKDu affects agricultural workers around the globe, but has been well-documented in the sugar cane industry, specifically. It primarily affects young men in seemingly good health, but who end up with a need for dialysis in their 30's and 40's. In Central America alone there have been over 20,000 premature deaths due to CKDu.

In the California Heat Illness Prevention Study (CHIPS), which took place from 2012-2015, 12% of their 295 participants sustained acute kidney injury (AKI) over the course of one day at work. In McCauley's research, 36% of participants had the criteria indicating AKI on at least one workday. Of these participants, 32% had stage 1 AKI on at least one workday; 3% had stage 2 AKI on at least one workday, and 0.4% had stage 3 AKI on at least one workday. The odds of AKI increased 22% for each five beats per minute increase in mean heart rate, and the odds increased 37% for each five degree increase in mean heat index (°F).

Athletes

HRI significantly impacts athletes, though it is dramatically underreported. HRI is the third leading cause of death among high school athletes. While hot and humid climate, obesity, low physical fitness, lack of acclimatization, previous incidence of heat stroke, and lack of sleep all can affect the occurrence of HRI, dehydration also plays a major role. Athletes sometimes experience fluid loss that accounts for 6-10% of their bodyweight, and is one of the most common risk factors for athletes who exercise in hot, humid conditions. With every 1% of bodyweight lost due to dehydration, core body temperature can rise an additional 0.15-0.2 degrees C. Identifying athletes at risk, limiting environmental exposure, and monitoring closely for signs and symptoms are all important components of preventing heat illness.

United States Armed Forces Personnel

Heat stress is a ubiquitous military problem during training and operations due to the environment, clothing / equipment and required work intensities (Department of Army, 2003). Heat stress can impair physical work capacity due to a multitude of physiological mechanisms (Nybo, Rasmussen, & Sawka, 2014), which can then progress in severity and induce a spectrum of heat related illnesses (Sawka, Leon, Montain, & Sonna, 2011). The military have incorporated doctrine to manage heat strain to optimize physical performance and abate serious heat illness (Department of Army, 2003; NATO, 2013), however despite these efforts heat illness hospitalizations and deaths continue to be a serious military problem despite imprecision in epidemiological data (Carter, Cheuvront, Williams, Kolka, Stephenson, Sawka, & Amoroso, 2005; DeGroot, Mok, & Hathaway, 2017). The military is continually considering low-tech technologies (DeGroot, Kenefick, & Sawka, 2015; Buller, Welles, & Friedl, 2017) and high-technology (Convertino & Sawka, 2017) approaches to abate heat strain and maintain fluid-electrolyte balance (Charkoudian, Kenefick, Lapadula, Swiston, Patel, Blanchard, ... & Cheuvront, 2016).

Risk Factors for HRI

Both employers and individuals have responsibilities in preventing HRI. While employers, sports teams managers, and military officials will never be able to control environmental temperatures, they can provide organizational framework to prevent HRI. These factors can be managed to allow outdoor workers to adjust to the heat, rest when necessary, and replenish fluids. Both workers and employers can be trained to recognize and respond to symptoms of HRI, and have protocol to return workers to the field after suffering from HRI.

On an individual level, certain characteristics put populations more at risk for HRI. These populations include the young and elderly, those who use medications and/or alcohol, those with chronic health conditions, and those who engage in strenuous physical activity. Individuals also have a responsibility for their own behaviors that can put them at risk for HRI, including hydrating before, during, and after work, getting a full night's sleep, and preventing hangovers. Individuals can control some of these risk factors, but other risk factors are incommutable and should be considered in occupational settings.

There are also situational risk factors for HRI, which neither employers nor employees can control. Illnesses like fever and gastrointestinal sicknesses can increase a worker's susceptibility to HRI. Risk for HRI increases for individuals who worked in the heat the day before, or who have previously suffered from HRI. One important distinction among agricultural work is the piece rate pay structure. Many farmworkers are paid based on the amount of produce they can harvest. This kind of incentive pay is a risk factor, because when people are paid by piece rate then they may be more likely to ignore the onset of heat related illness symptoms in order to keep working. Additionally, employee-provided worker housing typically does not have air conditioning, so workers are exposed to warm temperatures even out of work.

Exposure limits are guidelines for those who work in heat. They describe the maximum amount of heat and workload that workers can be exposed to (Tustin, Lamson, Jacklitsch, Thomas, Arbury, Cannon, ... & Hodgson, 2018). Exposure limits are only based on job risk factors, which include the environment, work demands, and type of clothing worn. Exposure does not take organizational or individual risk factors into account, which include acclimatization state, fitness, and health status. Most individuals can work safely within the exposure limits, and in fact, many can work in conditions above the limits. However, the margin of safety for an individual is very narrow and it does not take much to tip the scales toward a heat related illness. Workers can benefit from training to educate them about risk factors that they face to prevent HRI.

