

RESEARCH ARTICLE

Summarizing Recommendations for the Prevention of Occupational Heat-Related Illness in Outdoor Workers

A Scoping Review

Ashley Edgerly, PhD, BSN, RN¹ , Gordon Lee Gillespie, PhD, DNP, RN, FAAN¹, Amit Bhattacharya, PhD, CPE¹, and Beverly M. Hittle, PhD, RN, FAOHN¹

Abstract: *Background:* Outdoor workers face unique challenges in preventing heat-related illnesses (HRI). Although preventable, HRI and death from heat exposure continue. A review of the most recent recommendation for HRI prevention in outdoor workers in the United States was warranted. A scoping review using PRISMA guidelines was conducted to compile policy statements and recommendations on the prevention of HRI and synthesize them into a three-step plan for prevention using the Haddon Matrix. *Method:* PubMed, CINAHL, Medline, and websites from organizations and regulating bodies were searched for sources. Key terms such as occupational OR workers OR employers OR policymakers, HRI OR heat stress OR heat, prevention, recommendations OR position statements were used. Inclusion criteria were articles published within the last 5 years written in English and containing recommendations for preventing HRI in outdoor workers. Research not based on U.S. workers was excluded from the review. *Results:* Twenty sources comprised the review. Several themes emerged, indicating deficient recommendations for secondary and tertiary prevention. *Conclusion/Application to Practice:* This review's findings can be used by occupational health nurses (OHNs) in developing comprehensive interventions for preventing HRI and injury, using clear language, and following evidenced-based practices to increase workplace health and safety and promote equity.

Keywords: occupational heat-related illness, prevention, recommendations, farmworkers, occupational health nurse

Background

Climate change is projected to increase global temperatures; heat waves are expected to increase in duration and severity, severe and damaging storms and droughts are becoming more frequent, and air pollution is expected to increase (National Aeronautics and Space Administration [NASA], 2021). It is also causing an increase in food insecurity and displacement (Gamble et al., 2016). Protecting workers now and in the future from the consequences of climate change is imperative.

Outdoor workers face a unique set of challenges in their everyday routines, engaging in work that is often physically strenuous, where the climate is uncontrolled. Outdoor workers are disproportionately affected by climate change as they have to endure heat waves or other outdoor events such as increased air pollution (Gamble et al., 2016). Due to climate change, average and extreme temperatures are rising, and heat waves are becoming more common (NASA, 2021, putting outdoor workers, especially those with physically demanding jobs, at a higher risk for HRIs; Gamble et al., 2016).

Heat-related illness (HRI) is deadly to workers. In fact in the United States, there were 436 work-related deaths caused by heat between 2011 and 2023, and most deaths by heat occur during the first 3 days on the job (Arbury et al., 2016; Bureau of Labor Statistics, U.S. Department of Labor, 2023). Moreover, the majority of heat-related deaths in the United States are outdoor workers (Roelofs, 2018). HRI can also cause long-term effects such as neurological, cardiovascular, hepatic, hematologic, and renal damage (Adnan Bukhari, 2023).

Plans to prevent and treat HRI are needed to mitigate adverse outcomes. This scoping review had a twofold purpose:

Phases	Factors		
	Human (Employee)	Vector (Employer)	Environment (Policy)
Pre-event (Primary Prevention)			
Event (Secondary Prevention)			
Post-event (Tertiary Prevention)			

Figure 1. Haddon Matrix Example

Note. This figure depicts an example of the Haddon Matrix with the labels used by Haddon (1980). It has three phases: the pre-event, event, and post-event phases, and three factors: human, vehicle or vector, and environment.

(a) compile policy statements and recommendations from research, government and regulating bodies, and other organizations concerned with the prevention of occupational HRI in the United States and (b) synthesize them into a three-step plan for prevention and injury interventions based on the Haddon Matrix (Haddon, 1980).

Method

The Haddon Matrix is a tool for reducing injuries by assisting in developing strategies and planning for risk reduction (Haddon, 1980). The Haddon Matrix has two dimensions. The first is the time phases: pre-event, event, and post-event. The second dimension comprises host, vector, and environment-influencing factors (Haddon, 1980). In this review, the event was defined as occupational HRI stratified into primary (pre-event) recommendations for the prevention of HRI, secondary (event) recommendations, and tertiary (post-event) recommendations. The host is the worker, the vector is the employer, and the environment is the policy. Figure 1 depicts the original phases and factors of the Haddon Matrix with our use of them in parentheses.

Search Strategy

A scoping review was used following Arksey and O'Malley's (2005) five-stage methodological framework. The framework includes identifying the research question, identifying relevant literature, selecting the included studies, charting the data, which includes sorting information according to themes and reporting the results. We adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews (Tricco et al., 2018). See Figure 2, depicting the PRISMA 2020 Flow Diagram, showing our process of identifying and synthesizing the recommended prevention measures for HRI. A literature search and review of websites from leading

authorities on occupational HRI were used to identify relevant literature published from January 2018 through March 2023. Searches occurred for HRI prevention recommendations within the last 5 years, with the results from all sources compiled. The search began with PubMed, CINAHL, and Medline using key terms such as *occupational* OR *workers* OR *employers* OR *policymakers*, *HRI* OR *heat stress* OR *heat*, *prevention*, *recommendations* OR *position statements*. We limited the searches to exclude sources published before 2018 to obtain the most up-to-date recommendations.

The searches returned 175 records. Searches on PubMed occurred using the MeSH string ("Heat Stress Disorders" [MeSH Terms] OR "Heat Stress Disorders" [MeSH Major Topic]) AND "occupational groups" [MeSH Terms] AND ("Accident Prevention" [Mesh] OR "prevention and control" [Subheading] OR "Tertiary Prevention" [Mesh] OR "Primary Prevention" [Mesh] OR prevent*[tiab])). Searches on CINAHL Plus with Full Text and Medline with Full Text included the search string (*heat stress* or *thermal stress* or *hyperthermia*) AND (*prevention* or *intervention* or *treatment* or *program* or *control* or *strategy* or *management*) AND (*workers* or *employees* or *staff* or *personnel* or *worker*) AND (*recommendations* or *guidelines* or *best practice* or *suggestions*).

We searched the websites of authority organizations and regulating bodies including the Environmental Protection Agency, Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), American College of Occupational and Environmental Medicine, American Industrial Hygiene Association, and American Association of Occupational Health Nurses for position statements, guidelines, or recommendations and identified six records. Citation searches returned five more records.

We reviewed titles and abstracts for inclusion and exclusion criteria. Inclusion criteria were articles and position statements

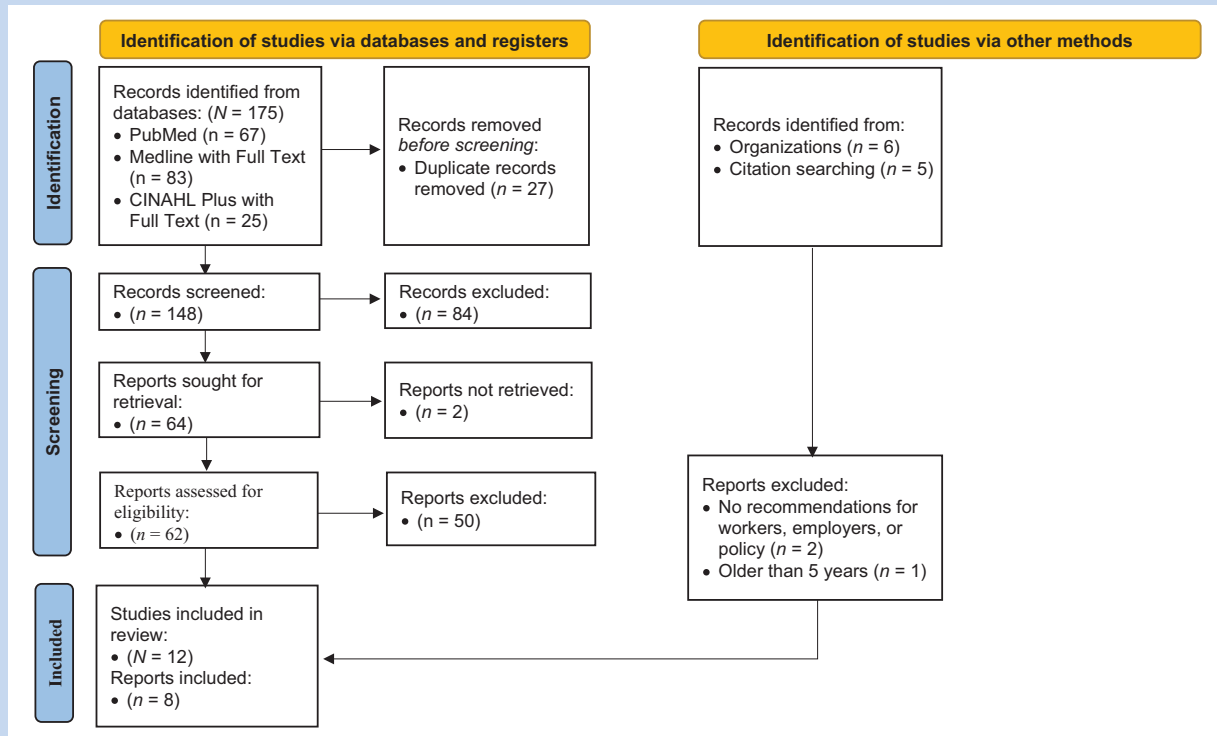


Figure 2. PRISMA 2020 Flow Diagram for New Systematic Reviews

Note. The diagram includes searches of databases, registers, and other sources.

containing recommendations for preventing HRI in workers. Because our focus is on policy statements and recommendations for U.S. workers, we excluded articles not focused on workers in the United States. Additional sources excluded were those without results for policy, employer, or employee HRI prevention, as uncovering this information was the purpose of this review.

