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Heat-Related Illness in Midwestern Hispanic Farmworkers: A Descriptive Analysis of Hydration Status & Reported Symptoms

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Abstract

Heat-related illness (HRI) is a largely undocumented phenomenon in Midwestern Hispanic migrant and seasonal farmworkers in the U.S. Frequently, the physiological burden of crop production is overlooked while workers are in the fields. We completed a mixed methods study using a cross-sectional survey among migrant and seasonal farmworkers about their experience with HRI symptoms (N=148) and conducted an intensive surveillance on a smaller group of workers (N=20) in field trials (N=57 trials) using a chest-strapped multi-parameter monitoring wearable sensor (MPMWS) which measured skin/body temperature, heart and breathing rate, kilocalories burned per hour and provided a physiological intensity (PI) score. The field trials were conducted across 3 classes of climate conditions and 3 PI score categories. We found in that those in the uncomfortable category (PI score >4.0) had a statistically significant (F-ratio −16.41, p <.001) higher body temperatures (mean =100.05 °F) than those with a mild PI (range 0–5) score ≤ 2.5 (mean = 99.56 °F) or moderate PI score > 2.5 – 4 (99.84 °F). We also found that those in the uncomfortable climate condition category had a higher mean heart rate and breathing rate than those working under mild and moderate field trials.

Introduction

Over the last twenty years global warming has resulted in increased risk for heat-related illness (HRI) yet very few changes in personal protective strategies exist for minority agricultural workers who must deal with rising temperatures and humid conditions (Park, Hannaford-Turner, & Lee, 2009). Hispanic farmworkers (HF) tend to seek employment on more labor intensive and time sensitive crop production tasks than non-Hispanic farmers who have machinery-assisted crop production that requires hiring fewer workers (Goldstein & Kopin, 2007). In the Midwest, climate change from elevated carbon emissions compared to 50 years ago has increased Spring and Summer temperature levels as a result of combined earlier snowmelt and higher mid-July temperatures with more humidity (Foufoula-Georgiou et al., 2016). For farmers in the Midwest, this has translated into more hazardous working conditions due to an increase in the number of humid days over 95°F in the summer (Pryor et al., 2014).

Little is known about the physiological burden of crop production work performed in hot weather conditions and even less is known about HRI in the Midwest as most studies are

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based in the southern states such as Arizona (Harlan et al., 2014), North Carolina (Moyce et al., 2017) (Beck, Balanay, & Johnson, 2017), Texas (Zhang, Chen, & Begley, 2015), California and Alabama (Singleton et al., 2016; Stoecklin, Bigham, Bennett, Tancredi, & Schenker, 2015). Also, there are few safety inspections for heat-related prevention/ management strategies on US farms except for the states of California (Arcury et al., 2015) and Washington (Reid & Schenker, 2016).

Despite decades of HRI research on military populations (Reynolds, Schumaker, & Feighery, 1998; Rickards, Ryan, Cooke, Romero, & Convertino, 2008), athletes (Lopez, Cleary, Jones, & Zuri, 2008; Maughan & Shirreffs, 2004), and other industrial workers(Nag & Nag, 2001; Singh, Bhardwaj, & Deepak, 2010) , the physiological impact of HRI in agriculture on minority workers while they perform crop production tasks is relatively unknown (Lam et al., 2013). Symptoms and physiological data in farmworkers related to HRI and climate change only exacerbate the need to study this problem (Kjellstrom et al., 2016; Luber & Lemery, 2015).

Background

The threat of HRI is largely physiological and at its worst may result in heat stroke (Kearney, Xu, Balanay, & Becker, 2014). Many minority farmworkers performing outdoor work tasks may not be consuming adequate fluids to replace the volume lost from excessive sweating and heavy exertion and are at risk (Kearney, Hu, Xu, Hall, & Balanay, 2016). Symptoms of heat-related illness include headache, tachycardia, muscle cramps, fever, nausea, difficulty breathing and dizziness; the incidence of these in farmworkers varies according to climate conditions, type of work performed and pre-existing health conditions (Crowe, Nilsson, Kjellstrom, & Wesseling, 2015). According to the Centers for Disease Control and Prevention (CDC), heat-related fatalities for all agricultural workers was 0.39 per 100,000 FTE workers compared to 0.02 for all U.S. civilian workers over a 15 year period (Luginbuhl, Jackson, Castillo, & Loringer, 2008) .

