JOURNAL OF NURSING SCHOLARSHIP

CLINICAL SCHOLARSHIP

Classification of Heat-Related Illness Symptoms Among Florida Farmworkers

Abby D. Mutic, MSN, CNM[1], Jacqueline M. Mix, PhD, MPH[2], Lisa Elon, MS, MPH[3], Nathan J. Mutic, MS, MAT, MEd[4], Jeannie Economos[5], Joan Flocks, JD[6], Antonio J. Tovar-Aguilar, PhD[7], & Linda A. McCauley, PhD, RN, FAAN, FAAOHN[8]

1 *Iota*, Certified Nurse Midwife, Doctoral Candidate, Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA
2 Postdoctoral Fellow, Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA
3 Senior Associate, Department of Biostatistics and Bioinformatics, Rollins School of Public Health, Emory University, Atlanta, GA, USA
4 Project Manager, Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA
5 Pesticide Safety and Environmental Health Project Coordinator, Farmworker Association of Florida, Apopka, FL, USA
6 Director of Social Policy and Associate Professor, Center for Governmental Responsibility, Levin College of Law, University of Florida, Gainesville, FL, USA
7 Co-Principal Investigator, Farmworker Association of Florida, Apopka, FL, USA
8 *Alpha Epsilon*, Dean and Professor, Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA

Key words
Adult health/adult care, community/public health/environmental health, environmental health, health disparities, work environment/working conditions

Correspondence
Ms. Abby D. Mutic, Emory University, Nell Hodgson Woodruff School of Nursing, 1520 Clifton Rd., Atlanta, GA 30322. E-mail: abby.mutic@emory.edu

Accepted August 22, 2017

doi: 10.1111/jnu.12355

Abstract

Background: Farmworkers working in hot and humid environments have an increased risk for heat-related illness (HRI) if their thermoregulatory capabilities are overwhelmed. The manifestation of heat-related symptoms can escalate into life-threatening events. Increasing ambient air temperatures resulting from climate change will only exacerbate HRI in vulnerable populations. We characterize HRI symptoms experienced by farmworkers in three Florida communities.

Methods: A total of 198 farmworkers enrolled in 2015–2016 were asked to recall if they experienced seven HRI symptoms during the previous work week. Multivariable logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for the association between selected sociodemographic characteristics and reporting three or more symptoms. Latent class analysis was used to identify classes of symptoms representing the HRI severity range. We examined sociodemographic characteristics of the farmworkers across the latent classes.

Results: The mean age (±*SD*) of farmworkers was 38.0 (±8) years; the majority were female (60%) and Hispanic (86%). Most frequently reported symptoms were heavy sweating (66%), headache (58%), dizziness (32%), and muscle cramps (30%). Females had three times the odds of experiencing three or more symptoms (OR = 2.86, 95% CI 1.18–6.89). Symptoms fell into three latent classes, which included mild (heavy sweating; class probability = 54%), moderate (heavy sweating, headache, nausea, and dizziness; class probability = 24%), and severe (heavy sweating, headache, nausea, dizziness, muscle cramps; class probability = 22%).

Conclusions: Farmworkers reported a high burden of HRI symptoms that appear to cluster in physiologic patterns. Unrecognized accumulation of symptoms can escalate into life-threatening situations if untreated. Our research can inform interventions to promote early recognition of HRI, on-site care, and appropriate occupational health policy. Administrative or engineering workplace controls may also reduce the manifestation of HRI.

Journal of Nursing Scholarship, 2018; 50:1, 74–82.

Clinical Relevance: This study advances the current knowledge of HRI symptoms in farmworkers and moves beyond reporting individual symptoms by utilizing latent class analysis to identify how symptoms tend to co-occur together in this population. It acknowledges multiple symptoms occurring as a result of occupational heat exposure and highlights the importance of symptom recognition.

The Centers for Disease Control and Prevention (CDC) estimates that 3,442 deaths in the United States were attributable to heat-related illness (HRI) between 1999 and 2003 (CDC, 2006). This number is most likely underestimated given that criteria to determine heat-related deaths vary by state (CDC, 2006) and heat exposure may not be recorded as the primary cause of death (Berko, Ingram, Saha, & Parker, 2014, July 30; Leigh, Du, & McCurdy, 2014; Oberlin, Tubery, Cances-Lauwers, Ecoiffier, & Lauque, 2010; Ostro, Roth, Green, & Basu, 2009). Increasing ambient temperatures resulting from climate change are a recognized climate-related occupational hazard (Schulte et al., 2016) and have profound effects on human health (Perera, 2017). Average surface temperatures have been rising since 1901, with the past decade (2006–2015) being the warmest ever recorded (Environmental Protection Agency, 2017). Populations most adversely impacted by HRI include the elderly, children, low-income, and outdoor workers, including farmworkers (Balbus & Malina, 2009; Schulte et al., 2016). Farmworkers' risk for heat-related death is nearly 20 times greater than that of other outdoor workers (Centers for Disease & Prevention, 2008). Between 1992 and 2006, 423 occupational heat-related deaths were reported in the United States, including 68 associated with crop work (Jackson & Rosenberg, 2010). Six of the 68 crop worker deaths occurred in Florida, a state with a consistently hot and humid climate (Jackson & Rosenberg, 2010).

