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Dissemination of Heat Safety Practices Among Florida Farmworker Crews

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Abstract

Objective: Evaluate the effectiveness of heat related illness (HRI) safety training tailored for farmworker harvesting crews.

Methods: We surveyed 52 farmworkers in three crews on heat safety knowledge, self-reported behaviors, and heat illness symptoms. Each provided a pre and post shift urine sample for analysis of specific gravity (USG). One crew received an HRI training program and a “buddy system” to remind co-workers to rest and hydrate.

Results: The intervention crewmembers exchanged more heat safety reminders during the day and reported more rest and hydration. Social network analysis shows how coworkers disseminated heat safety messages. There was no difference in USG among intervention or control crews.

Conclusion: Social networks within harvesting crews can be leveraged to disseminate heat safety messages. Dehydration measures indicate training is not sufficient to protect workers from symptoms of HRI.

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Conflict of Interest

NONE DECLARED

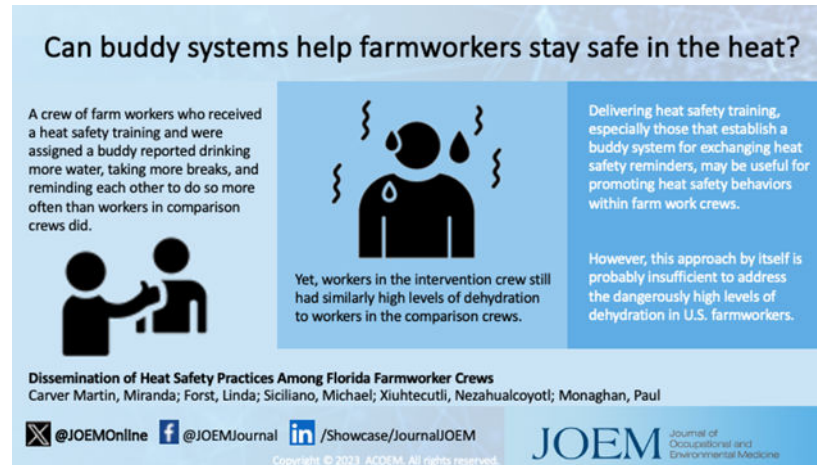
Ethical Considerations and Disclosures

The study protocol was approved by the institutional review board at the University of Florida, Gainesville (#201702033) and at the University of Illinois Chicago (#2022–0917). All participants provided verbal informed consent.

AI Statement

No AI was utilized in any stage during research development and design, data collection, analysis or manuscript preparation.

Graphical Abstract



Keywords

Farmworker safety; heat illness prevention; social network analysis

Introduction

Heat related illness (HRI) and adverse effects of recurrent dehydration are well documented among agricultural workers globally [1]. In the United States (U.S.), farmworkers' risk of heat-related mortality is estimated to be 35 times greater than that of workers in other industries [2] and is increasing due to climate change and the rise in average daily temperatures [3]. Legislation and enforcement of policies and practices to reduce the effects of heat on farmworkers are extremely limited.

Agricultural labor, which often involves strenuous physical activity for long hours in outdoor environments, creates ergonomic stressors that are difficult to control. Exposure to environmental hazards (especially heat) due to seasonal work demands makes agricultural settings particularly challenging from a health and safety standpoint. The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) recognize the inability to apply the most effective measures for preventing hazardous exposures—completely eliminating or substituting the hazard—in the workplace [4]. They therefore call for engineering and administrative controls as well as personal protective equipment, all of which require buy-in and uptake by employers and workers [5, 6].

Research has documented barriers to farmworkers' ability to take actions to protect themselves [1]. These include limited rest breaks, a lack of shade structures or cooling equipment, and competing priorities such as the need to wear heavy, layered clothing to protect from sun, abrasive plants, and chemicals [7–9]. Barriers include being paid by the pound and not hourly, distant hydration sources, distant and dirty bathrooms, and fear of retaliation by supervisors for disruptions to production [1, 8–14]. Effective interventions that

promote the uptake of effective heat safety practices are critical and have limited study. The purpose of this study was to 1) evaluate the overall effectiveness of a heat safety intervention for promoting heat safety behaviors among workers and improving hydration; and 2) identify specific features of the intervention that were related to favorable outcomes and thus warrant replication.