Organizational Risk Factors

Acclimatization

Physiological changes in the body occur as people become used to working in the heat, but these changes do not occur immediately. Physiological changes due to increased acclimatization include decreased core temperature at a given workload, lower threshold for the onset of sweating, greater sweat rate, reduced oxygen demand, and decreased perceived exertion (Ashley, 2018). Individuals who are physically fit acclimatize more easily as the benefits of enhanced cardiorespiratory fitness is similar to those of acclimatization. A number of agencies have developed acclimatization guidelines for workers in hot environments (Table 2).

Ashley (2018) and Lopez (2018) both presented that the adjustment period takes three to six days to fully acclimatize to heat, depending on temperature, time spent working in a hot environment, workload, and previous experience working in the heat (See Table 2). These data are drawn from Ashley and Lopez' recent research, and have yet to be published.

Table 2: Agency Acclimatization Guidelines (Ashley, 2018)

Agency	Acclimatization Guide
Occupational Safety and Health Administration (OSHA)	5 days beginning with 50% workload; increase to 100% by day 5
National Institute for Occupational Safety and Health (NIOSH)	New/inexperienced employees: 5 days beginning with 20% workload; increase 20% each day Experienced employees: 5 days beginning with 50% workload; increase to 100% by day 5
Mining Safety and Health Administration (MSHA)	6 days beginning with 50% workload; increase 20% each day

Table 3: Recommendations for Heat Acclimatization for Warm Conditions (Ashley, 2018; Lopez, 2018)

Recommendations for Heat Acclimatization for Warm Conditions						
	Light Work (125-275 W)		Moderate Work (275-375 W)		Hard Work (375-475 W)	
WBGT °F	Time spent working in hot environment	Heat acclimatization days	Time spent working in hot environment	Heat acclimatization days	Time spent working in hot environment	Heat acclimatization days
78-81.9	90-100%	2-3 days	70-100%	3-5 days	50-100%	6 days
82-84.9	80-100%	2-4 days	70-100%	3-5 days	50-100%	6 days
85-87.9	70-100%	3-5 days	60-100%	4-6 days	50-100%	6 days
88-89.9	60-100%	4-6 days	50-100%	6 days	50-100%	6 days
90+	50-100%	6 days	50-100%	6 days	50-100%	6 days

Workers can lose acclimatization when not exposed to heat, and there is an adjustment period when they are reintroduced into a hot environment. This adjustment period depends on how many days the worker was absent from the heat, and whether that absence was routine or was due to heat related illness. (Table 4).

Table 4. Recommendations for Re-Acclimatization for Warm Conditions (Ashley, 2018)

Recommendations for Re-Acclimatization for Warm Conditions

		GREEN				
Routine absence	Absence due to illness	Day 1	Day 2	Day 3	Day 4	Day 5
< 4	--	100				
4-5	1-3	90	100			
6-12	4-5	80	90	100		
12-20	6-8	60	80	90	100	
> 20	> 8	50	60	80	90	100

		YELLOW				
Routine absence	Absence due to illness	Day 1	Day 2	Day 3	Day 4	Day 5
< 4	--	90	100			
4-5	1-3	80	90	100		
6-12	4-5	70	80	90	100	
12-20	6-8	60	70	80	90	100
> 20	> 8	50	60	70	80	90

		RED				
Routine absence	Absence due to illness	Day 1	Day 2	Day 3	Day 4	Day 5
< 4	--	80	90	100		
4-5	1-3	60	80	90	100	
6-12	4-5	50	60	80	90	100
12-20	6-8	50	60	70	80	90
> 20	> 8	50	60	70	80	90

Federal agencies have issued their own re-acclimatization guidelines as well.

Table 5: Re-acclimatization Guidelines (Ashley, 2018)

Agency	Re-acclimatization Guide
Occupational Safety and Health Administration (OSHA)	5 days after 2 weeks away
National Institute for Occupational Safety and Health (NIOSH)	4 days begin with 50% work load
Mining Safety and Health Administration (MSHA)	4 days after 8 days away

Work to Rest Ratio

Work to rest ratio is another key risk factor to HRI, in particular, exertional heat stroke. Increases in core body temperature occur as a result of metabolic heat production due to work intensity combined with environmental conditions. When this work is performed in hot and humid conditions, the body's ability to dissipate heat is impaired, and there is an even greater need to allow rest breaks to attenuate the rise in core body temperature. Incorporating a structured work to rest ratio in the industrial setting can help decrease the risk of exertional heat stroke by allowing the worker's body to minimize the metabolic heat production from the work, allowing their core body temperature to decrease before beginning work again. The piece rate issue seen with agricultural workers often leads workers to work continuously without breaks, which combined with other HRI risk factors is a perfect storm for exertional heat stroke. Therefore, if set work to rest ratios could be established based on level of acclimatization, environmental conditions, and work intensity, the risk of exertional heat stroke with this population would be decreased. Furthermore, whether or not this safety policy can be implemented without negatively affecting the amount of pay workers are able to earn should be considered (i.e. despite allowing breaks, there is still an opportunity to earn money safely).