Analysis

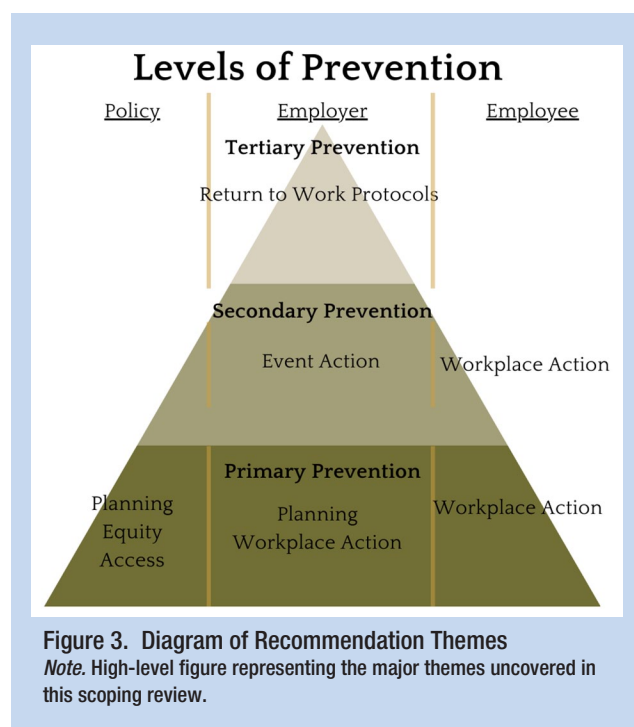
We compiled the recommendations and policy statements into an extraction table, separating the data by whom the recommendation was for worker, employer, or policy. Data on the population and setting were collected when relevant. Other data included in the table were the first author and date, source type, and study design.

We read the data line by line and coded them into themes using thematic analysis guidelines (Braun & Clarke, 2006). The thematic analysis process involves familiarizing oneself with the data, creating initial codes, searching for themes, reviewing themes, defining and naming themes, and generating a report (Braun & Clarke, 2006). Generating an initial extraction table familiarized us with the data. Coding was done line by line to generate initial codes. The codes were then sorted into themes that were then defined and named.

Next, the data underwent additional coding in line with the three levels of prevention with the Haddon Matrix format (Haddon, 1980; Table 2). The table presented the recommendations in three categories (or columns): policymakers, employers, and employees. The recommendations were further split by phases (rows) into primary, secondary, and tertiary prevention. We summarized the data to increase comprehension for potential consumers' ease of access and use while maintaining the experts' essential information and details.

Results

The final analysis included 20 sources: 17 articles and 3 organizational statements. We identified 192 recommendations from the sources. Many of the sources' recommendations addressed employers $n = 14$ (Centers for Disease Control and Prevention [CDC], 2018; Dong et al., 2019; Hesketh et al., 2020; Langer et al., 2021; Luque et al., 2020; Methner & Eisenberg, 2018; Morrissey et al., 2021; National Safety Council [NSC], 2022; Smith et al., 2021; Sol et al., 2021; Tustin et al., 2018; Wang et al., 2019). While 11 sources had recommendations aimed at policy (American Industrial Hygiene Association [AIHA], 2023; Arcury et al., 2019; Bartman et al., 2022; Chavez Santos et al., 2022; Dong et al., 2019; Hesketh et al., 2020; Langer et al., 2021; NSC, 2022; Vega-Arroyo et al., 2019), only four included



recommendations for workers (CDC, 2018; Methner & Eisenberg, 2018; Morrissey et al., 2021; Smith et al., 2021). See Figure 3 for a diagram of the recommendation themes. The population focus and location in the research articles varied (see Table 1).

Primary Recommendations

Prevention at the Policy Level

We identified three major themes for prevention at the policy level within primary recommendations: *planning*, *equity*, and *access*. The first theme, *planning*, addressed mandated heat standards, tailored and individualized plans, and data- and science-led plans. While some sources just recommended that heat standards be mandated, others suggested recommendations for their development, such as wording or topics, including surveillance, training, and reporting (AIHA, 2023; Arnold et al., 2020; Bartman et al., 2022; Dong et al., 2019; Langer et al., 2021; NSC, 2022; Vega-Arroyo et al., 2019). Tailored and individualized plans had recommendations for addressing individual factors that could affect HRI, such as health, age, culture, and behavior; labor/task or work rates; and environmental temperatures (Arnold et al., 2020; Bartman et al., 2022; Chavez Santos et al., 2022; Langer et al., 2021). Data- and science-driven recommendations included the use of research, and data collection through wearable devices, documentation, and other means (AIHA, 2023; Bartman et al., 2022; Dong et al., 2019; Hesketh et al., 2020).

The second theme, *equity*, addressed pay structures and reporting barriers. Recommendations included addressing

factors related to pay structure (Chavez Santos et al., 2022; Vega-Arroyo et al., 2019). Piece rate pay is commonly used to compensate farmworkers, and workers' pay is based on the amount they harvest instead of paying an hourly wage (National Farm Worker Ministry, 2020). Sources also recommended encouraging reporting and addressing the barriers to reporting (Chavez Santos et al., 2022; NSC, 2021). Access encompassed recommendations to improve access to resources such as healthcare and prevention measures (Bartman et al., 2022). Some recommendations for reducing barriers to prevention included providing restroom access to ensure workers can hydrate adequately (Chavez Santos et al., 2022).

Prevention at the Employer Level

Two themes emerged regarding employer recommendations: *planning* and *workplace action*. *Planning* comprised comprehensive HRI plans, emergency action plans, training and education, tailoring and individualizing, and acclimatization. Recommendations addressing comprehensive HRI plans included suggestions for plans to be written and comprehensive, including training environmental assessments and forming an employee work group to assist in developing policies and procedures (Luque et al., 2020; Methner & Eisenberg, 2018; Morrissey et al., 2021; NIOSH, 2018; NSC, 2022; Smith et al., 2021; Tustin et al., 2018).

The sources' recommendations for emergency action plans consisted of implementing an emergency action plan and suggestions of what the plan should include (Morrissey et al., 2021; NSC, 2022; Tustin et al., 2021). Recommendations included what types of education and training should be given and suggestions for how and when to provide it (CDC, 2018; Dong et al., 2019; Luque et al., 2020; Methner & Eisenberg, 2018; Mizelle et al., 2022; Morrissey et al., 2021; NSC, 2022; Smith et al., 2021; Tustin et al., 2021; Wang et al., 2019). Some examples include annual training, which is easily understood and incorporates components including recognition and risks of HRI, prevention measures, how to perform first aid, and acclimatization (Morrissey et al., 2021; Tustin et al., 2021).

Recommendations under the subtheme tailoring and individualizing prevention included tailoring interventions to personal and environmental factors such as underlying health conditions and medications that impact HRI risk, job demands, personal protective equipment (PPE) use, workload, and specific workplace conditions (Dong et al., 2019; Hesketh et al., 2020; Mizelle et al., 2022; Morrissey et al., 2021; NSC, 2022; Tustin et al., 2021; Wang et al., 2019).

Most sources had recommendations for acclimatization, such as requiring a plan for acclimatization and what it should look like (CDC, 2018; Luque et al., 2020; NSC, 2022; Sol et al., 2021; Tustin et al., 2018, 2021). The NSC (2022) recommended following an established and formal heat acclimatization program.

The theme of *workplace action* had four subthemes: engineering controls, monitoring, culture, and access.

Table 1. Data Extraction Table

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
Arnold et al. (2020)	Describes how Latinx children perceive heat hazards based on data from 30 in-depth interviews with Latinx child farmworkers. It reports the frequencies of HRI symptoms and protective behaviors among a sample of 165 Latinx child farmworkers. Finally, it examines associations between personal characteristics and experiences of HRI symptoms and protective behaviors among these children.	Journal article Baseline interviews from a longitudinal mixed methods study	Latinx child farmworkers North Carolina			Federal heat standard needed with enforcement Federal heat standard legislation should include provisions to ensure special protections for the rights of vulnerable child workers. Lawmakers need to revisit the appropriateness of the current age limits in agriculture, one of the most hazardous industries, by examining the age limits in every other industry in place to protect child workers.
Bertman et al. (2022)	To evaluate the efficacy of NIOSH recommendations while walking in the heat. It was hypothesized that working in accordance with the NIOSH recommendations during continuous heavy-intensity work in the heat would protect against excessive BML but not excessive T _c .	Experimental study Journal article	N/A Eight males Northeastern US			Individuals with robust rises in core temperature (T _c) need frequent rest breaks and should be guided with workplace biomedical monitoring (e.g., wearable devices) to protect from excessive hyperthermia and advise alternative rest intervals. Recommendations for work in the heat should encourage individualized hydration strategies based on factors including work intensity and sweat rate.
Chavez Santos et al. (2022)	To (a) evaluate the effectiveness of farmworker Spanish/English participatory heat education and a supervisor decision-support mobile application (HEAT intervention) on physiological heat strain and (b) describe factors associated with HRI symptoms reporting.	parallel, comparison group intervention study	Washington State			Related structural issues relevant to barriers to reporting symptoms, pay structure, restrooms, and access to healthcare are also critical to consider in reducing the risk of HRI for farmworkers. These multilevel issues should be addressed using a multi-level approach at workplace, community, and individual levels, including through policy development and through the implementation of policies and best practices tools in a manner tailored for agricultural workers
Langer et al. (2021)	Determine compliance with and effectiveness of California regulations in reducing farmworkers' HRI risk and identify the main factors contributing to HRI	Journal article Cross-sectional study	Latino farmworkers California	N/A	Supervisors should model behaviors. More important to stress frequent water consumption when temperatures and work rates are high	Practical recommendations to adjust work rates and rest breaks, targeted to specific tasks and especially on hot days for future revisions. Hydration recommendations adapted for the type of work and temperature. Cultural and behavioral-tailored HRI training

(continued)

Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
Lique et al. (2020)	Farmworkers who harvest and weed field crops are at increased risk for heat exposure and HRI. The study objectives were to (a) train crew leaders to use the OSHA heat safety tool app and evaluate the utility of the app from a crew leader perspective and (b) characterize heat safety knowledge, preventive practices, and perceptions of HRI risk among Hispanic farmworkers.		Six crew leaders completed a 2-hour OSHA heat-illness-prevention training, including the evaluation of a heat safety mobile app. Between August and October 2018, 101 Hispanic farmworkers participated in a cross-sectional study H-2A and seasonal farmworkers Georgia	Workers and supervisors should conduct their own health status checks before starting their work shifts. Electrolyte drinks should be consumed when work conditions require heavy physical exertion in hot and/or humid conditions for more than 2 h. Otherwise, cool water is an appropriate hydration beverage. Cooling during rest breaks should be performed (e.g., immersion, shade, hydration, removal of PPE). Cooling should be done for as long as possible to achieve optimal cooling benefits. Workers should utilize body cooling strategies available. During rest periods, clothing layers should be removed long enough (i.e., the entire rest period) to allow for optimal body cooling and adequate recovery prior to beginning the next work session.	Offer annual HRI prevention training for farmworkers and supervisors. Provide recommendations to farmworkers and supervisors related to HRI symptom recognition and corrective action to reduce heat stress. Monitor weather conditions to protect workers from HRI. Use occupational tools to monitor tasks and provide a relation from more demanding jobs to less-demanding jobs. Ensure that workers are properly acclimatized to working in hot weather conditions. Provide water and rehydration salt packets (electrolytes), and a personal water container so workers can obtain water every 30 minutes. Provide shade and movable shade structures to cool workers. Provide rest periods and shade at least 3 times in an 8-hr workday. Have emergency medical help available for workers having difficulty with HRI, especially on the hottest days of the summer. Provide transportation to workers for bathroom access when portable lavatories are distant from work being performed. Monitor workers at breaks and during work for low-severity symptoms. Train workers to be able to monitor themselves and notify the supervisor for help. Provide suggestions for clothing designed to protect the worker from HRI and the sun. Weather conditions such as humidity and temperature should be identified and monitored to predict HRI and identify steps needed to reduce stress. Rotating from more-demanding jobs to less-demanding jobs, ensuring that workers acclimatize to hot weather conditions. Providing water and rehydration every 30 min. Providing rest periods three times a day in an 8-hr workday. Recognizing severe symptoms that require immediate medical treatment. Workers should also monitor each other for signs and symptoms. Transportation should be provided to toilets, potable water, and medical treatment, if necessary. Regular training opportunities for farmworkers and crew leaders are recommended to stress the importance of HRI prevention. It is important to monitor weather conditions with the heat safety tool app to ensure that workers use recommended breaks to recover from mild heat stress symptoms. Acclimatization should become an important lesson as part of farmworker training and incorporated into the OSHA heat safety tool app. Companies and contractors should review their policies to ensure they provide this guidance to farmworkers and crew leaders at the beginning of each harvest season to modify work schedules for the first few weeks for newly hired workers, such as H-2A contract workers.	
Mizelle et al. (2022)	To explore how sociocultural and occupational factors and environmental heat stress influenced fluid intake and hydration status among Latino farmworkers working in eastern North Carolina.	Mixed methods research study	Latino farmworkers working in eastern North Carolina.		Employers need to be aware that environmental heat stress limits can be met in the morning hours. How employer-provided housing can impact hydration. Cooling and hydration practices, like the use of backpack-mounted water bladders, could permit safer work in higher WBGT environments.	
Morrissey et al. (2021)	To develop feasible, evidence-based occupational heat safety recommendations to protect the U.S. workers who experience heat stress	Journal article Expert narrative review summary	Workers at risk	Workers and supervisors should conduct their own health status checks before starting their work shifts. Electrolyte drinks should be consumed when work conditions require heavy physical exertion in hot and/or humid conditions for more than 2 h. Otherwise, cool water is an appropriate hydration beverage. Cooling during rest breaks should be performed (e.g., immersion, shade, hydration, removal of PPE). Cooling should be done for as long as possible to achieve optimal cooling benefits. Workers should utilize body cooling strategies available. During rest periods, clothing layers should be removed long enough (i.e., the entire rest period) to allow for optimal body cooling and adequate recovery prior to beginning the next work session.	Employers should facilitate and provide access to wellness programs Annual training for workers and supervisors that is easily understood, and includes recognition and risks of HRIs, prevention, first aid, and emergency response procedures. As well as education on hydration, acclimatization, and the effects of body cooling Use the buddy system if there are not designated personnel for monitoring workers. Develop strategies for fluid replacement, dehydration mitigation, and to inform workers of acceptable work-to-rest ratios and other heat mitigation strategies ahead of scheduled working shifts. Provide access to fluids, clean bathrooms, designated rest, cooling, and hydration center. Create and implement a gradual, progressive HA program (5–7 days) that are tailored to job demands. Onsite environmental measurements account for the influences of air temperature, humidity, wind speed, and radiant heat such as wet bulb globe temperature. Consider using valid and reliable physiological monitoring systems such as heart rate or body temperature monitoring devices. Consider under-ear cooling products when PPE cannot be removed. IFPE can be partially removed; work sites should provide cold towels and/or ice water for extremely cooling. When ambient temperatures are below 40°C (104°F), electric fans or air-conditioning should be used for evaporative cooling. If power is not available at the worksite, cooling strategies should include portable cooling modalities like ice in coolers, water, and ice towels. PPE should be thin, lightweight, promotes heat dissipation, and ventilated while still protecting against workplace hazards and which are absolutely essential for avoiding harm while completing the specific task at hand.	

(continued)

Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
Smith et al. (2021)	To evaluate the knowledge of migrant farmworkers about first aid for HRI symptoms.	Journal article Cross-sectional	Farmworkers Georgia	Knowing what symptoms to look for in employees and coworkers Approximate actions to take in mild heat illness	PPE should be the appropriate fit relative to proportional body differences and certified or reliable in work settings requiring physical fitness or skill testing during the hiring process (e.g., firefighting). EAP that addresses medical emergencies associated with heat stress Multiple EAPs within a company may be necessary to address various needs of different work sites Employers should identify the worksite managers and medical personnel to create, manage, coordinate, and execute EAPs. The EAP should be communicated to local emergency medical services and updated as applicable. The EAP should be disseminated, rehearsed, and reviewed annually with all staff and employees. Review of the worksite's EAPs should be included in new employee and supervisor onboarding training. After a worker experiences an HRI (e.g., EHS), a return-to-work protocol should be established under the direction of a physician, who is ideally familiar with exertional heat-illness recovery	
Wang et al. (2019)	To investigate whether using thermometers clipped on workers' shoes would result in different heat exposure estimation and work-rest schedules compared with using area-level meteorological data alone	Journal article Cross-sectional	Parks and Recreation Department workers Alabama	N/A	Regular training of supervisors Company-wide policies that support and promote heat-related first-aid actions Safety-oriented focus is needed by employers and crew leaders to promote a supportive culture for these preventive heat-illness first aid efforts Robust heat-related first aid training for farmworkers Support crew leaders and employers through the provision of preventive resources (e.g., water, shaded areas for rest, and adequate rest breaks)	
Sol et al. (2021)	To evaluate heat stress occurring in wildfire management activities with variable environmental conditions	Journal article Cross-sectional	Wildland firefighters Western United States	N/A	Temperatures from wearable thermometers, together with meteorological data, can serve as an additional method to identify occupational heat stress exposure and recommend work-rest schedules. Should use WBGT meters or collect real-time meteorological data specific to their workplace. If not feasible implement work-rest schedules based on heat index from temperature and humidity measurements. Train workers on adjusting the rest time with consideration of their personal risk factors. To decrease work-rest scheduling effects on productivity, perform strenuous outdoor work in the early morning hours, and schedule sedentary tasks during rest periods. Installing a form of shade on all mowers. Make cooling stations and personal protective equipment (PPE), such as cooling vests, available and train on proper use. Daily weigh ins during heat waves. Encourage frequent water breaks.	N/A
Methner & Eisenberg (2018)	To evaluate heat stress among employees engaged in strenuous work in an extremely hot outdoor environment	Journal article Cross-sectional	Park employees National park in North America	Self-monitoring via measuring pulse or temperature and pre- and post-shift body weight. Employees should keep radios within hearing distance	Reduce equipment weight Preparing workers individually and as a team by developing aerobic capacity through aerobic training and heat acclimation strategies. Prioritize acclimatization and fitness over aggressive fluid strategies. Provide WBGT measuring instruments to employees and train them on use and interpretation. Safety managers should observe work practices and create a list of estimates of metabolic load for each task to assist in determining appropriate work/rest regimens Develop a workgroup to decide among options and develop standard operating procedures for self-monitoring during periods of extreme heat. Schedule strenuous outdoor work for cooler months or performed at night or early in the morning if possible, stop work outdoors and inside buildings without air-conditioning during extreme heat Train employees to recognize early signs and symptoms of HRI in themselves and their coworkers and stop work if symptoms arise Allow employees to take rest breaks and fluid intake as needed. Provide a nearby cooling area Supply additional water to employees so they can wet their work clothes during the workday when temperatures are high. Establish a procedure for communication between the safety manager and employees so that work locations are known. Use the buddy system. If unable, use radios, report locations, and periodic welfare checks.	n/a
Tustin et al. (2018)	To determine whether the NIOSH and ACGIH exposure limits are protective of workers	Journal article Cross-sectional	Reports from 25 outdoor occupational HRIs (14 fatal and 11 nonfatal) investigated by OSHA from 2011 to 2016	n/a	Use WBGT when possible If unable, use Heat Index threshold of 85 °F (29.4 °C) Measure heat stress throughout the workday and take actions to prevent exposure limits from being exceeded. Create and HRI prevention program that includes acclimatization, recognition of HRI, first aid, engineering and administrative controls to reduce heat stress, medical surveillance, and prevention measures.	