Heat related illness in the general population also results in excess emergency room visits and hospitalizations (Knowlton et al., 2009), but many minority workers in agriculture do not have adequate access to healthcare (Arcury et al., 2015). Also, most of these providers who do see farmworkers are volunteers or in private practice, they lack occupational and environmental health training.

Given the unique caveats of the minority workforce in agriculture, the sparsity of Midwest samples in existing farm-related HRI research and the minority farmworker susceptibility characteristics of low income, limited educational opportunities and language barriers (Culp, Tonelli, Ramey, Donham, & Fuortes, 2011), we elected to conduct a descriptive study of this symptom cluster.

The purpose of this research was to use a mixed methods approach in examining heat-related illness (HRI) signs and symptoms in Midwestern migrant and seasonal farmworkers with HRI symptoms consisting of a cross sectional survey (CS) and an intensive surveillance (IS) on a smaller group of workers consisting of field trials while the workers actually performed crop production tasks. We sought to measure workers' physiological response to different climate conditions while they performed crop production tasks.

Methods

Hispanic farmworkers are typically contracted to work in the months of June and July to perform tasks such as manual detasseling of corn and picking of melons. In the Midwest, these workers are extremely transient, and the composition of these farm communities are quickly formed and dispersed.

Sample & Setting.

We used two farms in Iowa who hired farmworkers to perform crop production tasks, and workers were recruited via convenience-sampling. One farm contracted workers directly from Mexico who were guest workers, the second farm contracted workers from Texas and the Southwest. There were 245 workers available for possible participation. Both farms provided housing: one worker farm could only provide residential facilities for men, and the second farm accommodated families. Both farms provided water in the fields for their workers and a lengthy orientation training about hazards in the sun.

Farmers were eligible for inclusion if they were: 1) Hispanic or Latino farm worker, 2) male, and 3) aged 18–65 years. The rationale for selecting only men was because one grower hired exclusively males due to their housing provision. We also wanted to keep the two data files comparable as gender differences may exist in symptom reporting (Bauer, Chen, & Alegria, 2012; Gonzalez-Mercado et al., 2017).

Procedures.

For the cross-sectional (CS) group we asked workers who were hired during the months of June and July to complete a written questionnaire (see Table 1). It was provided in both English and Spanish. These workers were expected to perform tasks such as the manual detasseling of corn and picking melons. Both tasks required a great deal of walking through the field during hot/humid conditions. The survey focused on their work history, experience in agriculture, chronic health problems and heat-related symptoms consisting of extreme thirst, muscle cramps, confusion, dizziness, nausea and chest palpitations. We also asked questions about fluid intake (types of fluid consumed while working) and rest breaks taken during the day. At the end of the crop production season (late July) we also conducted a medical record audit to determine how many farmworkers reported to the on-site clinic for heat-related illness symptoms.

Intensive Surveillance (IS) consisted of repeat measures with 20 farm worker participants completing 57 field trials. Field trials were begun after 12PM each day during the work season and consisted of 2–4 hours (length determined by the employer). We also recorded type of clothing worn including personal protective equipment (PPE), when rest breaks were taken and if shade areas were sought while working. The length of the field trial was measured in minutes (excluding meals and scheduled breaks). Workers were fitted with a multi-parameter monitoring wearable sensor (MPMWS) that measured heart rate (HR), breathing rate (BR), skin temperature and kilocalories per hour. We also checked blood pressure and weight, so we were able to compute body mass index (BMI). Each of vital sign parameters from the MPMWS (HR, BR and body temperature) were measured continuously and cataloged on digital media attached to the worker. A small piece of paper with picture-based HRI symptoms identical to the CS group was given to workers at the end of each session. This paper was used so that participants could candidly communicate with the research team HRI symptoms during that field trial.

We measured climate conditions (see Summary table) using wet bulb globe temperature (WGBT) procedures that considers wind, barometric pressure, and relative humidity (Bernard, Ashley, Trentacosta, Kapur, & Tew, 2010; Cecchini, Colantoni, Massantini, & Monarca, 2010; Roberts, 2007).