Access to Fluid and Rehydration

Dr. Eric Coris presented about how HRI affects susceptible populations, such as those who play competitive outdoor sports. Athletes can have tremendous fluid losses through a day of competition in the heat and humidity. In extreme conditions under heavy exertion, players can experience as much as 9.4 liters of daily sweat losses, requiring as much as 12.2 liters of daily fluid consumption necessary to compensate.

Effort should be made to begin a session of exercise in the heat adequately hydrated. Prehydrating with 500 ml of water 2 hours prior to exercise is a reasonable practice to attempt to prevent pre-exertion hypohydration. Fluid consumption to minimize body mass losses during participation in the heat appears to be important in decreasing physiologic consequences of hypohydration. Fluid consumption is critical, as risk of heat related illness and decrements in athletic performance increase with hypohydration.

Recommendations to prevent HRI for collegiate football players include estimating fluid losses through sweat through several practices and customizing intake to offset hypohydration, trying to minimize losses during an exercise session to less than 2% body mass loss. When no data is initially available, consuming 8 oz (250 ml) every 15 minutes is a reasonable consumption goal until further data is available (CDC, 2017a). Finally, post-exercise hydration, with 20 ounces of fluid per pound of weight loss during participation can assist in recovering significant fluid losses from the preceeding event. For shorter duration events, with less electrolyte losses, rehydrating with cool, clean water is reasonable. For longer events, more than 2 hours with higher sweat losses, replacing lost electrolytes becomes increasingly important. Overhydrating with water, after significant electrolyte loss has occurred, can result in dangerous hyponatremia and must be avoided. For longer events in the heat, a carbohydrateelectrolyte beverage (sports drink) would be an appropriate way to replace electrolyte losses simultaneously with the fluid deficit.

Fluid consumption is critical, as athletic performance appears to decrease with hypohydration. In one study of runners, for example, 2% dehydration led to increased times and decreased running velocity in 1500-10000m distances. Similarly, another study found that less than 2% fluid deficits were associated with significantly decreased performance on psychomotor tests, and decreased performance was progressive with the degree of dehydration. Among college basketball players, fluid deficits of 2% trend towards decreases in the 30 second jump test and inaccuracy with free throw shooting, as well as increased heart rate.

Recognition and Treatment of HRI

Response to heat stress is a major component of preventing injury and death due to HRI. Dr. Rebecca Lopez (2018) outlined symptoms and treatment for three heat related illnesses: exercise-associated muscle cramps (i.e. heat cramps); heat exhaustion; and heat stroke.

Heat cramps- Recognition of heat cramps includes identifying symptoms, including visible muscle group cramping, localized pain, thirst, dehydration, sweating, and fatigue. Heat cramps must be differentiated from sickle cell trait muscle pain, which is not caused by heat exposure. Initial treatment of heat cramps includes rest, passive stretching, and ice massage. If an individual's sodium is depleted, he or she should consume fluids and food containing sodium.

Heat exhaustion- Recognition of heat exhaustion includes identifying symptoms like fainting or collapse with normal body temperature. Heat exhaustion is a circulatory failure, and its symptoms include heavy sweating, cold clammy skin, and fast, weak pulse, among other symptoms. First aid for heat exhaustion includes moving the victim to a cooler area, loosening clothes and taking a cool or ice bath, cooling the skin with water cool cloths, and rehydrating with sips of water (CDC, 2017b).

Heat Stroke- Heat stroke is the most severe exertional heat illness, and is considered a medical emergency. It is the result of metabolic heat production and environmental heat load, resulting in excessive heat production and/or inhibited heat loss (Lopez, 2018). Heat stroke is defined by hyperthermia, with body temperatures over 105oF/ 40.5oC. It is associated with central nervous system and potential for multiple organ system failure, which can lead to death. Victims of heat stroke show signs of confusion, a high body temperature over 103 degrees, hot, red, dry or damp skin, and a fast, strong pulse, among other symptoms. For heat stroke, immediate emergency medical response is necessary. While waiting for paramedics, those with the victim should move the him or her out of the heat and into shade, remove outer clothing, and place cold cloths on the head, neck, armpit and groin. Again, the CDC gives conflicting recommendations about using ice baths to cool victims of heat stroke (CDC, 2017b; CDC, 2017c). However, Dr. Eric Coris, Dr. Rebecca Lopez and Dr. Michael Sawka all recommended immediate, aggressive cooling using ice baths.