Methods

Overview

52 farmworkers across three work crews—one intervention crew of 19 and two comparison crews—participated in the study. The intervention crew received a PowerPoint training and brief refresher trainings and had designated buddies and heat safety “champions.” Post-intervention outcome measures included knowledge and attitude scales, behavioral self-report questions, and pre and post shift urinalysis during two observation days. Analyses included statistical comparisons of measures for intervention and comparison crews as well as a social network analysis of with whom workers in each crew reported exchanging heat safety reminders during the two observation days. This study follows the STROBE Guidelines for Observational Studies. The STROBE Checklist is available as Supplementary Digital Content (SDC, <http://links.lww.com/JOM/B928>).

Study Participants

Participants were recruited in April and May 2022 from among three work crews, totaling 52 Spanish-speaking farmworkers hired for seasonal work on a South Florida vegetable farm with which the Principal Investigator had established a working relationship. All members of the three farm-selected study crews enrolled in the study, totalling 54. Two enrollees left the country during the four-week study period and were dropped from the sample. Because workers are assigned to work with a single crew, the intervention and comparison populations were divided by crew: one was the Intervention Group (n=19); and two crews served as business-as-usual comparison groups (Comparison Crew 1 – n=17; Comparison Crew 2 – n=16).

Members of the three crews lived alongside one another in two different employer-provided housing complexes. Staff with the Farmworker Association of Florida (FWAF), a farmworker rights advocacy organization, introduced the purpose of the study and used a Spanish, IRB-approved form to obtain verbal consent. All participants received \$15 Wal-Mart gift cards after completing each survey to compensate them for their time. Four program champions (described below) received a second gift card to compensate their higher level of participation.

Intervention

The intervention group received a 45-minute heat safety training utilizing components of existing training programs; these were organized into 11 messages and recommendations for behavior change. Research assistants from FWAF facilitated an interactive training in Spanish. Messaging included best practices including rehydrating across the day, using a sports drink bottle provided during the training, taking rest breaks in the shade, wearing

heat-appropriate clothing, and having a coworker “buddy system.” Workers selected a buddy and were asked to watch out for them and remind them to hydrate and rest. In addition, four crew members who had relatively high knowledge and buy-in scores on a baseline assessment were invited to serve as program Champions. Over the next four weeks, the Champions received regular messages via a WhatsApp group chat about reminding their peers to practice heat safety. Two and four weeks after the initial training in April 2022, the intervention crew received brief refresher trainings that addressed specific topics in additional depth. The comparison groups (Comparison Crew 1 and Comparison Crew 2) were not offered the training, did not have a formal “buddy system,” and had no assigned Champions.

Evaluation of the Intervention

Instruments. Survey items were adapted from the heat safety training content and published literature on heat safety [7–9, 12, 13, 15]. There were two different survey instruments: 1) an *HRI knowledge and attitude questionnaire* administered once, during a non-workday in May 2022, and 2) a *heat safety behavior and daily work experience questionnaire* administered twice, at the end of each of two consecutive workdays in May 2022, four weeks after the initial training. Topics on the *HRI knowledge and attitude questionnaire* included knowledge about hydration, rest, safety precautions, risk factors, and first aid using four-point Likert scales. Attitude constructs include risk perception (4 items), competing priorities (4 items), efficacy (6 items), and buy-in (3 items). The surveys included labeled images to assist with comprehension. In addition, we asked participants to gauge the influence that several variables had over their behaviors regarding heat safety. Likert scales measured the relative influence of their knowledge, their discomfort in the field, their desire for high productivity, and the encouragement of coworkers, roommates, or their supervisor. The original survey was piloted with two farmworkers and adjusted. See Appendix A (<http://links.lww.com/JOM/B929>) for details regarding the items and measures used, including indices for measuring latent constructs. Topics on the post-workday *heat safety behavior and daily work experience questionnaire* included whether they experienced HRI symptoms, their recall of hydration practices, rest-taking behaviors. In addition, we asked them 1) whether or not they had received a reminder to rest and/or hydrate, 2) who gave them those reminders, and 3) whether they had given their coworkers any reminders to hydrate or rest. See Appendix B (<http://links.lww.com/JOM/B930>) for descriptive statistics summarizing how respondents answered these questions. In addition, we asked them to self-evaluate their own well-being during the day along with their perception of how strenuous their work was.