Factors that increase farmworker susceptibility to HRI include low income, lack of education, language barriers, poor housing conditions, and fear of deportation (Culp, Tonelli, Ramey, Donham, & Fuortes, 2011). Farmworkers report that they often delay or fail to seek medical treatment, frequently prioritizing work duties over health because of their socioeconomic vulnerability (Thierry & Snipes, 2015). When farmworkers are paid by a piece rate, they may not want to stop work to take rest breaks or to hydrate. Healthcare providers who serve farmworkers also acknowledge a lack of occupational and environmental health training, including training about HRI (Kelley, Flocks, Economos, & McCauley, 2013). Furthermore, in rural areas where farm work takes place, rapid access to emergency care may be limited due to distance and lack of transportation (Hoerster et al., 2011). Out of 139 who died from HRI in Florida from 2005 to 2012, 40% were not treated in an emergency room or hospital prior to death (Harduar Morano, Watkins, & Kintziger, 2016).

HRI occurs when innate thermoregulatory capabilities are overwhelmed by a consistently high core body temperature (Hanna & Tait, 2015). Mechanisms that promote thermal regulation include evaporative cooling, conduction, radiation, and convection (Becker & Stewart, 2011; Hanna & Tait, 2015; Jacklitsch et al., 2016). Evaporative cooling of the skin can be disrupted in hot and humid environments, accelerating dehydration and electrolyte imbalance. When thermal balance is disrupted, a series of symptoms can manifest, including heat rash, excessive sweating, peripheral edema, headache, heat cramps, nausea-vomiting, fainting, and, in severe cases, coma and death (Becker & Stewart, 2011; Bethel & Harger, 2014; Hanna & Tait, 2015). Symptoms such as excessive sweating and reddening of the skin are common and reflect the physiological response to heat. If interventions are not taken to reduce core body temperature, more serious cardiac and neurological symptoms develop, indicating a worsening medical condition (Becker & Stewart, 2011; Hanna & Tait, 2015). Dehydrated workers can develop cardiac arrhythmia and become disoriented and unaware of their worsening symptoms, potentiating further health decline and work-related injuries. Although, the body has compensatory mechanisms to counter the effects of HRI, many risk factors can compromise these mechanisms, including excessive body mass (Becker & Stewart, 2011; Hanna & Tait, 2015), age (Becker & Stewart, 2011; Hanna & Tait, 2015), limited fluid intake (Bethel & Harger, 2014), smoking (Pantavou, Lykoudis, & Nikolopoulos, 2016), medications (Becker & Stewart, 2011; Hanna & Tait, 2015), chronic health conditions (Becker & Stewart, 2011; Hanna & Tait, 2015; Harduar Morano et al., 2016), lack of rest breaks at work, gender (Harduar Morano et al., 2016; Pantavou et al., 2016), and outdoor work (Bethel & Harger, 2014; Xiang, Bi, Pisaniello, & Hansen, 2014). Fortunately, if identified early, HRI is both preventable and treatable (Glazer, 2005).

There are emerging data regarding the extent of farmworker recognition of HRI symptoms. In a cross-sectional survey of 300 North Carolina farmworkers, 94% reported working in conditions of extreme heat, and 40% reported at least one HRI symptom ever while working in agriculture (Mirabelli et al., 2010). In a study of 405 Georgia farmworkers, more than one third reported they experienced at least three heat-related symptoms during the previous week (Fleischer et al., 2013). In-person interviews conducted with 100 Oregon migrant farmworkers revealed that 64% experienced an HRI symptom during the previous work week, most commonly heavy sweating (50%) and headache (24%; Bethel & Harger, 2014). A study of 106 sugarcane harvesters in Central America reported that 82% experienced at least one HRI symptom, 59% experienced two, and 42% experienced three or more during the previous week. The most common symptoms reported among these sugarcane workers were headache (51%), tachycardia (35%), and muscle cramps (25%; Crowe, Nilsson, Kjellstrom, & Wesseling, 2015).

The purpose of the current study is to describe the prevalence and clustering of HRI symptoms experienced by farmworkers in three agricultural communities in Florida during hot summer months, and to identify subgroups of farmworkers with differential HRI symptom profiles using latent class analysis (LCA), a statistical technique that can be used to identify subgroups based on categorical data responses (Lanza, Collins, Lemmon, & Schafer, 2007; Lanza & Rhoades, 2013). This method may provide empirical evidence for stratifying farmworkers into HRI risk categories based upon the symptoms experienced to aid in early identification of severe HRI and prompt preventive or medical interventions.