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
Tustin et al. (2021). AOOEM work group on occupational HRI					Use engineering controls (devices or processes that reduce heat stress). Some engineering controls reduce environmental heat parameters such as temperature and/or humidity. Examples include air-conditioning, ventilation, and fans. At outdoor workplaces, shade structures (e.g., canopies) can block solar radiant heat. Fans or misting devices can increase convective and evaporative cooling rates in some circumstances. Engineering controls can also reduce workers' metabolic heat generation if they decrease workload. For instance, replacing manual lifts with a mechanical device (e.g., forklift) can reduce the physical activity level of warehouse worker. A primary reason appears to be those new workers, and long-term workers who return from an extended absence may lack acclimatization to heat stress. At heat stress prevention programs should include an acclimatization protocol that allows unacclimatized workers to develop acclimatization gradually and safely. These should be codified in employer safety plan practices. There are various methods to acclimatize workers gradually. The duration of heat stress exposure can be increased incrementally over a period of 7 to 14 days. For example, a new employee could work for 2 hours in the heat on his first day, followed by a 3-hour heat exposure on the second day. Alternatively, new workers can be given longer and more frequent rest breaks, compared to acclimatized existing workers. If an unacclimatized worker will work a full shift in the heat, she should be given hourly breaks in a cool location (e.g., an air-conditioned room or a shaded area) to allow dissipation of excess body heat acquired during the periods of work. It is also important to ensure that unacclimatized workers, particularly those who are new to the job, be monitored closely for early detection of heat-related signs and symptoms. Monitoring can be performed either by supervisors or by coworkers via a buddy system. The supervisor or buddy in the field must be able to recognize the warning signs of impending or severe heat illness, including mental confusion, incoordination, or sustained vomiting. The supervisor's responsibility is then to activate the employer's emergency response plan as spelled out in the employer's written heat-illness-prevention plan. The emergency response plan may often include calling the onsite emergency response plan or 911, as directed in their training. New workers should never work alone when heat stress is present. Any symptoms that could be heat-related should be investigated promptly, preferably by a knowledgeable healthcare professional, to ensure that heat exhaustion does not proceed to heat stroke. Employers should ensure that unacclimatized workers consume an adequate (but not excessive) quantity of fluid. Work/rest cycles or self-pacing heat stress can be mitigated by increasing the frequency and/or duration of rest breaks as heat stress rises. This concept is sometimes termed a work/rest cycle. In general, workers should rest for at least 15 min per hour when a heat stress hazard is present. Rest breaks should be mandatory because workers might put themselves at risk of HRI by skipping optional breaks. Self-pacing is an alternative to mandatory rest breaks. Self-pacing means that workers are empowered to reduce their work pace to avoid unsafe heat strain in hot conditions. Several industries have successfully implemented self-pacing. To be successful, self-pacing requires a supportive corporate safety culture that allows workers to lower their pace with no negative repercussions. Medical surveillance/monitoring: Medical monitoring evaluations are an important part of an HRI prevention program. The examinations should include obtaining the worker's medical and occupational history with an emphasis on past, present, and anticipated future exposures to heat; prior history of HRI; and personal risk factors for HRI. Employers should train employees and their supervisors (in their working languages) about heat stress safety. The training must include the identification of signs and symptoms of HRI. Workers should be taught first aid for HRI, with an emphasis on calling 911 (or the appropriate onsite emergency response number) and providing immediate cooling if someone shows any signs of heat stroke (e.g., confusion or slurred speech). Understanding proper hydration (e.g., at least 8 oz. of fluids every 15-20 mins) is an essential part of this training. Topics like acclimatization, the consequences of risk factors such as drug use and obesity on one's heat tolerance, and the role of metabolic heat in occupational HRI, should also be covered. Hazard assessment monitoring: The gold standard method for assessing heat stress at worksites is to measure WBGT and estimate workers' metabolic rate (e.g., workload). Provide adequate hydration fluids: The amount and type of fluids consumed are of particular importance for workers in hot environments. Employers should provide potable drinking water. The water should be cool and readily available near the job location. During prolonged periods (>2 h) of sweating in hot conditions, employers should also provide electrolyte-containing beverages such as sports drinks, to drink an adequate quantity of fluids to replace fluid losses from sweating, which can be substantial on hot days. Clinicians should also advise workers not to overconsume fluids, which can lead to exercise-associated hyponatremia. Pre- and post-shift weights are one way to monitor whether the worker consumed an appropriate quantity of fluids. Emergency response plan: workers and supervisors should be trained to recognize and provide first aid for HHS. Heat stroke is a medical emergency.	

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
					If there is evidence of heat stroke, such as abnormal behavior, confusion, or other signs of CNS dysfunction, first responders should notify emergency medical services by calling 911 or the appropriate on-site emergency response number. Concurrently, immediate cooling measures are necessary. An important early treatment of heat stroke is to apply ice and wet the worker's skin using a cold-water bath, garden hose, or any other available source of cool water. Supervisors and coworkers must be able to recognize signs and symptoms of heat strain, provide first aid, remove the affected worker from further heat stress exposure, and obtain definitive medical care. To assure that ill workers receive first aid, supervisors should monitor their employees for heat strain during the workday. Alternately, a buddy system, in which trained workers monitor each other, can be effective in some situations. Personal protective equipment: If engineering and administrative controls do not adequately reduce heat stress, employers could consider PPE. For heat stress, PPE can include air-, ice-, or water-cooled garments such as ice vests or wetted overgarments. Some industries require over garments that can increase workers' heat stress (e.g., fire-retardant clothing in aluminum smelters, etc.). Their use should be regulated to only being utilized in the immediate environment and will increase the need for shorter work-rest cycles.	
Arcey et al. (2019)	To document the health characteristics and occupational injuries of Latinx child farmworkers and delineate characteristics associated with their health and occupational injuries.	Journal article Cross-sectional	Latinx child farmworkers North Carolina	n/a	n/a	Need for documentation of child farmworker occupational health and safety. Need to change occupational safety policy to ensure that children working in agriculture have the same protections those working in all other U.S. industries
Hesketh et al. (2020)	To characterize the demographic and occupational characteristics of Washington workers who suffered from HRI from 2006 to 2017 using workers' compensation claims data	Journal article Cross-sectional	Workers with worker's compensation claims Washington State	N/a	Customize accident prevention programs to recognize the hazards of heat exposure at temperatures lower than the mandated action levels tailor HRI prevention strategies to their local environment and tasks.	Incorporate reliable and complete data on race and ethnicity into occupational safety and health data systems.
Dong et al. (2019)	To explore heat-related deaths among U.S. construction workers and a possible association with climate change.	Journal article Cross-sectional	Heat-related deaths in the Census of Fatal Occupational Injuries from 1992 to 2016 Construction workers United States		Tailor workplace intervention based on personal and environmental factors, and workload. Prevention programs should include acclimatization, work rotations, physiological monitoring, ergonomic solutions, access to water, active encouragement to drink, appropriate rest breaks in shade or cool areas, as well as training workers to recognize, prevent, and administer first aid for HRI. Altering work hours to limit work time in the hottest hours of the day Provide personal protective equipment to reduce heat exposure Make use of tools such as the OSHA-NIOSH Heat Safety Tool	Regulatory intervention is needed urgently. Despite existing OSHA guidance and general duty clause citations for work-related HRI, the recent failure of the Occupational Safety and Health Review Commission to uphold an OSHA general duty Clause citation in the death of a roofer from heat stroke demonstrates how severely the absence of an HRI prevention standard limits OSHA's enforcement ability. Such a standard is essential to enable OSHA to conduct inspections to identify hazards and enforce abatement. Municipal ordinances requiring rest breaks are a step in the right direction but fail to address important factors such as acclimatization. Construction workers will also benefit from broader societal efforts to address the root causes of anthropogenic climate change.
Vega-Arroyo et al. (2019)	To investigate the effects of work rate, hydration status, and clothing on core body temperature (CBT) on Californian farmworkers	Journal article Cross-sectional	Farmworkers California	n/a	n/a	The biggest challenge to reduce HRI risk among farmworkers is to maintain income for farmworkers who reduce their productivity due to environmental conditions. This is particularly true when the majority of workers are paid by piece rate and thus would decrease their income by reducing their work productivity. Statewide regulations that include mandatory work reduction would at least level the playing field for all agricultural workers in the state. Other solutions should also be tried, including scheduling work at cooler hours of the day, introducing more effective and acceptable hydration systems, and implementing mandatory hydration regimen

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
Centers for Disease Control and Prevention (CDC, 2018)				Workers should drink an appropriate amount to stay hydrated. If in the heat <2 hours and involved in moderate work activities, then drink 1 cup (8 oz.) of water every 15–20 min. If experiencing prolonged sweating lasting several hours, then drink sports drinks containing balanced electrolytes. Avoid alcohol and drinks with high caffeine or sugar. Generally, fluid intake should not exceed 6 cups per hour.	Employers should develop and use a comprehensive HRI prevention program at the workplace. Increase air velocity (if the air temperature is below 95°F). Use reflective or heat-absorbing shielding or barriers. Reduce steam leaks, wet floors, or humidity. Implement a buddy system and routinely check workers to ensure they make use of available water and shade, and they do not have symptoms of an HRI. Monitor the weather. Limit time in heat and/or increase rest time in a cool environment. Increase the number of workers per task. Require workers to conduct self-monitoring. Implement a heat alert program when a heat wave is likely. Employers need to provide training before hot work begins and tailor the training to cover worksite-specific conditions. Workers and supervisors should be trained on: • Recognition of the symptoms of HRIs. • First aid. • HRI risk factors. • Importance of acclimatization. • Importance of reporting HRI symptoms. Additionally, supervisors should be trained on how to implement appropriate acclimatization. Procedures for when a worker has symptoms of HRI. How to monitor weather reports and respond to advisories (such as with the OSHA-NIOSH Heat Safety Tool App). How to monitor and encourage adequate fluid intake and rest breaks. Acclimatization: • Workers become acclimatized to heat when they gradually work for longer periods in a hot environment. Benefits of acclimatization include less strain on the heart and vital organs, improved sweating (higher volume, earlier onset), and increased ability to perform physical tasks in the heat. • Employees must make certain that workers acclimatize by gradually increasing the time they work in hot conditions over 7–14 days. • New worker's exposure schedule: - Day 1: Exposures to heat should be less than 20% of usual work duration. - Increase a maximum of 20% per day after Day 1. • Experienced workers exposure schedule (for those returning after an absence of 1 week or more): - Day 1: 50% of usual work duration - Day 2: 60% - Day 3: 80% - Day 4: 100% Hydration: • Employers should provide appropriate hydration. • Water should be cool and near the work area. • Individual drinking cups should be provided. • Encourage workers to hydrate themselves. Rest breaks • Employers should ensure and encourage rest and hydration breaks. • Permit breaks when a worker feels discomfort. • Assign new workers lighter work and longer, more frequent breaks. • Shorten work and increase rest periods: • As temperature, humidity, and sunshine increase. • When there is no air • If protective clothing or PPE is worn. • For heavier work	