Both IS and CS farming operations had a "volunteer" on-site medical clinic staffed largely by nurse practitioners. It was the responsibility of the farm manager/occupational health nurse to excuse a worker from field activities. Research team members (4 non-nurse undergraduate students and the investigators here with practice credentials) were available either on-site or by phone call for consultation.

Measures.

For the cross-sectional (CS) group we measured heat-related symptoms were based on an inventory from the Pacific Northwest Agricultural Safety & Health Center (PNASH) that included Spanish terms describing extreme thirst, muscle confusion, dizziness, nausea and chest palpitations (PNASH, 2012). We followed-up on these workers using a medical record audit to evaluate the actual identification of HRI complaints from an on-site clinical provider.

For the intensive surveillance (IS) group we closely monitored them during an afternoon field trial (with a chest-strapped Zephyr® status monitor while they performed crop production tasks. This Zephr monitor was a multi-parameter monitoring wearable sensor (MPMWS) that permitted the calculation of kilocalories burned per hour and a "physiological intensity" score that estimates the burden of cardiovascular work based on the heart rate scaled linearly with low effort = 0 and max = 5 (Lee, Seto, Lin, & Migliaccio, 2017). The body mass index (BMI) was based on mid-day anthropometric data using actual weights and a tape measure. Blood and serum measures were obtained with traditional venipuncture.

Analysis.

Descriptive analysis included frequencies, means, standard deviations (SD), and analysis of variance (ANOVA) with computed F ratios / p-values. We used a Fisher's exact for small cell tables (n<6). Age-adjusted odds ratio (OR) and 95% confidence intervals (CI) for workers who self-reported heat stress symptoms, the reference group was the < 35-year-old workers.

Human Subjects.

All survey instruments and physiological monitoring followed the requirements of the University of Iowa Institutional Review Board (IRB), including the compensation offered for worker participation. Participants who completed the CS questionnaire were give a pair of sunglasses as compensation for participating in the study and the IS group were paid with $75 in gift cards. Both farm managers/owner-operators provided written consent and were fully aware of the study objectives. The IS group also completed a written consent form.

Results

The CS survey group (N=148) and IS participants are described in Table 2. There were no significant differences between the groups although the self-reported chronic health conditions for diabetes and hypertension differed slightly ($p < .05$).

Cross Sectional Survey (CS).

The most frequently occurring symptom across all farmworkers was extreme thirst (19.6%), but muscle cramps (7.4%) and feeling light-headed or dizzy (5.4%) were also indicated by participants (Table 3). Younger workers (aged 18–34 years) were more likely to report distressing heat symptoms of stomach cramps (8.6%) than the ≥35 year-old participants (2.2%); however the ≥35 years were more likely to report the less distressing skin rash (4.4%) than the younger workers (1.7%). In terms of remedial measures to deal with a “hot day,” more younger workers stated they used salt tablets (60.3%) than older workers (34.4%) and this was statistically significant ($p<.05$).

There were no significant age differences in terms of increased fluid intake, wearing lighter clothing, taking rest breaks or seeking shade while working. The CS group N=101 (68.9%) reported consuming “water only” while working in the fields; soda (carbonated beverages) were reported by 19.6% and 4.7% reported using sports drinks. No workers reported consuming alcoholic beverages during working hours. In the follow-up medical record audit of all clinical visits in the CS group during the three weeks they were engaged in crop production, N=4 (2.7%) reported to the on-site medical clinic for dehydration and heat-related symptoms, none of these workers required hospitalization and/or IV fluid administration.

Field Trials (n=57) were completed by the 20 participants in the IS group. We observed that the older group had more comorbid diseases relative to younger workers (< age 35) including: diabetes 3.6%, hypertension 7.2%, heart disease 2.4% and kidney disease 1.2%. Except for one case of hypertension and diabetes, these disease states were absent in the younger farmworkers. In general, younger workers were less experienced in performing crop production tasks (mean 4.48 years, $SD = 2.9$) than those ≥ 35 years with more farm experience (mean 5.83 years, $SD = 3.5$) and more obese.

Intensive Surveillance (IS).