Methods

Study Design and Population

The Girasoles (Sunflower) study utilizes a prospective cohort of seasonal and migrant farmworkers to investigate the impact of working in hot and humid environments and the extent of HRI in Florida. Girasoles is a collaborative effort among researchers at Emory University, the University of Florida, and the Farmworker Association of Florida (FWAF), a grassroots organization. The FWAF is a membership organization with more than 10,000 members who work primarily in the vegetable, citrus, mushroom, sod, fern, and foliage industries in 15 counties in Florida. The FWAF works in communities composed of low-income, ethnic-minority, migrant, and seasonal farmworkers, many of whom are undocumented. Most of these farmworkers have little formal education and speak little or no English; therefore, all written materials, including the informed consent, were read aloud. This article focuses on farmworkers in the Apopka, Pierson, and Immokalee communities during the summer months of 2015 to 2016. Trained community workers from the FWAF recruited a convenience sample of farmworkers through phone calls, home visits, and community events.

Farmworkers were eligible if they were 18 to 54 years old, had worked in agricultural settings for at least 2 weeks prior to the study, did not have type I diabetes mellitus, and were not currently pregnant. Farmworkers reported to the study site for consent, an occupational heat-related illness survey, and clinical assessment. The university institutional review board reviewed and approved all procedures.

Measures

A demographic, health, and work characteristics survey adapted from previously used occupational HRI surveys with farmworker populations (Fleischer et al., 2013), was administered in the farmworkers' primary language by trained interviewers. Survey items included questions about seven HRI symptoms experienced during the previous work week: heavy sweating, headache, sudden muscle cramps, nausea or vomiting, confusion, dizziness, or fainting while working. Each response was recorded as "yes, experienced" if reported in the last week; otherwise, "no." The number of reported symptoms was summed and classified into a dichotomous variable indicating three or more symptoms experienced. We ascertained the ambient temperature and relative humidity during the time of recall from the Florida Automated Weather Network.

Statistical Analysis

Variables were summarized using means and standard deviations for continuous variables and frequency counts and percentages for categorical variables. The relationship of "reporting 3 or more HRI symptoms" with participant demographic (age, gender, nationality), health-related (body mass index [BMI], history of hypertension or diabetes, alcohol consumption, smoking), and work-related variables (work type, days worked per week, hours worked per day) was assessed with multivariable logistic regression. First, a generalized linear mixed model adjusting for the random effect of participants clustering in households was compared to a model without such adjustment; based on fit statistics Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC; lower values indicating a better fit), the simpler model had a better fit and is reported.

LCA (Lanza et al., 2007), a data-driven approach to identify subgroups within our population, was used to describe the classification of reported symptom types during the previous week. Model selection strategy included evaluating the likelihood ratio G^2 statistic, AIC, and BIC (lower values indicating a better fit), the entropy statistic (higher values indicating better class separation; values of ≥0.6 indicate acceptable model discrimination; Zhu et al., 2016), and consideration of class composition as physiologically plausible. Item response probabilities were used to determine if classes could be distinguished from one another and to assign meaningful categories. A general guideline is to use 0.5 as the cutoff (Berglund, 2016); due to sample size considerations, a conservative cutoff of 0.4 for item response probabilities was used to determine membership of particular symptoms within each latent class. SAS version 9.4 (Cary, NC, USA) was used for all statistical analyses, and LCA was performed by using the PROC LCA software, which is publicly available at http://methodology.psu.edu (Lanza et al., 2007).

Results

Farmworkers' ages ranged from 19 to 54 years, with a mean age (±*SD*) of 38 (±8) years. Of the 198 farmworkers in the sample, 61% were female, 86% were Hispanic, 63% were of Mexican origin, and 82% spoke Spanish as their primary language (**Table 1**). Nearly half were married and on average had 6.5 (±4) years of education. The majority of farmworkers were overweight or obese (79%), a quarter reported drinking alcohol, and 14% had ever smoked. On average, farmworkers in our sample had been working in U.S. agriculture for about 12 (±7.8) years, worked 5.1 (± 0.9) days per week, and 7.5 (±1.4) hours per day. The mean ambient temperature for the previous work week was 84°F (28.9°C) with a relative humidity of 74%.

During the previous work week, 84% of participants reported experiencing at least one symptom and 40% reported three or more symptoms. The average number of symptoms experienced was 2.2 (*SD* ±1.7). The frequency of the type of HRI symptoms reported during the previous week were heavy sweating (66%), headache (58%), dizziness (32%), muscle cramps (30%), nausea-vomiting (24%), fainting (10%) and confusion (9%; **Table 2**). In multivariable modeling, we found that females had a three times greater odds of experiencing three or more symptoms compared to males (odds ratio [OR] = 2.67; 95% confidence interval [CI] 1.10–6.50), controlling for other variables of interest. No other characteristics were found to be significantly associated with reporting more symptoms (**Table 3**).