If a worker's temperature is above 105oF, removing clothing and applying cold cloths will like result in long-term complications or death. Death from heat stroke only occurs when the victim is not cooled aggressively enough. Deaths are attributed to misdiagnosis due to lack of or inaccurate temperature readings; no care or delay in care; inefficient cooling modality; and immediate transport.

Return to Work, Training, and Activity after HRI

The American College of Sports Medicine (ACSM) developed recommendations for athletes returning to play for all HRI. Victims of HRI should refrain from exercise for at least seven days following release from medical care, and follow up one week after the incident for physical examination, as well as lab testing or diagnostic imaging of the affected organs based on a clinical course of the HRI incident. Once cleared, the individual can begin activity in a cool environment and gradually increase duration, intensity and heat exposure over two weeks to demonstrate heat tolerance and acclimatization. If return to vigorous activity is not accomplished in four weeks, physicians can consider a laboratory exercise-heat tolerance test. The individual achieves full medical release if he or she is heat tolerant after two to four weeks of full activity.

The National Athletic Trainers Association (NATA) released similar guidelines relating to returning to play. NATA recommends a 7 to 21 day rest period, normal blood work results, physician clearance, and progression of physical activity. Physicians evaluating the individual's health should observe signs/symptoms of heat tolerance and gradual increase in exercise demands, but all activity should be supervised by a healthcare/medical professional. Importantly, progression of intensity of activity should be slowed, delayed or stopped if any signs or symptoms are experienced.

Heat cramps and heat exhaustion have different follow up treatments that lead to individuals returning to activity (Lopez, 2018). Before a victim of heat cramps can be cleared to return to activity, the cause of the cramps should be determined. Electrolyte depletion, fatigue, or a combination of both can cause cramps, and the individual should be educated about proper hydration, as well as the effects of diet and exercise on cramp prevention.

The first step for follow up treatment for heat exhaustion is to determine the cause of the episode. Causes of heat exhaustion include fluid and sodium depletion, lack of heat acclimatization, and exercise or activity demands that do not match fitness level. The presence of heat stroke must be ruled out, and the cause of event should be eliminated or modified.

A crucial lesson from the sports medicine field is the early recognition and treatment of heat related illness. Response time and aggressive cooling are critical factors in the recovery of heat related illness, and indeed is the only way to prevent death in the case of a heat stroke. Lopez (2018) recommends having a plan for how to treat HRI on-site. Determining initial causes of HRI is key to treatment and implementation of a return to work protocol.

Individual Factors Affecting HRI

Medications

Anticoagulants, cardiovascular medicines, antipsychotics, antidepressants and anticholinergic agents have been found to be high risks factors for HRI. Kalish et al. (2016) found a significantly higher risk of incident hospital admissions for dehydration or HRI in patients that have been taking such medicines. In addition, among cardiovascular medicines, angiotensin-converting enzyme inhibitors (ACEI) combined with diuretics were found to be the two most dangerous risks, because they both decrease an individual's thirst and fluid intake and thereby decrease their body thermoregulation. Alcohol use highly correlated with hospital admission for dehydration or HRI (Pryor, Bennett, Brad, O'Connor, Young, & Chad, 2015).

Medical History

Personal medical history can also be an individual risk factor for HRI. Pryor et. al (2015) pinpointed chronic diseases such as cardiovascular diseases, skin disorders, viral infections as HRI risk factors. If these conditions are not well-managed, they can weaken the immune system's capacity to cope with temperature rise. Illnesses like fever and gastrointestinal afflictions can also affect an individual's susceptibility to HRI (Lopez, 2018). Finally, physical fitness, including obesity, can make an individual more prone to suffering from HRI.

Individual Behaviors

Workers themselves can reduce risk factors associated with HRI. Hydration, sleep deprivation, and alcohol use can all increase an individual's risks for HRI (Lopez, 2018). Other intrinsic factors can include inadequate heat acclimatization, overzealousness (piece rate pay), fever or other illness, high work intensity or low physical fitness (Casa, DeMartini, Bergeron., Csillan, Eichner, Lopez, ... & Yeargin, 2015). Only some of the intrinsic risk factors associated with HRI can be modified. However, education of how some of these factors can increase the risk of HRI can help lessen the chance of HRI. For example, educating workers about their fluid needs can ensure that they arrive to work in a hydrated state and maintain their hydration status throughout their work shift. Education about how the lack of breaks or pushing through while ignoring signs and symptoms of HRI can lead to a fatal case of heat stroke may help the workers have a better understanding of how they can better manage their hydration, sleep, and breaks throughout the work day.