There were differences in reported disease status in the IS group (N=20) that were not verified with clinical and lab findings at baseline (pre-field trial). The mean calculated BMI was 33.1 (SD=7.1) with N = 2 (10%) obese (BMI 31–39) and N=6 (30%) morbidly obese (BMI> 40). While N=4 (20%) participants indicated a prior history of diabetes, when we checked non-fasting serum glucose levels we found one slightly elevated. Fluid intake was encouraged by crew leaders, the farm managers ensured water was readily available at the end of a "corn row," but it was the workers' responsibility to carry water with them in personal containers for use before reaching water trucks. While we did not find any participants not wearing hats, most had on long sleeve shirts due to the pollen and skin irritation of the high corn stalks. We also found workers using bandanas; they frequently soaked these at the end of corn rows with bottled water.

The mean serum osmolarity was 278.19 mOsmol/kg (SD= 4.24) and all values were in normal. For BMI younger participants were more over-weight: the very obese group > 40 kg/m^2 mean age was 23.7 years (SD=2.9) which was significantly younger (f ratio=5.95, p =0.005) than the obese BMI (≥ 30 −40) age 33.4 years (SD=33.4) and normal BMI (<30) age 41.1 years (SD=10.2) groups. Heat stress symptoms were mostly concentrated in the obese (BMI kg/m^2 ≥ 30 −40) and very obese group (BMI>40) including extreme thirst (19.6%), muscle cramps (7.4%) and feeling light-headed or dizzy (5.4%). For hypertension, no one in the IS group reported hypertension by medical history, but we found six with systolic pressure > 150 mm Hg or diastolic >90 mm Hg.

Physical Intensity (PI) score was classified into ≤2.5 (mild), 2.5–4 (moderate) and >4 (uncomfortable) across all 57 field trials in the IS phase (see Table 4). The minutes of continuous work time was based on when the farm manager asked the workers to stop. Work time was shorter for those field trials where the field trial PI score was uncomfortable (mean=129.1 minutes) compared to 153.2 minutes (moderate) and 154.7 minutes (low). We did find significantly higher kilocalories were consumed per hour in the PI uncomfortable category and saw a significantly higher mean body temperature high PI score field trial groups (mean = 100.05 °F, SD=0.42) compared to the mild and moderate groups. There were also higher kilocalories per hour expended in the PI uncomfortable field trials.

The most frequent symptom reported was extreme thirst in 26 (45.6%) of the trials. For the 57 field trials, we classified by climate condition measurements using WBGT readings [into mild = < 24 °C, moderate = 24–26.9 °C and uncomfortable ≥ 27 °C]. In terms of symptom reporting, the more severe symptoms across the uncomfortable [≥ 27 °C] field trials included muscle cramps (N=1, 2.7%), headache (N=4, 13.8%) and nausea (N=3, 11.1%). We did find that most of the symptoms were reported at the beginning of the field trials under "mild" climate conditions (< 24 °C). Additional symptoms reported in rank order were excessive sweating, stomach cramps, muscle cramps, and weakness. The ≥ 27 °C (uncomfortable) field trials resulted in higher heart rate (p= 0.014), higher respiratory rates (p-.003), and higher PI scores (p=0.003) compared to the mild and moderate WGBT field conditions.

Discussion

The rationale for the mixed method approach was warranted as workers in general may have under-reported HRI symptoms. Asking workers about HRI symptoms in a larger-sample cross sectional (CS) survey was needed to estimate odds ratios, but we also needed to directly observe their physiological responses to crop production tasks under different climate conditions with the IS approach. The field trials, as described in our protocols, were not experimental and participants were subject to random climate conditions and work demands by their farm employers. The research team did not report WGBT or other climate measures to the farm manager as we wanted to observe when farm crew leaders made decisions. Many times there were congruent decisions on the part of the farm manager with our physiological and climate data. In general, we found field trials shorter when climate conditions were uncomfortable, and we also found shorter work periods when indicated by our WGBT readings. During field trials when WGBT readings were ≥ 27 °C farm crew leaders determined more rest breaks were needed and water was made available, but we did not see very good tracking of individual fluid intake by farm supervisors nor any reminders to consume and given quantity.