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
American Industrial Hygiene Association. (2023).						Advocate for and help implement simple, clear, and explicit regulations written in plain language that requires thermal stress to be taken seriously, placing explicit legal responsibility on employers, schools, and other organizations to mitigate thermal hazards. Encourage education, awareness, training materials, regulations, and guidance on thermal stress to be provided in written and spoken languages that workers, athletes, and participants can understand, including those with low literacy skills or who are functionally illiterate. Advocate for laws and regulations that require providing workers with both cool portable water and unlimited restroom access. Research shows that people, especially women, may be reluctant to drink enough water when sanitary facilities are inadequate. Encourage the provision of rest areas/cooling stations that are easily accessible and well-equipped with appropriate tools and technologies necessary to cool workers down. Encourage the provision of guidance regarding cooling station temperature ranges. Encourage the publication of well-developed guidance Raise awareness of thermal stress-related hazards, particularly among vulnerable, under-served, special-needs, and low-income populations. Encourage training on how to prevent, identify, and respond to the early signs of thermal stress as well as heat or cold-related medical emergencies. Advocate for worker and supervisor training on the proper selection and use of appropriate personal protective equipment and clothing to reduce the risks of heat or cold-related injuries and illnesses. Encourage governmental, academic, or corporate investments in research to quantify the level of heat or cold exposure across industries and identify effective, evidence-based interventions to implement to reduce the risks of thermal-related injuries, illnesses, and fatalities. Encourage governmental, academic, or corporate investments in the research, development, evaluation, and deployment of sensor technologies and in our ability to turn data into actionable knowledge and functional protection. Sensor technologies should become accessible to and affordable for all populations with heat or cold exposure risks. Technology testing should include appropriate representation of different populations and environments, should be transparent and reproducible, and follow good practice for evaluations. Advocate for incorporating consensus standards into government requirements and guidance documents. Support the development and availability of tools for calculating thermal exposure to evaluate safe working conditions, such as the OSHA-NIOSH Heat Safety Tool App.

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
						Help policymakers, supervisors, workers, occupational and environmental health and safety professionals, and other stakeholders understand the limitations of data gathered from various sources, such as wearables and weather forecasts to estimate environmental conditions or an individual's thermal stress levels. Encourage the United States Congress to enact legislation requiring OSHA to issue a nationwide standard to protect indoor and outdoor workers from hazardous heat indoors and outdoors. Encourage OSHA to issue such a standard. Advocate for the enactment of State legislation to protect indoor and outdoor workers from hazardous heat indoors and outdoors. Encourage state departments of labor to issue a standard to protect indoor and outdoor workers from hazardous heat indoors and outdoors.
National Safety Council (2022)					All employers should establish a written HRI prevention program and emergency action plan to respond to and report any signs/symptoms of HRI. The written program should include: • An assessment of both outdoor and indoor work environment for the impact of heat on their employees and based upon the assessment, establish a heat-related illness prevention program and implement an emergency action plan for workers experiencing a HRI designated site or organizational competent person to oversee the program • An established heat index based upon temperature, humidity, and the amount of direct sunshine that would trigger the program implementation • A formal acclimatization plan for new employees and current employees at the start of hotter months as well as a formal acclimatization plan for returning workers such as those who had extended absences and need to undergo re-acclimatization. • Ensured access to nearby potable water, scheduled and frequent rest periods during the workday, shade for outdoor work environments, and air circulation for indoor work environments • Worker training on HRI prevention, recognition, and reporting • Medical monitoring programs, with consideration to preplacement and periodic medical evaluations • An emergency response plan for any heat-related events such as first aid and emergency action plan (EAP). NSC strongly recommends employers assess both the indoor and outdoor work environment for the potential impact of heat on their employees and based on that assessment, establish a written HRI prevention program or procedure, including acclimatization and an emergency action plan for employers to respond to and report any signs/symptoms of HRI. An effective heat acclimatization program gradually increases worker exposure to heat and metabolic workload over a 7- to 14-day period with cooling off and fully rehydrating between shifts. Acclimatization also typically requires at least two hours of heat exposure per day which can be broken into two 1-hr periods. If a worker stops heat exposure for a few days, acclimatization will be maintained, but after about a week away from working in the heat, acclimatization will be lost. Employees who eat regular meals such that food replaces electrolytes lost in their sweat experience better acclimatization.	OSHA should develop and establish an enforceable performance-based federal HRI standard Policy should include the establishment of a series of heat indices that can be used as permissible exposure limits (PELs) in different parts of the country Provide information on how to prepare for heat waves and how to recognize and respond to HRI, and how to protect workers from HRI • Require employers to conduct an assessment of both the outdoor and indoor work environment for the impact of heat on employees, and based upon the assessment, establish a plan to protect workers from experiencing an HRI. Elements of the plan should include: - Establish a heat acclimatization plan for new and returning workers - Designate a site-competent person to oversee the HRI prevention program - Determine the heat index for the work environment - Use the hierarchy of controls to reduce the risk of HRI - Train managers and workers on the hazards of heat and the HRI prevention program - Provide medical surveillance for employees covered by the HRI prevention program

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Table 1. (continued)

Citation	Purpose	Type of article/ source type	Population and setting	Recommendations for workers	Recommendations for employers	Recommendations for policy
				NSC strongly recommends that employers have a formal acclimatization plan for employees working in hot environments. NSC recommends employers ensure access to nearby potable water, scheduled, and frequent rest periods during the workday. Shade should be provided for outdoor work environments and for rest periods. Air circulation for indoor and outdoor work environments is also critical during work and with rest periods. NSC recommends employers establish effective maintenance programs to ensure air-conditioning and air-cooling units in work vehicles, including commercial long-haul trucks with sleeper berths, are operable and reliable. Workers in the heat for less than 2 hr and/or involved in moderate work activities should drink 1 cup (8 oz.) of water every 15–20 min. During prolonged sweating that last several hours, workers should drink sports drinks that provide balanced electrolytes. Employers must also train their employees to recognize symptoms of HRI and to report signs and symptoms of HRI not only for themselves but also for their coworkers. Effective training includes training on recognition of symptoms and risk, proper hydration, including hydration before and after work, care and use of heat-protective clothing and equipment, effects of various factors (e.g., drugs, alcohol, obesity, etc.) on heat tolerance, the importance of acclimatization, hydration, reporting symptoms, and giving or receiving appropriate first aid. Employees should be trained about personal risk factors for HRI including underlying health conditions or certain medications may impact risks. Employers should provide all policies and training materials in languages that employees understand and also have accessible thermometers available at the worksite. NSC recommends employers establish a medical surveillance/monitoring program to help identify potential risks for HRI, including preplacement and periodic medical evaluations, as well as a plan for monitoring workers on the job. Employers should work with a licensed healthcare provider to conduct a comprehensive exam and confidential medical history examination as well as a physical examination. This should include an assessment of the use of therapeutic drugs, over-the-counter medications, supplements, alcohol, or caffeine that may increase the risk of heat injury or illness. An assessment of obesity should include the worker's ability to wear and use PPE. Providing appropriate PPE includes not only ensuring proper PPE for body size, but also ensuring PPE is appropriate for heat conditions by providing auxiliary body cooling and protective clothing	NSC strongly recommends that employers have a formal acclimatization plan for employees working in hot environments. NSC recommends employers ensure access to nearby potable water, scheduled, and frequent rest periods during the workday. Shade should be provided for outdoor work environments and for rest periods. Air circulation for indoor and outdoor work environments is also critical during work and with rest periods. NSC recommends employers establish effective maintenance programs to ensure air-conditioning and air-cooling units in work vehicles, including commercial long-haul trucks with sleeper berths, are operable and reliable. Workers in the heat for less than 2 hr and/or involved in moderate work activities should drink 1 cup (8 oz.) of water every 15–20 min. During prolonged sweating that last several hours, workers should drink sports drinks that provide balanced electrolytes. Employers must also train their employees to recognize symptoms of HRI and to report signs and symptoms of HRI not only for themselves but also for their coworkers. Effective training includes training on recognition of symptoms and risk, proper hydration, including hydration before and after work, care and use of heat-protective clothing and equipment, effects of various factors (e.g., drugs, alcohol, obesity, etc.) on heat tolerance, the importance of acclimatization, hydration, reporting symptoms, and giving or receiving appropriate first aid. Employees should be trained about personal risk factors for HRI including underlying health conditions or certain medications may impact risks. Employers should provide all policies and training materials in languages that employees understand and also have accessible thermometers available at the worksite. NSC recommends employers establish a medical surveillance/monitoring program to help identify potential risks for HRI, including preplacement and periodic medical evaluations, as well as a plan for monitoring workers on the job. Employers should work with a licensed healthcare provider to conduct a comprehensive exam and confidential medical history examination as well as a physical examination. This should include an assessment of the use of therapeutic drugs, over-the-counter medications, supplements, alcohol, or caffeine that may increase the risk of heat injury or illness. An assessment of obesity should include the worker's ability to wear and use PPE. Providing appropriate PPE includes not only ensuring proper PPE for body size, but also ensuring PPE is appropriate for heat conditions by providing auxiliary body cooling and protective clothing	- Establish an emergency action plan in the event of a heat-related incident Provide shade in outdoor environments, and air circulation in indoor environments. Provide rest periods in a cool or shaded location that take into consideration metabolic heat load, radiant heat exposure(s), and clothing and nearby potable water Have written procedures outlining steps needed to prevent HRI and support acclimatization specific to workplace locations and characteristics Designate a competent person to ensure the program is implemented, carried out, and employees are trained and protected Encourage reporting by employees of any signs and symptoms of HRI Respond to signs/ symptoms of HRI Establish a medical monitoring/surveillance program Train employees on HRI Develop an emergency action plan Utilize recognized alert limits/exposure limits to trigger action

Note. Extraction table used to collect and present the data for this scoping review.

Table 2. Haddon Matrix Table.