Practical Recommendations

Organizational Actions to Prevent HRI

Based on research and recommendations from State of the Science presenters, CDC, NIOSH, and athletics, SCCAHS recommends the following to employers to decrease risk factors for HRI among their workers.

- Provide a five- to six-day acclimatization period for workers who have just begun working in the heat, starting workers at 20 50% workload, and increase the workload over the acclimatization period.
- Provide appropriate work to rest ratio.
- Encourage workers to drink small amounts of water every 20 minutes, consuming about one quart of water every hour.
- Design a protocol for returning a worker to the field after experiencing HRI, providing for a seven- to 21-day rest period based on the severity of the illness. Return workers to work at lower exertion levels, and gradually build workload with close attention paid to potential HRI symptoms.

Individual Actions to Prevent HRI

Workers have a responsibility to drink water to stay hydrated before, during, and after work. Because sleep deprivation and alcohol use can increase risks for HRI, workers should do their best to get a full night's sleep and prevent hangovers. Additionally, both workers and employers need awareness that worker medications, physical fitness, acute illnesses and chronic illnesses can affect their health.

Recognizing HRI Symptoms and HRI Emergency Response

Both workers and employers can watch for symptoms of HRI in the field, and need training on how to do so. The most important HRI to be aware of is heat stroke—it is a medical emergency and can be deadly without treatment. SCCAHS recommends that employers develop an emergency response plan to educate workers and crew leader about what to do in HRI emergency, and to keep tarps and ice on the worksite to create ice baths for workers suffering from heat stroke.

Research Recommendations

Conflicting HRI Response Recommendations

Recommendations for immediate response to HRI differ. At the State of the Science meeting, multiple presenters talked about how ice baths can save the lives of heat stroke victims awaiting emergency response. Indeed, presenters recommended that farm crews keep a tarp and ice available on site as a part of a first aid kit to respond to victims of heat stroke. However, the CDC offers conflicting recommendations for how to immediately address heat stroke. Some published resources say to cool the victim with ice or ice baths if possible, while other resources actively discourage that practice. Top internet searches from popular sources like www.mayoclinic.org and www.webmd.com advise to cool the victim with cool water, not ice water in the case of HRI emergency (Mayo Clinic, 2018; WebMD, 2018).

There is a need for consistent recommendations and disseminationof accurate and current information to save lives in situations in which agricultural workers of all types (farmers, farm workers, nursery and landscape workers, fishers and forestry workers) need to depend on non-medical personnel to act as first responders.

Intervention Testing

SCCAHS has begun research to test both behavioral and technological interventions. The PISCA: Pesticide & Heat Stress Education for Latino Farmworkers that is Culturally Appropriate project is evaluating the effectiveness of an HRI curriculum used to educate farmworkers about HRI using regionally- and culturally-specific elements. Another SCCAHS research project, Using Social Marketing to Prevent HRI and Improve Productivity Among Farmworkers, evaluates the effectiveness of a social marketing approach to behavior change to help farm labor supervisors be more effective change agents with their workers. This approach utilizes the crew leader's position to help them model and encourage good safety behaviors among the workers they supervise to implement HRI safety practices and compliance with regulations. The Pilot Study of Mobile App Monitoring to Prevent Heat-related Symptoms Among Hispanic Farmworkers project tests and evaluates an OSHA mobile application among migrant and seasonal farmworkers to reduce the risk of HRI, and assess the feasibility of recruiting farmworker crew leaders to train-the-trainer intervention and measure implementation of the health intervention. Another SCCAHS pilot project, A Novel Approach (Sweat Patches) to Monitoring Pesticide Exposure in Farmworkers develops and assesses the accuracy and precision of laboratory techniques used to measure pesticides and their metabolites from sweat patches; documents challenges and problems experienced by farmworkers in using sweat patches; and determines the levels and variance in concentrations of pesticides and metabolites obtained from sweat to those obtained from urine.

Despite this HRI research occurring at SCCAHS and at other NIOSH Ag Centers around the country, there is still a need for further interventions testing. Some ideas that came out of the HRI State of the Science meeting included the development of clothing for farmworkers that protect them from pesticide exposure but also keep them cool. Other technological ideas included technological interventions like a wearable temperature button that would alert workers when their core body temperature rose into a danger zone, and a pill that workers can swallow to measure core body temperatures throughout the day.