As for physiological measures, elevated blood pressure and tachycardia were occasionally issues for the farmworkers. Research team members informed the participant privately of their vulnerability before proceeding with a field trial, but we did not notify the employer. Specifically, two IS participants had acute hypertension before working the start of crop production when the climate condition was potentially unsafe at WGBT > 27 °C. We recommended that the impacted individuals seek permission from their supervisor to rest, but they refused. Three individuals experienced mean heart rates >115 per minute wearing the MPMWS device during particularly undesirable field conditions (i.e. hilly terrain) so the PI assigned a research assistant to “tag along and to call “911” in case of worker collapse and to provide emergency first aid for heat exhaustion.

In the cross-sectional (CS) survey group, the frequency between those self-reporting HRI symptoms and the actual number seeking medical treatment suggests self-management (e.g. resting in the field, seeking shade and/or increasing fluid intake). In the CS group the peak number of clinical visits was during the first week of field work; with a decrease in later weeks most likely due to heat acclimatization (Stoecklin-Marois, Hennessy-Burt, Mitchell, & Schenker, 2013). While the majority in our CS data indicated they were consuming water for fluid replacement, the use of sodas and sports drinks was quite alarming. We also noted the use of salt tablets among younger workers that we have previously documented (Culp et al., 2011). Our finding that workers in the CS group were consuming beverages high in caffeine and sugar is consistent with others (Bethel, Spector, & Krenz, 2017). One study of Hispanic farmworkers found that the consumption of caffeinated drinks may be related to a desire to stay alert and that the consumption of soft drinks many have been related to on-site water provided by growers may have been influenced by workers’ perception of poor water quality (Lam et al., 2013). No workers reported alcohol consumption while working in our CS group, but others have reported heavy episodic drinking while away from home in migrant farm camps, one study reported 48.5% in the previous 3 months among Hispanic farmers (Arcury et al., 2016).

Intensive surveillance (IS) participants occasionally posed some ethically challenging events in this investigation. In general, farm supervisors used good judgment in keeping workers out of harm’s way when climate conditions were not optimal for crop production. Although there was no direct influence by the research team on working conditions, we did see that the “uncomfortable” climate conditions resulted in declining productivity as heart & breathing rates increased. On these field trials farm managers offered more frequent rest periods or dismissed workers earlier in the afternoon than originally scheduled. This was also confirmed in our observations when field trials were classified by the physical intensity score PI > 4 (exhausting & uncomfortable) where field trials were ended by supervisors at 129 minutes versus 154 minutes when workers PI scores were < 2.5 (mildly challenging). We noted that in field trials with PI>4 the mean body temp was higher (100.05 °F) than PI < 2.5 trials where mean body temp was 99.56 °F. These field trials also resulted in more symptom reporting including extreme thirst, muscle cramping and confusion. Indeed, about one third of our intensive surveillance (IS) group workers were obese. These higher BMI participants often had higher body temperatures Obesity in young Hispanic farmworkers has been reported previously (Qenani, MacDougall, & Roy, 2016), but the physiological stress posed by the environment was concretely measured in this study where others may not have implemented the level of surveillance we conducted here. One possible reason that some obese Latino farmworkers enroll in crop production work is because they see the strenuous activity and excessive sweating as an opportunity to lose weight (Lam et al., 2013).

We also observed older workers (>35 years) tolerating the field trials and hotter climate conditions remarkably well with stable blood pressure and heart rates in the IS group. Physiologic susceptibility such as higher intake of caffeinated drinks and sodas and poor cardiorespiratory, renal or endocrine health have been known to increase HRI symptoms and these behaviors are more common in young people (Gronlund, 2014). There are also possible ethnic differences in younger workers compared to non-minority youth. According to one study many American teens employed in agricultural jobs, worked fewer hours per week than Hispanic workers and less time in the fields (Bonauto, Keifer, Rivara, & Alexander, 2003).

Personal protective equipment (PPE) and clothing influences heat dissipation and is physiologically related to HRI symptom frequency (Choi, Kim, & Lee, 2008). Shirts made with a with heavy material or higher insulation value fabric is known to cause heat intolerance (Bakkevig & Nielsen, 1994). In our study, long sleeve shirts were commonly observed in the IS group. This is consistent with the National Agricultural Worker Survey where 77% of workers reported wearing a long-sleeve shirt, but this practice was slightly higher (83%) in “unauthorized” workers (Gabbard, Nakamoto, & Daniel Carroll, 2015). In our study, the long-sleeved shirts protected the upper extremities and decreased exposure to pollen and other irritants from the corn plants. Additionally, long sleeves provided some protection from solar radiation and sunburns.