Prevention recommendations	Employee recommendations	Employer recommendations	Policymaker recommendations
Primary	1. Knowledge a. Know what symptoms to look for in self and coworkers b. Learn the approximate actions to take for heat illness 2. Hydration a. Drink an appropriate amount to stay hydrated. b. If in the heat <2 hours and involved in moderate work activities, then drink 1 cup (8 oz.) of water every 15–20 minutes. c. Should not exceed 6 cups per hour d. If experiencing prolonged sweating lasting several hours, then drink sports drinks containing balanced electrolytes. e. Avoid alcohol and drinks with high caffeine or sugar.	1. Planning a. Compressive HRI Plans i. Create a comprehensive and written HRI prevention program. 1. Plans should be reviewed prior to each working season 2. Establish a procedure for communication 3. Developed by a workgroup ii. Plans should include: 1. Acclimatization plans 2. Recognition of HRI 3. First aid 4. Engineering and administrative controls such as: a. Work rotation b. Physiological monitoring c. Ergonomic solutions 5. Medical surveillance including: a. Worker's medical history including use of therapeutic drugs, over-the-counter medications, supplements, alcohol, or caffeine b. Occupational history c. Prior history of heat-related illness; d. Personal risk factors for heat-related illness such as age and obesity e. Ability to wear and use PPE 6. Prevention measures b. Emergency action plans i. Develop and implement an EAP EAPs should include: 1. Identifying who is responsible to create, manage, coordinate, and execute EAPs. 2. An assessment of both outdoor and indoor work environments for the impact of heat on their employees 3. Action plan for workers experiencing a heat-related illness. 4. An established trigger for program implementation ii. EAP should be communicated to local Emergency Medical Services iii. The EAP should be disseminated, rehearsed, and reviewed annually with all staff and employees and updated as applicable c. Training and education i. Policies and training materials should be both written and in person and be provided in a way that is most easily understood and in languages that employees understand ii. Offer annual HRI prevention training for workers and supervisors that includes: 1. Recognize early signs and symptoms of HRI in themselves and their coworkers 2. Risks of heat-related illnesses 3. Personal risk factors for heat-related illness including underlying health conditions or certain medications may impact risks. 4. Prevention d. Proper hydration at least 8 oz. Of fluids every 15–20 mins), acclimatization, and the effects of body cooling, work-to-rest ratios, and other heat mitigation strategies and clothing, proper PPE 1. First aid and emergency response procedures. 2. Proper hydration, including hydration before and after work 3. Care and use of heat-protective clothing and equipment 4. Effects of various factors (e.g., drugs, alcohol, obesity, etc.) on heat tolerance 5. Importance of and procedures for acclimatization 6. Importance of and procedures for reporting symptoms 7. How to use WBGT measuring, monitor weather reports, and respond to advisories (such as with the OSHA-NIOSH Heat Safety Tool app). i. Education should have an emphasis on calling 911 and providing immediate cooling if someone shows any signs by any available cooling source such as: 1. Applying ice and wet the worker's skin using a cold-water bath, garden hose, or any other available source of cool water. e. Tailoring and individualizing i. Tailor workplace prevention and intervention based on personal and environmental factors, workload and specific workplace conditions ii. Train workers on adjusting the rest time with consideration of their personal risk factors. iii. Customize accident prevention programs to recognize the hazards of heat exposure at temperatures lower than the mandated action levels	1. Planning a. Heat standard mandate i. Enact and Enforce Federal and State heat standards 1. Standards should be simple and clear, with explicit regulations written in plain language ii. Require employers to conduct an assessment of both the outdoor and indoor work environment for the impact of heat employees, and based upon the assessment, establish a plan to protect workers from experiencing a heat-related illness. Elements of the plan should include: 1. Establish a heat acclimatization plan for new and returning workers 2. Determine the heat index for the work environment iii. Designate a site-competent person to oversee the program iv. Use the hierarchy of controls to reduce the risk of heat-related illness v. Train managers and workers on the hazards of heat and the heat-illness-prevention program vi. Provide medical surveillance for employees covered by the HRI prevention program vii. Establish an emergency action plan in the event of a heat-related incident viii. Have written procedures outlining steps needed to prevent heat-related illness and support acclimatization specific to workplace locations and characteristics ix. Designate a competent person to ensure the program is implemented, carried out, and employees are trained and protected x. Encourage reporting by employees of any signs and symptoms of a heat-related illness xi. Respond to signs/symptoms of heat-related illness xii. Establish a medical monitoring/surveillance program xiii. Train employees on heat-related illness xiv. Develop an emergency action plan xv. Utilize recognized alert limits/exposure limits to trigger action b. Tailor and individualize plans i. Use a multilevel approach to address workplace, community, and individual-level issues. ii. Include provisions to ensure special protections for the rights of vulnerable workers including child workers. 1. Appropriateness of the current age limits 2. Ensure that children working in agriculture have the same protections as those working in all other U.S. industries 3. Individualized hydration strategies based on factors including work intensity and sweat rate 4. The implementation of policies and best practices tools in a manner tailored for agricultural workers 5. Practical recommendations to adjust work rates and rest breaks, targeted to specific tasks and especially on hot days for future revisions. 6. Establishment of a series of heat indices that can be used as permissible 7. Exposure limits (PELs) in different parts of the country 8. Hydration recommendations adapted for type of work and temperature. 9. Cultural and behavioral Tailored HRI training

(continued)

Table 2. (continued)

Prevention recommendations	Employee recommendations	Employer recommendations	Policymaker recommendations
	f. Acclimatization. i. Have a formal plan for acclimatization ii. Ensure that workers are properly acclimatized to working in hot weather conditions by gradually increasing the time they work in hot conditions over 7–14 days. 1. New workers exposure schedule: Day 1: Exposures to heat should be less than 20% of usual work duration. Increase a maximum of 20% per day after Day 1. 2. Experienced workers exposure schedule (for those returning after an absence of 1 week or more): Day 1: 50% of usual work duration; Day 2: 60%; Day 3: 80%; Day 4: 100% iii. Prepare workers individually and as a team by developing aerobic capacity through aerobic training and heat iv. If a worker stops heat exposure for a few days, acclimatization will be maintained, but after about a week away from working in the heat, acclimatization will be lost. v. Employees who eat regular meals such that food replaces electrolytes lost in their sweat experience better acclimatization. vi. Ensure that unacclimatized workers, especially new employees are monitored closely for HRI vii. Prioritize acclimatization and fitness over aggressive fluid strategies 2. Workplace action a. Engineering and environmental control i. Utilize engineering controls to reduce heat stress including: 1. Air conditioning/ff. 2. Proper ventilation 3. Fans 4. Use reflective or heat-absorbing shielding or barriers. 5. Reduce humidity. 6. Shade structures, 7. Replace manual lifts with a mechanical device 8. Reduce equipment weigh 9. Increase the number of workers per task 10. Schedule strenuous outdoor work for cooler months or performed at night or early in the morning and when possible, 11. stop work outdoors and inside buildings without air-conditioning during extreme heat ii. Monitor weather conditions: 1. The gold standard method for assessing heat stress at worksites is to measure WBGT and estimate workers' metabolic rate 2. If unable use Heat Index threshold of 85° F (29.4° C) iii. Occupational tools to monitor tasks such as: 1. OSHA-NIOSH Heat Safety Tool 2. Wearable thermometers iv. Monitoring by supervisors 1. When not possible use the buddy system 2. If unable use radios, report locations, and periodic welfare checks v. If-monitoring by: 1. Recognition of signs and symptoms 2. Pre- and post-shift weights for dehydration. b. Culture i. Supervisors should model behaviors. ii. Create a safety-oriented focus to promote a supportive culture with no negative repercussions for the use of prevention measures c. Access i. Facilitate and provide access to wellness programs ii. Have emergency medical help available for workers having difficulty with HRI iii. Provide and mandate rest periods and shade at least 3 times in an 8-hour workday rest breaks should be mandatory 1. Encourage workers to self-pace iv. Provide and encourage hydration 1. Provide portable clean cold water with personal water containers such as backpack-mounted water bladders 2. During prolonged periods (>2 h) of sweating provide electrolyte-containing beverages such as sports drinks 3. Advise workers not to overconsume water due to risk of hyponatremia.	f. Acclimatization. i. Have a formal plan for acclimatization ii. Ensure that workers are properly acclimatized to working in hot weather conditions by gradually increasing the time they work in hot conditions over 7–14 days. 1. New workers exposure schedule: Day 1: Exposures to heat should be less than 20% of usual work duration. Increase a maximum of 20% per day after Day 1. 2. Experienced workers exposure schedule (for those returning after an absence of 1 week or more): Day 1: 50% of usual work duration; Day 2: 60%; Day 3: 80%; Day 4: 100% iii. Prepare workers individually and as a team by developing aerobic capacity through aerobic training and heat iv. If a worker stops heat exposure for a few days, acclimatization will be maintained, but after about a week away from working in the heat, acclimatization will be lost. v. Employees who eat regular meals such that food replaces electrolytes lost in their sweat experience better acclimatization. vi. Ensure that unacclimatized workers, especially new employees are monitored closely for HRI vii. Prioritize acclimatization and fitness over aggressive fluid strategies 2. Workplace action a. Engineering and environmental control i. Utilize engineering controls to reduce heat stress including: 1. Air conditioning/ff. 2. Proper ventilation 3. Fans 4. Use reflective or heat-absorbing shielding or barriers. 5. Reduce humidity. 6. Shade structures, 7. Replace manual lifts with a mechanical device 8. Reduce equipment weight 9. Increase the number of workers per task 10. Schedule strenuous outdoor work for cooler months or performed at night or early in the morning and when possible, 11. stop work outdoors and inside buildings without air-conditioning during extreme heat ii. Monitor weather conditions: 1. The gold standard method for assessing heat stress at worksites is to measure WBGT and estimate workers' metabolic rate 2. If unable use Heat Index threshold of 85° F (29.4° C) iii. Occupational tools to monitor tasks such as: 1. OSHA-NIOSH Heat Safety Tool 2. Wearable thermometers iv. Monitoring by supervisors 1. When not possible use the buddy system 2. If unable use radios, report locations, and periodic welfare checks v. If-monitoring by: 1. Recognition of signs and symptoms 2. Pre- and post-shift weights for dehydration. b. Culture i. Supervisors should model behaviors. ii. Create a safety-oriented focus to promote a supportive culture with no negative repercussions for the use of prevention measures c. Access i. Facilitate and provide access to wellness programs ii. Have emergency medical help available for workers having difficulty with HRI iii. Provide and mandate rest periods and shade at least 3 times in an 8-hour workday rest breaks should be mandatory 1. Encourage workers to self-pace iv. Provide and encourage hydration 1. Provide portable clean cold water with personal water containers such as backpack-mounted water bladders 2. During prolonged periods (>2 h) of sweating provide electrolyte-containing beverages such as sports drinks 3. Advise workers not to overconsume water due to risk of hyponatremia.	c. Data and science-led plans i. Address the root causes of anthropogenic climate change ii. Individuals with robust rises in core temperature (T_c) need frequent rest breaks and should be guided with workplace biomedical monitoring (e.g., wearable devices) to protect from excessive hyperthermia and advise alternative rest intervals. iii. Documentation of child farmworker occupational health and safety. iv. Deployment of sensor technologies and in our ability to turn data into actionable knowledge and functional protection. v. Sensor technologies should become accessible to and affordable and should include appropriate representation of different populations and environments, should be transparent and reproducible, and follow good practice for evaluations. vi. Support the development and availability of tools for calculating thermal exposure to evaluate safe working conditions, such as the OSHA-NIOSH Heat Safety Tool App. 2. Equity, which had two subthemes a. Pay structure i. mandatory work reduction for piece rate workers. b. Reporting barriers i. Encourage reporting of any signs and symptoms of a heat-related illness ii. Remove barriers to reporting symptoms 3. Access a. Include provisions that ensure worker have: i. Access to healthcare ii. in outdoor environments and air circulation in indoor environments iii. Breaks and rest periods in a cool or shaded location iv. Mandatory hydration regimen v. Easily accessible and adequate sanitary facilities, rest areas/cooling stations, and hydration