Multiple latent class models were constructed and model fit statistics were compared (**Table 4**). Balancing model selection criteria and physiological interpretability, we chose a three-class model with classes designated as mild (heavy sweating; class probability = 54%), moderate (heavy sweating, headache, nausea-vomiting and dizziness; 24%), and severe (excessive sweating, headache, dizziness, nausea-vomiting, sudden muscle cramps and fainting; 22%; see **Figure 1**). Model entropy was 0.72, indicating moderately distinct class separation. When comparing the distribution of sociodemographic characteristics across the latent classes, we found that a higher proportion of females were in the moderate and severe symptom classes (54% female in mild vs. 70% female in moderate and severe symptom classes; $p = .04$). No other meaningful differences were found.

Table 1. Demographic, Health, and Work Characteristics in Summer, Florida 2015–2016 (total sample, $N = 198$)

Characteristics	*n*	% or mean (*SD*)
Years of age	198	38.0 (8.2)
Gender		
Male	78	39%
Female	120	61%
Hispanic	169	86%
Nation of origin		
United States	3	2%
Mexico	125	63%
Haiti	28	14%
Guatemala	34	17%
Other[a]	8	4%
Primary language		
Spanish	163	82%
Haitian Creole	28	14%
Other[b]	7	4%
Married	88	45%
Years of education	198	6.5 (4)
Health-related		
Body mass index		
Normal (18.5 to <25)	41	21%
Overweight (25 to <30)	87	44%
Obese (≥30)	69	35%
Drinks alcohol	51	26%
Smoked ever	27	14%
Work-related		
Primary work type		
Nursery	61	31%
Fernery	70	35%
Crop	67	34%
Years in U.S. agriculture	198	12.0 (7.8)
Days worked per week	197	5.1 (0.9)
Hours worked per day	198	7.5 (1.4)

[a]Other nations of origin include Dominican Republic, El Salvador, Honduras, and Puerto Rico.
[b]Other languages include Canjobal, Mam, and Zapotec.

Table 2. Heat-Related Illness Symptoms Among Farmworkers in Summer, Florida 2015–2016 (total sample, $N = 198$)

Characteristics	*n*	% or mean (*SD*)
Heat-related illness symptoms reported		
Heavy sweating	130	66%
Headache	115	58%
Dizziness	63	32%
Muscle cramps	59	30%
Nausea/vomiting	47	24%
Fainting	20	10%
Confusion	18	9%
Number of heat-related illness symptoms		
None	32	16%
1	41	21%
2	43	22%
3	30	15%
4	30	15%
5	11	6%
6	5	3%
7	2	1%
Average number of heat-related illness symptoms	194	2.2 (1.7)

Note. Missing values are excluded from the table; percentages are based on nonmissing data.

Table 3. Association of Selected Characteristics With Reporting Three or More Symptoms of Heat-Related Illness

Characteristics	Unadjusted OR (95% CI)[a]	Adjusted OR (95% CI)[a]
Years of age (reference = 19–31)		
32–37	0.77 (0.33, 1.80)	0.83 (0.34, 2.03)
38–42	0.46 (0.21, 1.05)	0.53 (0.22, 1.30)
43–54	0.44 (0.17, 1.11)	0.58 (0.20, 1.62)
Gender (reference = male)		
Female	2.13 (1.15, 3.95)	2.67 (1.10, 6.50)
Nationality (reference = Mexican)		
Other	0.96 (0.53, 1.75)	1.38 (0.59, 3.26)
Years of education	1.04 (0.96, 1.13)	1.03 (0.94, 1.14)
Body mass index	1.00 (0.94, 1.07)	0.99 (0.92, 1.07)
Reported hypertension or diabetes (reference = no)	0.59 (0.31, 1.16)	0.70 (0.33, 1.50)
Drinks alcohol (reference = no)		
Yes	1.10 (0.57, 2.12)	2.06 (0.88, 4.81)
Smoked (reference = never)		
Ever	0.60 (0.25, 1.46)	0.98 (0.33, 2.91)
Work type (reference = nursery)		
Fernery	0.58 (0.28, 1.19)	1.13 (0.44, 2.94)
Crop	0.82 (0.40, 1.70)	0.69 (0.26, 1.81)
Days worked per week	0.84 (0.60, 1.17)	0.90 (0.60, 1.35)
Hours worked per day	0.93 (0.76, 1.15)	0.90 (0.68, 1.17)

Note. OR = odds ratio; CI = confidence interval.
[a]Mutually adjusted estimates are based on farmworkers who had completed data for all variables ($n = 192$).

Table 4. Fit Statistics for Latent Class Analysis Models of Heat-Related Illness Symptoms

N classes	G^2	AIC	BIC	Entropy
2	84.6	114.6	163.9	0.72
3	62.4	108.4	184.0	0.72
4	50.1	112.1	214.0	0.73
5	43.0	121.0	249.3	0.74
6	36.8	130.8	285.4	0.78
7	31.5	141.5	322.4	0.75

Note. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria.