Medical Analysis

SCCAHS has funded one research project that focuses on medical analysis, Heat Stress and Biomarkers of Renal Disease. In this project, researchers are investigating hypotheses regarding the increase in occurrence of Chronic Kidney Disease (CKD) in agricultural workers in Mesoamerica. The potential mechanism for this increase remains elusive; it may be associated with working in hot environments causing recurrent dehydration leading to decreased renal blood flow, high demands on tubular reabsorption, and increased levels of uric acid or possible activation of the fructokinase pathway. These underlying processes may result in chronic tubular injury and fibrosis. In this study, the research team is measuring physiological indicators of HRI in farmworker populations in Florida, incorporating a metabolomics approach to enhance understanding of pathways through which perturbation of renal function occurs. This research team proposes to determine if biomarkers of renal damage

shown in Mesoamericans are also present among farmworkers residing in the U.S. that immigrated from Mexico to work in agriculture.

Dr. Linda McCauley, the PI on this project, called for further research involving metabolomic analysis of workers with heat exposure and investigation of heat exposure and the microbiome. New approaches for understanding the cellular mechanisms and interplay between biochemical and organ systems that underlie clinical symptoms of illness are becoming available. Data from these types of studies can provide a deeper understanding of HRI and set the scientific basis for targeted interventions for HRI. In addition, there is increasing evidence in the literature of that translocation of bacteria from the gut into the bloodstream plays a role in the etiology of the inflammatory response that accompanies HRI (Lim, 2018; Armstrong, Lee, & Armstrong, 2018). Examination of the interplay between gut bacteria, heat stress, and inflammation is an area of inquiry that is timely and necessary for ameliorating the adverse health effects of working in the heat.

Economic Analysis

Productivity is a major motivator for employers, who must rigorously manage costs and efficiencies in order to keep producing the food the nation depends on. There is a need for more economic analysis to investigate how HRI among farmworkers affects their abilities to harvest at optimum rates, and to test whether HRI prevention activities, like proper acclimatization, hydration, and work to rest ratio, can increase productivity.

Conclusions

The Southeast is and will continue to be affected by climate change. Rising temperatures mean outdoor workers in our region will be exposed to more extreme environments. While athletes, military personnel, and farmworkers are all affected working in the heat, farmworkers do not have access to the same resources, worker protections, and medical care. We need solutions for HRI for all outdoor workers, especially low-cost technologies and trainings to protect farmworkers, who drive our food system, yet who are most at risk.

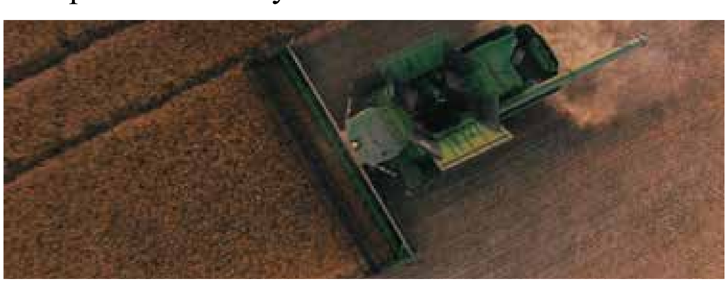
Appendix

Presentation Abstracts

Occupational Heat Stress Exposure, Assessment: Limits on Sustainable Exposures

Thomas Bernard- Professor, College of Public Health, and Sunshine Education and Research Center (ERC), University of South Florida

Occupational heat stress is a well-known, under-appreciated workplace hazard. Heat stress assessment is based on the job risk factors of environment, metabolic rate and clothing. The widely accepted Association Advancing Occupational and Environmental Health© (ACGIH) threshold limit values© (TLVs) and NIOSH recommended exposure limits (REL) for heat stress assessment use wet bulb globe temperature (WBGT), metabolic rate and clothing adjustments to the ambient WBGT. Among others, the ACGIH© TLV© and NIOSH REL for occupational exposure limits are based on the premise that the exposure can be sustained for long periods of (e.g., four or more hours). This history of the approach and a re-analysis of the data provide insight to the sensitivity, specificity, and odds ratio for the risk of unsustainable exposures. Clothing adjustment values to WBGT started in the 1980s. A series of studies considered five clothing ensembles, three relative humidities and three metabolic rates. The proposed clothing adjustment values (CAVs) were robust for most clothing, over a range of humidity and metabolic rates. These studies confirmed the basic exposure limits based on Lind and extended them to other than woven work clothes through CAVs. With more attention on outdoor workers and greater use of Heat Index, the data used to evaluate the ACGIH© TLV© and NIOSH REL can be used to explore the ability of Heat Index to serve a



protective function. Recent work from OSHA also suggests an alert threshold for outdoor work.