(continued)

Table 2. (continued)

Prevention recommendations	Employee recommendations	Employer recommendations	Policymaker recommendations
		v. Supply additional water to employees so they can wet their work clothes vi. Provide clean and acceptable and easily accessible bathrooms consider portable options and provide transportation to bathrooms when needed vii. have monitoring devices such as thermometers available at the worksite viii. Provide shade and movable shade structures to cool workers. ix. Make cooling stations and personal protective equipment (PPE), such as cooling vests, available and 1. If power is not available at the worksite, cooling strategies should include portable cooling modalities like ice in coolers, water, ice towels. x. Provide PPE that is: 1. The appropriate fit, thin, lightweight, promotes heat dissipation, ventilated while still protecting against worksite hazards xii. Use cooling PPE when able like ice vests xiii. When PPE is required that can increase heat stress, for example, fire-retardant clothing in aluminum smelters: 1. Only utilized in the immediate environment 2. Consider under gear cooling products when PPE cannot be removed. If PPE can be partially removed, worksites should provide cold towels and/or ice water for extremity cooling. xiv. In work settings requiring physical fitness or skill testing during the hiring process (i.e., firefighting), appropriate clothing and PPE should be worn. xv. Provide a rotation from more-demanding jobs to less-demanding jobs.	
Secondary	1. Monitoring a. Workers and supervisors should conduct their own health status checks before starting their work shift. b. Self-monitoring by: i. Measuring pulse ii. Temperature iii. Pre- and post-shift body weight. c. When unable to use the buddy system Employees should use devices such as radios for communications and keep them within hearing distance 2. Cooling and resting a. Cool during rest breaks by i. Immersion ii. Shade iii. Removal of PPE and clothing layers Cooling should be done for as long as possible	1. Potential HRI should be investigated immediately, by a healthcare professional with knowledge of HRI when available 2. In the possibility of heat stroke, call 911 or the appropriate onsite emergency response number. Concurrently, immediate cooling measures are necessary. Cool via any available source to apply ice and wet the worker's skin using a cold-water bath, garden hose, or any other available source of cool water.	
Tertiary		1. Planning a. Establish return-to-work protocol for workers who experience an HRI	

Recommendations for engineering controls encompassed reducing workplace HRI through various methods, including ventilation, air-conditioning, and scheduling techniques (CDC, 2018; Dong et al., 2019; Methner & Eisenberg, 2018; Mizelle et al., 2022; NSC, 2022; Sol et al., 2021; Tustin et al., 2018, 2021; Wang et al., 2019).

Recommendations for monitoring included monitoring, self, others, and environmental means such as the buddy system, wearable devices, monitoring the weather, and using Wet Bulb Globe Temperature (WBGT) meters (CDC, 2018; Luque et al., 2020; Methner & Eisenberg, 2018; Morrissey et al., 2021; NSC, 2022; Tustin et al., 2018, 2021; Wang et al., 2019). The WBGT is the standard for measuring heat stress, including direct sunlight, temperature, humidity, wind speed, sun angle, and solar radiation (US Department of Commerce, n.d.).

Work culture recommendations were focused on a safety-oriented focus and modeling behaviors (Langer et al., 2021; Smith et al., 2021). Access encompassed workers' access to prevention such as wellness programs and adequate access to restrooms, hydration, and PPE (CDC, 2018; Dong et al., 2019; Langer et al., 2021; Luque et al., 2020; Methner & Eisenberg, 2018; Morrissey et al., 2021; NSC, 2022; Smith et al., 2021; Tustin et al., 2018, 2021; Wang et al., 2019).

Prevention at the Employee Level

The primary recommendations for prevention at the employee level had the least information and comprised one theme: workplace action, which had two subthemes: knowledge and hydration. The recommendation for knowledge included knowing HRI symptoms and what actions to take (Smith et al., 2021). The recommendations for hydration focused on specific instructions for employees to follow (CDC, 2018; Morrissey et al., 2021).

Secondary and Tertiary Recommendations

Very few sources had secondary or tertiary recommendations. There were no recommendations for prevention at the policy level. Recommendations mostly focused on employers (see Figure 4). Secondary recommendations for prevention at the employer level consisted of event actions such as prompt assessment of possible HRI and calling 911 in case of possible heatstroke (Tustin et al., 2021). Tertiary recommendations for prevention at the employer level suggested establishing a return-to-work protocol for workers who experience HRI (Morrissey et al., 2021).

Secondary employee recommendations had one theme, workplace action, with two subthemes: monitoring and cooling and resting. Monitoring consisted of suggestions for several types of monitoring, including health checks, self-monitoring, and the use of devices when unable to use the buddy system to monitor coworkers (Methner & Eisenberg, 2018; Morrissey et al., 2021). Cooling and resting focused on how workers should cool themselves: suggesting that workers cool for as long as possible, removing PPE, and immersing in cold water (Morrissey et al., 2021).

Discussion

Using the Haddon Matrix, we compiled and summarized recommendations from researchers and position statements from leading organizations regarding the prevention of occupational HRI. Several major themes emerged from this scoping review that are important factors to consider in the prevention of occupational HRI.

Implementing primary prevention recommendations at the policy level is the initial step in prevention, as the policy level dictates the responsibilities of both employers and employees. While various sources offered recommendations in this area, they did not constitute the majority. This could be attributed to the lack of the implementation of mandating heat standards, causing sources to feel that their recommendations at the policy level have been disregarded or that they will not produce meaningful outcomes. However, recently, OSHA issued a Notice of Proposed Rulemaking for Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings (Occupational Safety and Health Administration [OSHA], n.d.). While this is a significant step toward protecting workers, it may be a while before the protections take effect, as the process of rule-making at OSHA takes an average of 10 years (US Government Accountability Office, 2012). Delays in the agency's internal processes could further harm workers, and a reevaluation, incorporating scientific methodologies to expedite the development of standards, is warranted.

When the policies are implemented, it is important to follow expert guidance. For example, policymakers also should be mindful that many recommendations may not be practical for all settings. For example, smaller companies and farms likely cannot hire onsite medical staff for monitoring, and some engineering controls are inaccessible due to cost or settings (Gubernot et al., 2015). Considering this, to protect workers at smaller farms, local governments could partner with organizations to provide medical access to those in need. For example, Farmworker Justice (2024) is an organization that provides training, educational materials, and other resources to assist community health centers provide quality care to farmworkers.

The recommendation inadequately emphasized the crucial need for policy to adapt to the evolving environment impacted by climate change. This aspect holds significant importance and warrants increased consideration. Science-driven policies addressing the effects of climate change are necessary to prevent future problems from occurring due to climate change-related HRI. Policies should be backed by science and follow evidence-based practice. This finding is consistent with the literature in other fields that climate change poses a significant threat to human health and needs action now. There are numerous methods through which policies can mitigate climate change. However, the key factor is taking action. Many countries, including the United States, have signed the Paris Agreement, but few are achieving their objectives (Hamilton et al., 2021). One state, California, has partnered with Japan in an effort to strengthen and coordinate efforts on combating climate change,