Discussion

Farmworkers in this study report a high burden of HRI symptoms that cluster in physiologic patterns ranging from mild to severe. Previous HRI literature differentiates mild from severe HRI when symptoms progress from heat exhaustion to heat stroke and the body is no longer able to thermoregulate its internal cooling mechanisms (Jacklitsch et al., 2016). The results of this study challenge the traditional classification of mild or severe HRI symptom burden by elucidating three distinct physiologically meaningful clusters of symptoms. This LCA approach is a first step toward identifying co-occurring symptoms and away from subjectively classifying groups of symptoms as mild or severe. Additionally, the three-class model has value in a clinical setting for classifying the severity of an HRI illness. For individuals experiencing HRI, this model may better equip them to determine when their symptoms progress to a point that they need to rest or to seek treatment. From a public health standpoint, these classifications also have value as the basis for HRI prevention policies. Unrecognized accumulation of symptoms can escalate into life-threatening situations if untreated. Our research can inform interventions to promote early recognition of HRI, on-site care, and appropriate occupational health policy. Administrative and/or engineering workplace controls may also reduce the manifestation of HRI.

Similar to previously reported gender differences in HRI symptom reporting (Spector, Krenz, & Blank, 2015) we observed that females reported more symptoms. Gender differences in symptom reporting may be due in part to cultural biases that prevent the willingness of men to disclose the occurrence of severe symptoms (Hunter, Fernandez, Lacy-Martinez, Dunne-Sosa, & Coe, 2007). Male Latino farmworkers are traditionally viewed as resilient to adversity, strong, stoic, and resourceful in their workplace (Roy, Tremblay, Robertson, & Houle, 2015). Biological factors such as high body surface to mass ratio and or morphology and adipose distribution among

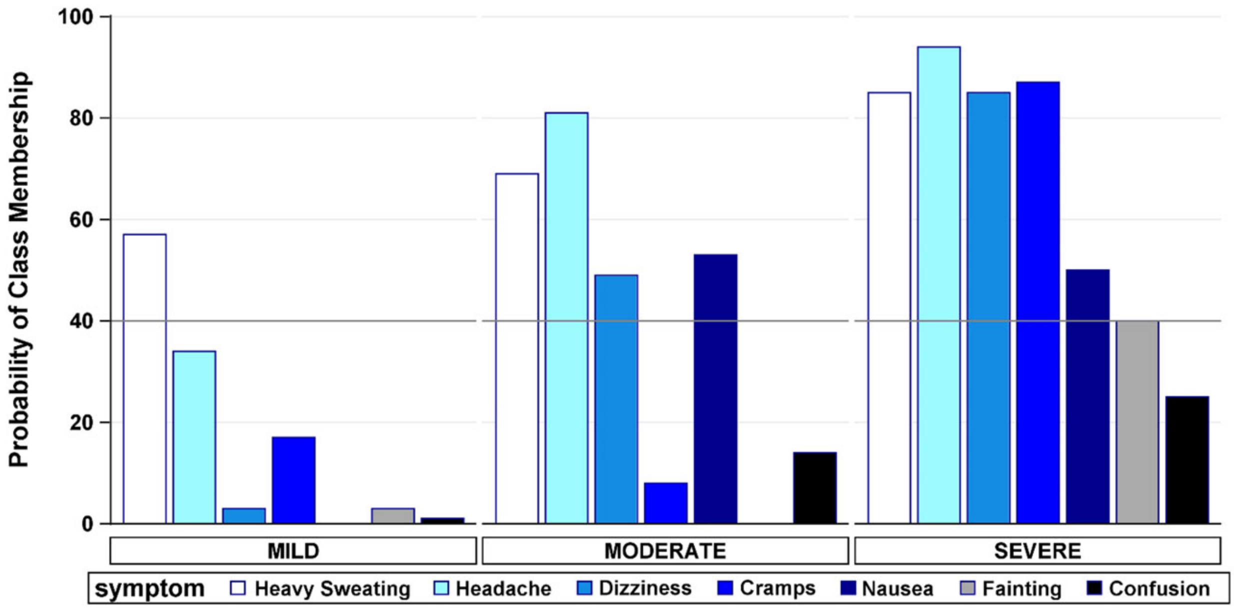

Figure 1. Latent class analysis on seven heat-related illness symptoms: class membership and item probabilities.

women could also contribute to this difference (Hanna & Tait, 2015). We did not observe a correlation between number of symptoms reported and BMI as other studies have reported, and this could be due to our unique study population. Consistent with previous reports of age-associated trends in HRI among other farmworker populations (Spector et al., 2015), younger individuals were more likely to experience three or more symptoms relative to older participants.