Acclimatization, Decay, and Re-Acclimatization

Candi Ashley- Professor, Exercise Science, University of South Florida

Acclimatization, a process whereby an individual gradually becomes accustomed to work in the heat, is one of the most important means of decreasing heat strain and preventing exertional heat illness. Occupational exposure limits for heat stress generally assume workers are heat acclimatized. In a study looking at heat-related illness in agricultural workers, lack of acclimatization was attributed to a number of heat-related illnesses and fatalities. A 2014 report looking at 20 cases of heat-related illness or death among workers found that an acclimatization program was often missing. This may be due to the projected loss of productivity during an acclimatization program, and thus the reluctance to set aside days for the acclimatization process.

Establishing and adhering to heat policies and heat acclimatization guidelines is imperative in ensuring worker safety. Acclimatization guidelines often consist of modifying the number of days for acclimatization based on individual differences, the duration of the heat exposure, work intensity, the amount of protective equipment worn. For example, an industrial setting that mandates the use of protective clothing for worker safety can utilize a heat acclimatization protocol that ramps up the amount of time the worker is exposed to the extreme environment or the work intensity or expected work output. Monitoring the environment by measuring the wet-bulb globe temperature

(WBGT) or heat index (HI) allows individuals supervising workers to modify other factors that may increase the risk of heat illness. Also, determination of the rate of loss of acclimatization with days away from the heat could help determine the time needed for re-acclimatization.

Management & Return to Work/Activity Following Exertional Heat Illness
Rebecca Lopez- Program Director, Athletic Training Professional Program, University of South Florida

The risk of HRI is evident when individuals are working in hot environments. A heat safety protocol should be in place to not only prevent HRI but to also have a plan of action for the management of HRI should one occur. It is essential that the heat safety protocol also include a return to activity protocol once HRI symptoms have resolved. This protocol should consist of how to gradually and safely return an individual back to work or activity in the heat and prevent the reoccurrence of HRI. The purpose of this presentation is to present the latest evidence on the immediate management of HRI as well as the factors that should be considered and addressed when an individual that has experienced HRI returns to activity in the heat. Immediate management and the return to activity following exercise-associated muscle cramps, heat syncope, heat exhaustion and exertional heat stroke will be discussed.

Attending to Heat Illness & Pesticide Exposure among Farmworkers: Results from an Attention Placebo-Controlled Design
Joseph Grzywacz- Chair, College of Human Sciences, Florida State University and SCCAHS PI

The objective of the PISCA Project is to determine the effectiveness of educational curricula for improving knowledge and attitudes pertaining to pesticide exposure and heat illness among immigrant Latino farmworkers. A pesticide safety curriculum meeting requirements for the revised Agricultural Worker Protection Standard (WPS) was tested against an attention placebo-controlled curriculum (heat illness) in a sample of Latino farmworkers (N=127). Analyses compared pre-test to post-test changes in pesticide and heat illness knowledge, attitudes (i.e., perceived severity and self-efficacy) about pesticides and heat illness, and behavioral intentions to engage in preventive behaviors. Results thus far show that pesticide safety knowledge significantly increased from pre-test to post-test in the overall sample, but did not differ for farmworkers assigned to the pesticide safety curriculum relative to those assigned to the heat illness curriculum. Behavioral intentions related to pesticide safety increased among participants in the WPS pesticide safety curriculum, but these behavioral intentions decreased among those in the heat illness safety curriculum ($p < .05$). Heat illness knowledge and behavioral intentions related to heat illness prevention increased more for farmworkers assigned to the heat illness curriculum relative to those assigned to the pesticide safety curriculum. The PISCA Project concludes that the developed curricula show good promise for meeting the spirt of the revised WPS and for reducing the burden of heat-related fatality and morbidity among farmworkers, most of whom are immigrant.

The Girasoles (Sunflower) Study: Exploring the Physiologic Heat Stress Response
Linda McCauley- Dean, School of Nursing, Emory University and SCCAHS PI

For the last 10 years, Emory University and the Farmworker Association of Florida have partnered to address the occupational health needs of the

agricultural workers in Florida. From the initial work that examined the 3 main hazards faced by this vulnerable population (heat hazards, chemical hazards, and ergonomic hazards), the health impacts of working in the heat was identified by the Farmworker Association of Florida as a key and timely issue for in-depth study. Through this process, the Girasoles Study was developed which examined the physiologic heat stress response of agricultural workers in 5 communities across the state of Florida. Through a 3-day protocol, participants wore heat biomonitoring equipment to capture body core temperature, heart rate, worksite temperature, and physical activity. Participantsalso provided blood and urine samples for the determination of hydration levels and basic metabolic lab values. Survey data included self-reported heat-related illness symptoms and work practices. This presentation will discuss key results from this work as well as describe future directions and recent findings in the examination of heat stress and acute kidney injury.