We did not see large numbers of farmworkers in the on-site clinic for HRI symptoms in the CS participants based on our post-season medical record audit. Delay in seeking medical assistance in minority farmworkers has been previously reported (Thierry & Snipes, 2015). Hispanic farmworkers have a history of not complaining due to a fear of losing their employment or not being hired the following work season (Liebman, Juarez-Carrillo, Reyes, & Keifer, 2016). Indeed, migrant and seasonal farmworkers may be influenced in many ways by their peers in symptom reporting, for this reason we decided to use a small folded piece of paper to report symptoms discretely to the research team after each field trial. In general, farm housing units for seasonal workers are over-crowded and not climate-controlled (Arcury, Trejo, Suerken, Ip, & Quandt, 2017). Air-conditioned (AC) housing or air conditioned rest locations are rare in farm work areas (Quandt, Wiggins, Chen, Bischoff, & Arcury, 2013). The housing units on the two farms sampled here were not closely inspected by the research team, but no AC units were known to be present. Shade tents or canopies were used in the fields in the IS group, this has been reported by others and also a humanitarian gesture by benevolent employers (Kearney et al., 2016).

Our IS group physiological findings support the physiological intensity of crop production labor . Kilocalories per hour and mean body temperature was higher in the when the physical intensity (PI) scores in field trials were >4.0 or extremely challenging in terms of physical exertion. This finding is consistent with a study of sugarcane workers (Crowe et al., 2015). where 6.8kcal/min was found at 26°C WBGT which was reached by 7:30 am on most days. This kcal rate was not sustained for long periods of time, but is more challenging than the production tasks of corn detasslers here. Indeed, sugarcane workers had more upper extremity effort as they were cutting plants manually fluctuated with the surgarcane density in the fields.

Implications for Occupational Health Practice

Occupational health professionals (OHPs) must develop strategies for preventing HRI in non-English speaking minorities and developing workplace educational interventions that take into account a number of complexities that include climate conditions and physical intensity of the work being performed. This includes health literacy, poor safety precautions, language barriers, piece-rate pay, undocumented worker status, and geographical isolation as many are young people who are far away from home for the first time (Liebman & Augustave, 2010). This is very different from the industrial work environment and OHPs may need to rethink the actual control they have over the pace of crop production tasks, the climate conditions and the behavior of workers in consuming fluids. Calories consumed at meal times may need to be increased when adverse climate conditions are present.

There are few OSHA inspections on farming operations during peak crop production times and sometimes safety-related activities like HRI precautions are overlooked in an effort meet harvest objectives in a timely manner (Gadomski, Vargha, Tallman, Scribani, & Kelsey, 2016). Workers may not be aware of sun-safety risks and most state-OSHA offices do not track HRI-related training (Lin & Chan, 2009). The Occupational Safety and Health Administration (OSHA) recently developed a smartphone application for determining unsafe work environments based on live data-feeds and a heat-stress index with risk appraisal (available at www.osha.gov), but few farmer managers in our experience knew about it. This OSHA app helps farm owners who do not have adequate equipment for measuring environmental conditions. Workers need to have adequate fluid replacement, rest breaks and monitoring for HRI symptoms while working in the fields.

Identifying culturally-sensitive ways to screen Hispanic workers for field work is challenging, particularly for fitness and their ability to acclimate to changing climate conditions (Buchanan et al., 2010; Menzel & Gutierrez, 2010; Peak, Gast, & Ahlstrom, 2010). Screening for health problems is often left to labor contractors for minority farmworkers (Gonzalez, 2017). This means that no professional occupational health assessment is conducted, and at-risk workers are placed in work that is often physiologically demanding in remote areas where emergency medical services may be required.