Many farmworkers believe their work environments can be unsafe, yet they often have little control over their working conditions and lack proper heat hazard training (Kelley et al., 2013). In the current study, despite participants reporting a high burden of HRI symptoms, only 16% reported receiving training on HRI prevention practices. This finding is consistent with other occupational researchers reporting 77% of farmworkers in Georgia lack heat training or access to regular breaks, shade, or medical attention (Fleischer et al., 2013). Currently, Washington and California are the only states that have established heat hazard regulations in order to prevent HRI in farmworkers (Mirabelli et al., 2010). The International Council of Nurses (ICN) works closely with the National Nurses Council and other labor organizations to raise awareness of potential occupational hazards and at-risk settings. The ICN believes it is the ethical, moral, and legal responsibility of healthcare stakeholders, including government and political officials, to ensure that workers' rights to a healthy and safe workplace are protected (ICN, 2017). Employers also have a duty to protect workers from recognized workplace hazards such as HRI under the Occupational Safety and Health Act by providing water, rest, and shade. Unfortunately, the guidelines lack protocols and necessary surveillance to ensure adequate provision of water, rest, and shade. The lack of Occupational Safety and Health Administration oversight, coupled with a lack of required education in most states, underscores the need for farmworkers and growers to understand co-occurrence and severity of symptoms of HRI and how to seek medical attention for themselves or co-workers when dangerous symptoms occur. Occupational health and safety nurses have a unique and critical role in the field to assess dangerous risks to health, respond to illness with early life-saving treatment, report work-related incidents, and educate workers about HRI prevention. Nurses are also called to conduct, translate, and implement important research findings efficiently so workers live healthier, more productive lives.

Recognizable symptoms of HRI should serve as signals to take preventative action against a heat-induced cascade of physiological symptoms that could end in death. Symptom awareness by the farmworkers can effectively occur in the field, and occupation health nurses should be a part of this process through practice and research. The need for continued development of HRI prevention strategies will continue to grow in light of population aging trends and an increased prevalence of chronic disease, making workers more vulnerable to HRI. Successful interventions for farmworkers must be based on knowledge of the pattern and prevalence of such symptoms in the population. Although we have previously reported on the strong community interest in health effects associated with working in hot environments (Flocks, Kelley, Economos, & McCauley, 2012; Mac et al., 2017), more research is needed to develop, implement, and evaluate successful, culturally appropriate interventions.

Limitations

Our study design and data collection efforts were dependent on strong engagement from farmworker community members, yielding a convenience sample of farmworkers. Our sample population is mainly Hispanic workers with specific heat, humidity, and other environmental exposures due to their occupational tasks. For these reasons, our data may not be generalizable to other populations. Symptoms were recalled from the previous week, making them subject to recall bias. In our LCA, we were able to determine three underlying subgroups in our sample based upon their pattern of symptoms. However, we may have enrolled healthier, more motivated farmworkers that may be more knowledgeable about HRI prevention practices and may not have experienced more severe symptoms. In addition, our sample size may not have allowed us to capture the full spectrum of symptoms experienced in this population. We may have observed different underlying symptom profiles with a more robust sample size. Lastly, we were not able to determine the temporal order of symptom occurrence.

Conclusions

This study advances the current knowledge of HRI symptom classification and moves beyond symptom and illness characterization. It acknowledges multiple symptoms occurring as a result of heat exposure and raises awareness of how symptoms cluster together. Unrecognized accumulation of symptoms may lead to life-threatening situations, and early recognition of HRI is essential in keeping farmworkers safe and healthy in their workplace. Ideally, early recognition of symptom clusters by occupational health nurses or emergency clinicians could reduce the overall prevalence and morbidity associated with HRI. Further investigation using symptom recall at the end of several workdays could lead to better estimates of HRI risk and reporting of HRI cases. Ultimately, future nursing and public health research should evaluate if HRI symptom clusters are predictive of objective health outcomes.

Acknowledgments

Research reported in this article was supported in part by the Centers for Disease Control–National Institute for Occupational Safety and Health under award number R01OH010657. This study was approved by the Emory University Institutional Review Board, IRB00075192. Abby Mutic is a 2016–2018 Jonas nurse leader scholar.

Clinical Resources

- American Nurses Association. Healthy work environment: http://nursingworld.org/MainMenu-Categories/WorkplaceSafety/Healthy-Work-Environment
- Centers for Disease Control and Prevention. Recommendations: https://www.cdc.gov/niosh/topics/heatstress/recommendations.html
- Occupational Health and Safety Administration. Heat illness index of educational resources, using the heat index, training, and online toolkit: https://www.osha.gov/SLTC/heatillness/index.html
- American Academy of Family Physicians. Heat-related illnesses: http://www.aafp.org/afp/1998/0901/p749.html
- Migrant Clinicians Network. Heat-related illness: http://www.migrantclinician.org/issues/heat-stress.html
- Centers for Disease Control and Prevention. Heat stress: https://www.cdc.gov/niosh/topics/heatstress/default.html
- National Weather Service. Heatwave: https://www.weather.gov/media/owlie/heatwave.pdf
- Occupational Safety and Health Administration. Occupational heat exposure: https://www.osha.gov/SLTC/heatstress/prevention.html
- Occupational Safety and Health Administration. Protecting workers from the effects of heat: https://www.osha.gov/OshDoc/data_Hurricane_Facts/heat_stress.pdf