Heat Illness Prevention in Athletes

Eric Coris- Director, Primary Care Sports Medicine, University of South Florida

Dramatically underreported, heat-related pathology contributes to significant morbidity as well as occasional mortality in athletic, elderly, pediatric and disabled populations. Among US high school athletes, heat illness is the third leading cause of death. Significant risk factors for heat illness include dehydration, hot and humid climate, obesity, low physical fitness, lack of acclimatization, previous history of heat stroke, and sleep deprivation, among others. Dehydration, with fluid loss occasionally as high as 6-10% of bodyweight, appears to be one of the most common risk factors for heat illness in patients exercising in the heat. Core body temperature has been shown to rise an additional 0.15-0.2 degrees C for every 1% of bodyweight lost to dehydration during exercise. Identifying athletes at risk, limiting environmental exposure, and monitoring closely for signs and symptoms are all important components of preventing heat illness. However, monitoring hydration status and early intervention may be the most important factors in preventing severe heat illness. Our heat team developed a 12 point heat illness symptom index scale to evaluate heat illness symptom burden in a large team of exercising athletes on an ongoing basis. There were statistically significant correlations of the scale score with weight loss during practice, rating of perceived exertion, player position, and ambient heat index, as hypothesized. As a clinical and research community, we continue to struggle with optimal prediction, assessment, treatment, and prevention of heat-related illness in the exercising athlete or worker. Further study is needed on the pathophysiology of heat-related illness and the optimal prevention measures to mitigate occupational heat-related stress.

Heat related illness in a changing climate and demography of Florida

Vasubandhu Misra- Professor, Earth, Ocean and Atmospheric Sciences, Florida State University

This presentation discussed the challenges of a future changing climate with a changing demography on coping with heat related illness in Florida. A prime example of such complex interactions comes from the tragic deaths in the aftermath of Hurricane Irma in 2017 of senior citizens who were in a nursing home in Hollywood, Florida. The talk will show the results of climate projections and trends over Florida and the potential risks they pose. This will be juxtaposed with a population report of the current and future trends to set up potential scenarios of heat related illness threats.

Exertional Heat Illness: Physiology, Pathology, and Modifying Factors

Michael Sawka- Professor, Biological Sciences, Georgia Tech University

Physical exercise in the heat is associated with a thermoregulatory burden (hyperthermia from elevated skin, core and tissue temperatures) that mediates cardiovascular challenges which can impair tissue perfusion, alter metabolism and contribute to fatigue and serious HRI. Serious HRI includes heat exhaustion, heat injury, and heatstroke.

Heat exhaustion is defined as a syndrome of hyperthermia that occurs during or immediately after exertion in the heat, accompanied by minor central nervous system dysfunction (headache, dizziness, mild confusion), which resolve with intervention. It is primarily a cardiovascular event (insufficient cardiac output) frequently accompanied by sweaty hot skin, dehydration, and collapse. Heat injury is a moderate to severe illness characterized by hyperthermia with evidence of damage to end organs (e.g., liver, renal, gut) and tissues (e.g., rhabdomyolysis) without sufficient neurologic symptoms to be diagnosed as heatstroke. Heatstroke is a severe illness (often life-threatening) characterized by profound mental status changes with high body temperatures, usually but not always higher than 40.5° C (104° F). Heatstroke is often categorized as classic or exertional; classic heatstroke is observed primarily in otherwise sick and compromised individuals, and exertional heatstroke is observed primarily in apparently healthy and physically fit individuals during or after vigorous exercise. In heatstroke, neuropsychiatric impairments (e.g., marked confusion, disorientation, combativeness, and seizures) develop early and can be complicated by liver damage, rhabdomyolysis, disseminated intravascular coagulation, water and electrolyteimbalance, and renal failure. In fulminant heat stroke, patients have the full spectrum of abnormalities associated with the systemic inflammatory response syndrome.

HRI can occur in low-risk individuals who have taken appropriate precautions relative to situations to which they have been exposed in the past. Historically, such unexpected cases were attributed to dehydration (which impairs thermoregulation and increases hyperthermia and cardiovascular strain), but it is now suspected that a previous heat exposure or a concurrent event (e.g., sickness or injury) might make these individuals more susceptible to HRI, which is called the "Multiple Hit Hypothesis". Precautions to sustain exercise-heat performance and mitigate the risk of HRI include maintaining adequate hydration, being heat acclimated and managing the exercise-heat exposure. Heat acclimation is specific to the type and intensity of the heat stress; and induces physiological adaptations that improve thermoregulation, attenuate physiological and psychological strain. The physiological adaptations include improved sweating, improved skin blood flow, lowered body temperatures, improved blood pressure regulation, improved fluid balance, altered metabolism, and enhanced cellular protection.

Notes

Notes

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