Study Limitations.—The small sample size for the IS group and the number of trials were largely influenced by the brief time workers traveled to Iowa and then disperse, often within a 4–6-week window of time. Another limitation is that muscle cramps were reported in the CS group, but there may have been some confusion in workers about heat-induced symptom cramps versus musculoskeletal strain from repetitive injury or work-related tasks (Tonelli, Culp, & Donham, 2014).

Volunteer and sampling bias is most likely present here, these farmers may have been more safety-compliant than other Midwestern farmers as they made their crop production operations accessible to the research team. We did not provide any climate condition data from our instruments to crew leaders, supervisors or farm managers; but they genuinely seemed concerned about the welfare of their employees. Both farms provided water in the fields for their workers and a lengthy orientation about hazards in the sun and appeared to make climate-sensitive work decisions (Bethel & Harger, 2014). It is highly likely all workers, not just research participants, had rest breaks similarly to those in the IS group. It is also possible that more water and or more remedial measures to prevent HRI symptoms were taken because we were present.

Conclusion.—Prevention of HRI is hampered in Midwest farming because of the pressing needs to increase productivity and keep farmworkers in the fields. Hispanic young people sometimes engage in high risk jobs like working on farms because of poor employment opportunities near their home (Vela Acosta, Sanderson, Cooper, Perez, & Roberts, 2007). A farmer-focused training program for Midwest growers should be implemented on how to prevent HRI (i.e. understanding the heat index). Farm managers and workers should know how to recognize HRI symptoms. Farmers should seek occupational health professional consultation on screening for eligibility before farmworkers are transported so far from home and provide on-site first-aid treatment for heat exhaustion in the event an incident occurs. We desperately need more surveillance and a better understanding of the physiological demands of crop production tasks.

Applying Research to Practice

Occupational health professionals (OHPs) must develop strategies for preventing heat-related illness (HRI) in minority farmworkers, which requires having a solid understanding of the physiological intensity of performing crop production tasks. Climate conditions may result in unsafe working conditions. Crew leaders and farm managers may need to closely monitor environmental temperatures and humidity using the OSHA tools available to them in determining when to offer work breaks and cease crop production tasks on any given workday. Even mild and moderate climate conditions can facilitate HRI-symptoms. A “climate of safety” needs to be developed on farms so that workers are not viewed negatively if they report HRI symptoms. It should be evident from this study that OHPs are not functioning in an industrial work environment. How long workers are in the fields, and when and who is available to participate in any given field trial is entirely based on the employer. Workers in the crews are quickly and spontaneously assigned to different locations on the farm. We have attempted to adopt our methods to this type of workplace. Employers need to ensure workers have adequate fluid and caloric intake for this very challenging work effort. The most common symptom reported was extreme thirst. Additionally, OHPs need to screen of workers' eligibility for specific farm tasks. Obese and morbidly obese farmworkers may have more distress when in the farm field. We found higher heart and breathing rates and more co-morbid disease states of diabetes and hypertension in those who were over-weight.

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Table 1.

Summary of Study Groups, Procedures, and Measures

Group	Procedure	Definition
Cross Sectional (CS) Group	Definition	Larger sample of workers (n=148) who completed a heat-related illness (HRI) survey
	HRI Symptom Survey	A heat-related illness (HRI) symptom survey derived from the PNASH during the first week of farm work of crop production tasks.
	Medical Record Audit	A post-season medical record audit conducted to determine individuals who sought medical attention for Heat-Related Illness symptoms.
Intensive Surveillance (IS) Group	Definition	A smaller sample of workers (n=20) focused who fitted with a multi-parameter monitoring wearable sensor that measured a physiological response to the effort of farm work tasks.
	Physiological Response	Measured heart rate, breathing rate/chest excursion, skin temperature and kilocalories per hour. Baseline blood pressure, serum glucose and serum osmolarity was taken before field work commenced.
	Field Trial	A period of 2–4 hours starting after 12PM. The length of the field trial was determined by the farm crew leader based on their own perception of safety. Field trials were measured in minutes. There were n=57 field trials complete by participants in the IS group. These field trials are repeat measures but vary due to random climate conditions and length of work session (as determined by their employer/crew leader).
	Wet Bulb Globe Temperature (WGBT)	Climate condition measure that takes into account natural elements of the climate conditions. WBGT = $0.7T_w + 0.2T_g + 0.1T_d$ where T_w = Natural we-bulb temp (humidity indicator), T_g = Globe thermometer temp (solar radiation), and T_d = Dry-bulb temp (normal air temp). The WBGT considers wind, barometric pressure, and relative humidity. Research team measured climate conditions were not communicated to crew leaders, it was up to their employer to determine unsafe heat and humidity conditions.
	Physiological intensity (PI)	The physiological intensity score is a summary computation of heart rate and the intensity of the work performed based on a scale of 0–5. This measure were taken continuously during field trials.
	Core Body Temperature	A computed estimate of core body temperature based on the skin sensors. This measure were taken continuously during field trials.
	HRI Symptom Survey	A small piece of paper with a picture-based HRI symptoms with Spanish &English word descriptions were given at the end of each field trial. These HRI adopted from the PNASH survey.