References

Balbus, J. M., & Malina, C. A. (2009). Identifying vulnerable subpopulations for climate change health effects in the United States. *Journal of Occupational & Environmental Medicine*, *51*(1), 33–37. https://doi.org/10.1097/JOM.0b013e318193e12e

Becker, J. A., & Stewart, L. K. (2011). Heat-related illness. *American Family Physician*, *83*(11), 1325–1330.

Berglund, P. A. (2016). *Latent class analysis using PROC LCA*. Paper 5500-2016. Retrieved from http://support.sas.com/resources/papers/proceedings16/5500-2016.pdf

Berko, J., Ingram, D. D., Saha, S., & Parker, J. D. (2014, July 30). Deaths attributed to heat, cold, and other weather events in the United States, 2006–2010. *National Health Statistics Report*, (*76*), 1–15.

Bethel, J. W., & Harger, R. (2014). Heat-related illness among Oregon farmworkers. *International Journal of Environmental Research and Public Health*, *11*(9), 9273–9285. https://doi.org/10.3390/ijerph110909273

Centers for Disease Control and Prevention. (2006). Heat-related deaths—United States, 1999–2003. *Morbidity and Mortality Weekly Report*, *55*(29), 796–798.

Centers for Disease Control and Prevention. (2008). Heat-related deaths among crop workers—United States, 1992–2006. *Morbidity and Mortality Weekly Report*, *57*(24), 649–653.

Crowe, J., Nilsson, M., Kjellstrom, T., & Wesseling, C. (2015). Heat-related symptoms in sugarcane harvesters. *American Journal of Industrial Medicine*, *58*(5), 541–548. https://doi.org/10.1002/ajim.22450

Culp, K., Tonelli, S., Ramey, S. L., Donham, K., & Fuortes, L. (2011). Preventing heat-related illness among Hispanic farmworkers. *AAOHN Journal*, *59*(1), 23–32. https://doi.org/10.3928/08910162-20101228-01

Environmental Protection Agency. (2017). *Climate change indicators: U.S. and global temperature*. Retrieved from https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature

Fleischer, N. L., Tiesman, H. M., Sumitani, J., Mize, T., Amarnath, K. K., Bayakly, A. R., & Murphy, M. W. (2013). Public health impact of heat-related illness among migrant farmworkers. *American Journal of Preventive Medicine*, *44*(3), 199–206. https://doi.org/10.1016/j.amepre.2012.10.020

Flocks, J., Kelley, M., Economos, J., & McCauley, L. (2012). Female farmworkers' perceptions of pesticide exposure and pregnancy health. *Journal of Immigrant and Minority Health*, *14*(4), 626–632. https://doi.org/10.1007/s10903-011-9554-6

Glazer, J. L. (2005). Management of heatstroke and heat exhaustion. *American Family Physician*, *71*(11), 2133–2140.

Hanna, E. G., & Tait, P. W. (2015). Limitations to thermoregulation and acclimatization challenge human adaptation to global warming. *International Journal of Environmental Research and Public Health*, *12*(7), 8034–8074. https://doi.org/10.3390/ijerph120708034

Harduar Morano, L., Watkins, S., & Kintziger, K. (2016). A comprehensive evaluation of the burden of heat-related illness and death within the Florida population. *International Journal of Environmental Research and Public Health*, *13*(6), 551. https://doi.org/10.3390/ijerph13060551

Hoerster, K. D., Mayer, J. A., Gabbard, S., Kronick, R. G., Roesch, S. C., Malcarne, V. L., & Zuniga, M. L. (2011). Impact of individual-, environmental-, and policy-level factors on health care utilization among US farmworkers. *American Journal of Public Health*, *101*(4), 685–692. https://doi.org/10.2105/AJPH.2009.190892

Hunter, J. B., Fernandez, M. L., Lacy-Martinez, C. R., Dunne-Sosa, A. M., & Coe, M. K. (2007). Male preventive health behaviors: Perceptions from men, women, and clinical staff along the U.S. Mexico border. *American Journal of Men's Health*, *1*(4), 242–249. https://doi.org/10.1177/1557988306294163

International Council of Nurses. (2017). *Occupational health and safety for nurses*. Retrieved from http://www.icn.ch/images/stories/documents/publications/position_statements/ICN_PS_Occupational_health_and_safety.pdf