Source Recommendations Themes

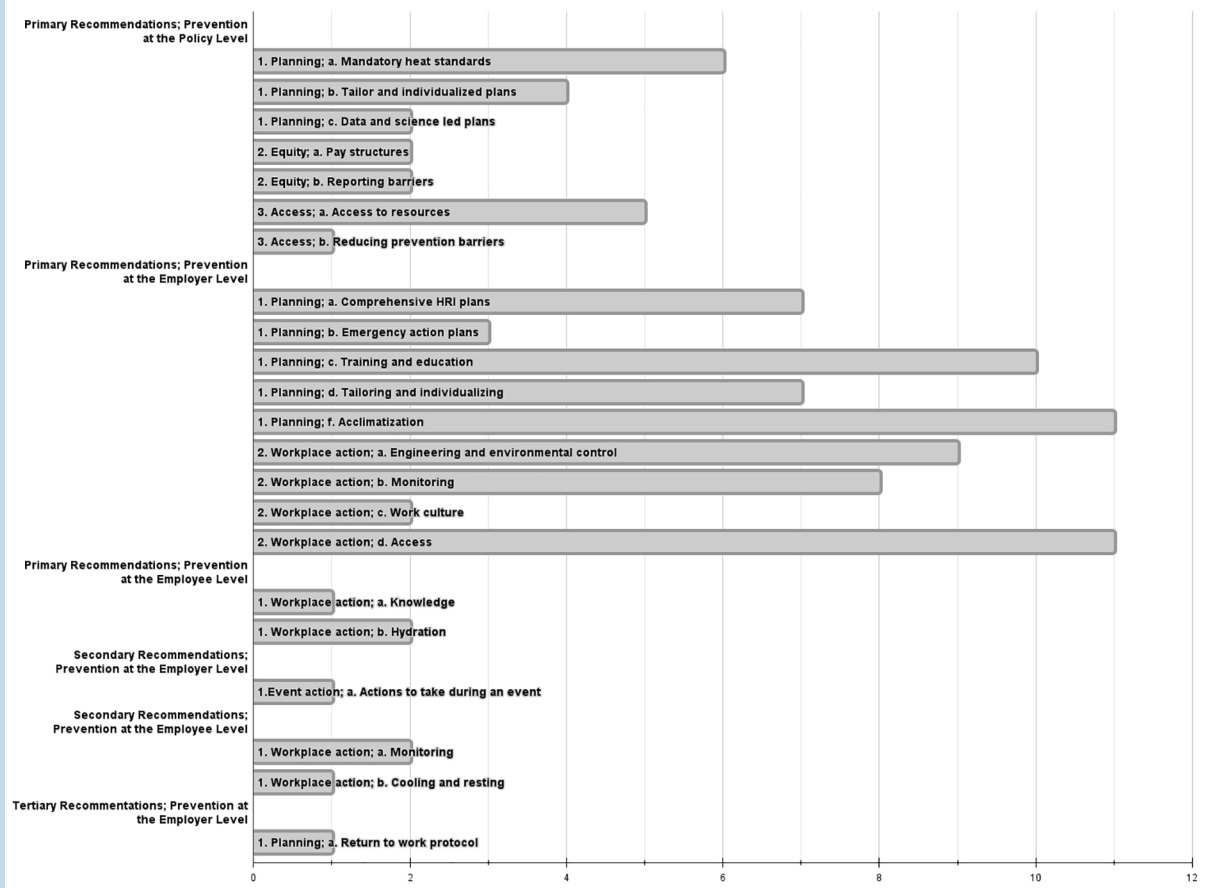


Figure 4. Source Recommendations Themes

Note. This graph depicts the themed data and the number of sources that recommended each of the subthemes.

promoting economic and trade relations through renewable energy, and other climate change mitigation actions (the State of California, United States of America & Japan, 2022).

While equity did not receive as much focus, it is a necessary topic in its contribution to HRI via pay and reporting barriers. Workers should not have to risk their safety or health for fear of retaliation from employers for reporting dangerous working conditions. According to Snipes et al. (2017), up to 69% of injuries that occur on farms go unreported, because Latino workers fear discrimination and threats or fear of deportation. Furthermore, it is essential that workers' compensation does not jeopardize their well-being. Piece rate pay is problematic as it encourages skipping breaks and working beyond one's physical limits. According to the National Farm Worker Ministry (2020) in North Carolina, following piece rate pay, a worker would need to pick 635 pounds of sweet potatoes in an hour to make pay equal to minimum wage, as a 35-pound bucket of sweet potatoes is worth roughly 45 cents.

Access to means of HRI prevention is critical. Addressing worker access was a frequent recommendation; however, there was less focus on barriers that exist to prevention (Bartman et al., 2022; Chavez Santos et al., 2022; Langer et al., 2021; NSC, 2022; Vega-Arroyo et al., 2019). This is important as, according to the literature, access does not always result in workers' use of prevention measures (Bethel et al., 2017). There could be various underlying reasons for not using prevention measures, such as a reduced willingness to stay hydrated due to difficulties in accessing restrooms, particularly for women (AIHA, 2023). Ensuring there are no barriers to prevention is just as important as creating plans to implement them.

It seems that sources tend to focus their recommendations on the employer level, which could be attributed to their desire for their recommendations to provide the most benefit. Because there are no federal heat standards, employers are in control of preventing HRI. One area of focus was the development of comprehensive HRI plans. The recommended components are

Table 3. Recommended HRI Prevention Plan Components

• Procedures for communication
• Acclimatization plans
• Recognition of HRI
• First aid
• Engineering and administrative controls
• Work rotation
• Physiological monitoring
• Ergonomic solutions
• Prevention measures
• Plans for fluid replacement
• Dehydration mitigation
• Access to and encouragement of using prevention measures, such as water and rest breaks in cool, shaded areas
• Medical surveillance including:
I. ' medical history
II. Use of therapeutic drugs, over-the-counter medications, supplements, alcohol, and caffeine
III. Occupational history
IV. Prior history of HRI
V. risk factors for HRI, such as age and obesity
VI. Ability to wear and use PPE

Source: Dong et al. (2019), NIOSH (2018), Tustin et al. (2018).

listed in Table 3. Emergency action plans are another essential component of planning. Recommended considerations for emergency action plans included establishing a trigger, identifying who is responsible for plan execution, and reviewing and rehearsing the plan (Morrissey et al., 2021; NSC, 2022; Tustin et al., 2021). Recommendations for emergency action plans included having a trigger for when to implement the plan, designating an established person to oversee the plan, communicating the plan to local emergency services, and reviewing and rehearsing plans (Morrissey et al., 2021; NSC, 2022). Triggers for implementing an emergency action plan can include a local heat advisory, an employee showing symptoms, or a specified heat index or WBGT. (US Department of Commerce, n.d.)

Another area in which the majority of sources had recommendations was for training and education. This may be due to the finding that there seems to be a lack of properly educating workers on HRI and prevention and insufficient training to Langer et al. (2021; Smith et al., 2021). For example, when asked about personal risk factors, acclimatization, and

hydration, only 14.2% of farmworkers could answer all the questions correctly. A lack of or insufficient training could increase the risk of adverse outcomes if employees cannot recognize HRI or are unaware of proper treatment. It is important to train workers via the most beneficial and effective means. OHNs could create engaging training and educational videos for farmworkers, as it has been previously reported that most workers prefer videos (Courville et al., 2016).

Similar to the recommendations at the policy level, sources had recommendations for tailoring and individualizing. This is probably because certain factors can increase the risk of HRI. For example, workers with two or more risk factors, such as increased body mass index, medications, chronic illnesses, use of alcohol and energy drinks, a history of HRI, working a second job in the heat, and extensive skin pathology, were likelier to develop HRI (34% vs. 19%; McCarthy et al., 2019). While employers cannot personally use this information to protect workers due to the Health Insurance Portability and Accountability Act, hiring OHNs or having access to

healthcare where OHNs who are specifically trained in HRI can be advantageous for employers (US Department of Health and Human Services, 2020).

A major focus of primary prevention at the employer level was on acclimatization. This is likely due to the importance of acclimatization in preventing death. The majority of HRI-related deaths occur in the first 3 days of work, with 71% on the day of exposure (Gubernot et al., 2015; Luque et al., 2020). According to the CDC (2018), acclimatization should occur over a 7- to 14-day period with the following guidelines:

- New workers: On Day 1, heat exposure should be less than 20% of the usual work duration, and it should increase to a maximum of 20% per day after that.
- Experienced workers (after an absence of 1 week or more): On Day 1, heat exposure should be 50% of the usual work duration, increasing to 60% on Day 2, 80% on Day 3, and 100% on Day 4.

The recommendations often were not employee-directed, perhaps because the employer is responsible for educating the worker. Recommendations included workers knowing the symptoms of HRI and what actions to take (Smith et al., 2021). However, workers deserve to know more. Workers must understand their rights and responsibilities to advocate for themselves and be partners in their health and safety.

Overall, secondary and tertiary recommendations were limited and absent. Although primary prevention of HRI is critical, HRI continues to occur, indicating the need for secondary and tertiary levels of prevention. Secondary prevention focuses on minimizing the impact when HRI occurs, and tertiary prevention seeks to mitigate any lasting effects of HRI. At a minimum, employees should receive guidance and recommendations for when HRI occurs and what they should do after an event. In addition, policy should address secondary and tertiary prevention in planning and developing standards for HRI.

Limitations

This report has several limitations. As with any review, there is a risk of bias. This scoping review was limited to U.S. studies published within the last 5 years, which could limit the information and, therefore, the results. For example, recommendations from NIOSH (2016), Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments, were not included because they were more than 5 years old. The review does not include guidelines for specific occupations but provides a general overview for all outdoor workers, which may not be generalizable.

Conclusion

This scoping review uncovered gaps in the reported HRI prevention recommendations for workers, employers, and policy. This review showed a significant lack of secondary and

tertiary prevention in the literature and position statements from leading authorities. Although primary prevention is essential to prevent the initial event, secondary and tertiary prevention are necessary to mitigate adverse outcomes if an event occurs. We propose that HRI prevention planning and implementation involve all three phases: pre-event, event, and post-event. Occupational HRI is not just the problem and responsibility of the individual worker and employer; it is a complex issue comprising many factors and phases that merit consideration. Creating comprehensive HRI guidelines incorporating all heat event phases and factors would help to mitigate adverse outcomes. The guidelines should provide clear recommendations on preventing, identifying, and managing HRI before, during, and after an event.

Implications for OHN Practice

OHNs are uniquely skilled and positioned in the workplace to address HRI with a holistic approach. To support a safe working environment and mitigate the effects of HRI, OHNs can lead in developing guidelines for the prevention of occupational HRI. Tailored guidelines should incorporate various HRI contributors, including biological factors (e.g., overall health, age, underlying medical conditions, and exertional levels for specific jobs) and environmental factors (e.g., WBGT and heatwaves). Guidelines also should include climate change considerations, such as planning for adverse events and reducing causal factors for climate change. The social determinants of health and vulnerable working populations are additional guideline considerations, as are cultural factors that could impact learning and the use of prevention measures.

OHNs should work with policymakers to implement policies that address all aspects of prevention and disparities and include extra protections for vulnerable working populations. In collaborating with policymakers and stakeholders, OHNs can ensure the guidelines are easily accessible, understandable, practical, and user-friendly. OHNs can assist in developing plans covering all three phases of prevention, which employers can use for their workers' safety.

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In Summary

- Including primary, secondary, and tertiary recommendations can provide a more comprehensive plan for HRI prevention.
- OHNs can lead in the development of comprehensive heat standards that are easily tailored, uses clear language, promotes equity, and follows science-based evidence.
- OHN's should collaborate with the community to help employers develop effective and comprehensive prevention plans for heat-related illnesses that are easy to understand and follow.
- OHN's should work with the community to identify and address barriers to prevention and ensure that policy and workplace plans are understandable and applicable to specific workplaces.

ORCID iD

Ashley Edgerly  <https://orcid.org/0000-0003-0220-2581>

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