Note. HRI= heat-related illness; PNASH = Pacific Northwest Agricultural Safety and Health Center; WBGT= wet bulb globe temperature

Table 2.

Cross-Sectional Sample (N = 148) Compared with Intensive Field Surveillance Group (N=20)

Characteristic	Cross-Sectional Survey Group (%)	Intensive Surveillance Group N (%)
Male	148 (100.0)	20 (100.0)
Age Group		
18–34 yrs	64 (43.2)	10 (50.0)
≥ 35 yrs	85 (57.4)	10 (50.0)
Born Outside US	148 (100.0)	7 (30.5)
Language Mostly Spanish	127 (85.8)	11 (55.0)
Education*		
Elem (k-6)	37 (25.0)	4 (20.0)
Jr. High (7–9)	26 (17.6)	5 (25.0)
HS (10–12)	59 (39.9)	8 (40.0)
Some College	22 (14.9)	3 (15.0)
Self-Reported Health Conditions**		
Hypertension	6 (4.1)	0
Diabetes	4 (2.7)	4 (20.0)

Table 3.

Self-Reported Heat-Related Illness Symptoms in the Farm Worker Cross-Sectional Survey Group (n = 148)

Symptom	18–34 yrs (N = 64) N (%)	≥ 35 yrs (N = 85) N (%)	Odds Ratio*	95% CI
Extreme Thirst	14 (21.9)	14 (16.5)	0.74	0.31–1.61
Muscle cramps	5 (7.8)	6 (7.1)	0.89	0.26–3.08
Confusion	3 (4.7)	6 (7.1)	1.54	0.37–6.43
Light-headed or dizzy	3 (4.7)	5 (5.9)	1.27	0.29–5.53
Nausea	3 (4.7)	3 (3.6)	0.75	0.15–3.86
Chest Pounding	2 (3.1)	1 (1.2)	0.37	0.33–4.16

* Reference group for the Odds Ratios (OR) were farmworkers 18–34 years of age

Table 4.

Physiological Measures During Field Trial Work Time (N = 57)

	Mean (SD)			F- ratio	p
Physical Intensity (PI) Score	Mild PI ≤ 2.5	Moderate PI >2.5–4.0	Uncomfortable PI >4.0		
	N=18	N=28	N=11		
Work Time (minutes)	154.7 (49.2)	153.2 (39.1)	129.1 (35.2)	1.44	NS
Kilocalories per Hour	362.2 (95.1)	481.9 (118.9)	537.2 (162.5)	8..41	0.001
Mean Body Temp, °F	99.56 (0.12)	99.84 (0.19)	100.05(0.42)	16.41	<.001
WGBT	Mild < 24 °C	Moderate 24–26.9 °C	Uncomfortable ≥ 27 °C		
	N=15	N=15	N=27		
Heart Rate per Minute	89.1(9.03)	85.20 (13.56)	97.15 (14.26)	4.59	0.014
Breathing Rate per Minute	16.80(2.31)	17.93 (4.76)	20.67 (3.36)	6.48	0.003
PI Score	3.04(1.02)	2.58 (0.84)	3.65 (1.19)	5.11	0.009
Body Temp Change °F	1.10 (0.27)	1.07 (0.36)	1.24 (0.38)	1.39	NS

Note Definition of a field trial: A period of crop production work 2–4 hours in length starting after 12 pm. PI = physiological intensity;

WGBT = Wet bulb globe temperature; NS= not significant