Jacklitsch, B., Williams, W. J., Musolin, K., Coca, A., Kim, J-H., & Turner, N. (2016). *Criteria for a recommended standard: Occupational exposure to heat and hot environments*. Publication no. 2016–106. Cincinnati, OH: National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2016-106/pdfs/2016-106.pdf

Jackson, L. L., & Rosenberg, H. R. (2010). Preventing heat-related illness among agricultural workers. *Journal of Agromedicine*, *15*(3), 200–215. https://doi.org/10.1080/1059924X.2010.487021

Kelley, M. A., Flocks, J. D., Economos, J., & McCauley, L. A. (2013). Female farmworkers' health during pregnancy: Health care providers' perspectives. *Workplace Health & Safety*, *61*(7), 308–313. https://doi.org/10.3928/21650799-20130617-07

Lanza, S. T., Collins, L. M., Lemmon, D. R., & Schafer, J. L. (2007). PROC LCA: A SAS procedure for latent class analysis. *Structural Equation Modeling*, *14*(4), 671–694.

Lanza, S. T., & Rhoades, B. L. (2013). Latent class analysis: An alternative perspective on subgroup analysis in prevention and treatment. *Prevention Science*, *14*(2), 157–168. https://doi.org/10.1007/s11121-011-0201-1

Leigh, J. P., Du, J., & McCurdy, S. A. (2014). An estimate of the U.S. government's undercount of nonfatal occupational injuries and illnesses in agriculture. *Annals of Epidemiology*, *24*(4), 254–259. https://doi.org/10.1016/j.annepidem.2014.01.006

Mac, V., Tovar-Aguilar, J., Flocks, J., Economos, E., Hertzberg, V., & McCauley, L. (2017). Heat exposure in Central Florida fernery workers: Results of a feasibility study. *Journal of Agromedicine*, *22*(2), 89–99.

Mirabelli, M. C., Quandt, S. A., Crain, R., Grzywacz, J. G., Robinson, E. N., Vallejos, Q. M., & Arcury, T. A. (2010). Symptoms of heat illness among Latino farm workers in North Carolina. *American Journal of Preventive Medicine*, *39*(5), 468–471. https://doi.org/10.1016/j.amepre.2010.07.008

Oberlin, M., Tubery, M., Cances-Lauwers, V., Ecoiffier, M., & Lauque, D. (2010). Heat-related illnesses during the 2003 heat wave in an emergency service. *Emergency Medicine*

Journal, *27*(4), 297–299. https://doi.org/10.1136/emj.2008.067934

Ostro, B. D., Roth, L. A., Green, R. S., & Basu, R. (2009). Estimating the mortality effect of the July 2006 California heat wave. *Environmental Research*, *109*(5), 614–619. https://doi.org/10.1016/j.envres.2009.03.010

Pantavou, K. G., Lykoudis, S. P., & Nikolopoulos, G. K. (2016). Milder form of heat-related symptoms and thermal sensation: A study in a Mediterranean climate. *International Journal of Biometeorology*, *60*(6), 917–929. https://doi.org/10.1007/s00484-015-1085-8

Perera, F. P. (2017). Multiple threats to child health from fossil fuel combustion: Impacts of air pollution and climate change. *Environmental Health Perspectives*, *125*(2), 141–148. https://doi.org/10.1289/ehp299

Roy, P., Tremblay, G., Robertson, S., & Houle, J. (2015). "Do it all by myself": A salutogenic approach of masculine health practice among farming men coping with stress. *American Journal of Men's Health*, *11*(5), 1536–1546. https://doi.org/10.1177/1557988315619677

Schulte, P. A., Bhattacharya, A., Butler, C. R., Chun, H. K., Jacklitsch, B., Jacobs, T., ... Wagner, G. R. (2016). Advancing the framework for considering the effects of climate change on worker safety and health. *Journal of Occupational and Environmental Hygiene*, *13*(11), 847–865. https://doi.org/10.1080/15459624.2016.1179388

Spector, J. T., Krenz, J., & Blank, K. N. (2015). Risk factors for heat-related illness in Washington crop workers. *Journal of Agromedicine*, *20*(3), 349–359. https://doi.org/10.1080/1059924x.2015.1047107

Thierry, A. D., & Snipes, S. A. (2015). Why do farmworkers delay treatment after debilitating injuries? Thematic analysis explains if, when, and why farmworkers were treated for injuries. *American Journal of Industrial Medicine*, *58*(2), 178–192. https://doi.org/10.1002/ajim.22380

Xiang, J., Bi, P., Pisaniello, D., & Hansen, A. (2014). Health impacts of workplace heat exposure: An epidemiological review. *Industrial Health*, *52*(2), 91–101.

Zhu, L., Ranchor, A. V., van der Lee, M., Garssen, B., Sanderman, R., & Schroevers, M. J. (2016). Subtypes of depression in cancer patients: An empirically driven approach. *Supportive Care in Cancer*, *24*(3), 1387–1396. https://doi.org/10.1007/s00520-015-2919-y