Biospecimens. All workers brought a first-morning urine sample from home and provided a urine specimen at the end of the day during the two consecutive work days. These were analyzed for urine specific gravity (USG) using a digital refractometer (Reichert TS Meter-D, Depew, NY). Measurement of urine specific gravity is a widely-used technique in the field. Specific methods are described elsewhere [16].

Protocol for Data Collection. At the end of the four-week intervention, all participants completed the *HRI knowledge and attitude questionnaire* while Spanish-speaking research

staff from FWAF read the questions aloud from a projected slideshow. During two subsequent workdays, paper copies of the ***Heat safety behavior and daily experience questionnaire*** were provided without the projector but with Spanish-speaking research staff available to assist. On both workdays, we collected and analyzed urine samples before and immediately after work. One intervention crew participant was absent for the knowledge and attitude questionnaire and did not provide a pre-shift urine sample on observation Day 1. Another was absent for observation Day 2 and thus did not provide urine samples or the heat safety behavior and daily work experience questionnaire. In addition, one comparison crew participant did not provide a Day 1 pre-shift urine sample, and two other participants (one intervention, one comparison) did not provide a Day 1 post-shift urine sample. All other measures were completed.

Data Analysis

We used IBM SPSS Statistics (Version 28) to generate descriptive statistics for all measures by both crew and intervention conditions. No imputations were performed to account for missing data, which were simply treated as missing. To investigate differences in the network structures of verbal exchange of heat safety reminders across crews, we conducted a sociocentric network (also known as whole network) analysis using the crew as the boundary-defining characteristic, following Tovar-Aguilar [17]. This analysis used data from the ***Heat safety behavior and daily experience questionnaire*** administered at the end of two consecutive workdays. We formed a series of asymmetrical (or directed) adjacency matrices indicating the workers who were named as giving reminders in rows and the workers who mentioned receiving reminders from those colleagues in columns. We constructed binary matrices for each crew, for each type of behavioral reminder (hydration and rest), on each day of work (e.g., Intervention Crew Day 1 hydration reminder). We also constructed valued matrices aggregating connections across workday and/or behavioral focus (e.g., Comparison Crew 1 rest reminders across both days). Within the overall matrix for each crew, values could range from 0–4, as there were four opportunities for a colleague to give a reminder to another (hydration and rest on each day). Sociocentric measures generated for each matrix included density (the average number of entries in each matrix) and the number of isolates (those workers who never gave nor received reminders) [18]. We used NetDraw software [19] to produce a digraph for each matrix and visualize the network structures across crews, workdays, and behaviors. See Appendix C (<http://links.lww.com/JOM/B931>) for the full set of network visualizations.

Finally, to explore the potential predictors and impacts of giving and receiving reminders to hydrate and rest in the field, we tallied the reminders given and reminders received for each worker within each matrix and imported these data into SPSS for bivariate analysis. Spearman's rank correlation analyses were used to explore bivariate relationships between the social factors and the other individual-level variables. When the relationships between variables appeared to be non-monotonic, we used Kruskal-Wallis tests with collapsed measures as appropriate. We used the Mann-Whitney U test to compare differences between the intervention and control groups since the dependent variables were not normally distributed. See Appendix D (<http://links.lww.com/JOM/B932>) for detailed results of these analyses.

The study was approved by the Institutional Review Board at the University of Florida (#201702033).

Results

Participant Demographics

Participants almost entirely identified as males from Mexico, and over a third (37%) were from the state of Guanajuato. There were fewer than two women in the study, so issues of gender were not explored. Over half (56%) reported having the equivalent of a middle school level of education. Ages ranged from 19 to 50 years, with a mean of 29. Participants' years of experience working in agriculture ranged from one to 30 years, with a mean of nine. Most participants had also been working on the farm for several months of the season, ranging from one to ten months with a mean of seven. Crews differed significantly only in the number of months workers had spent on the farm ($p=.03$; $\eta^2=.11$), where workers in Comparison Crew 1 (C1) had spent significantly fewer months on the farm during that season than workers in the Intervention Crew ($p=.03$). When the two Comparison Crews were combined, their demographics did not differ significantly from the Intervention Crew.

Differences by Intervention Condition

Table 1 describes the knowledge and attitude composite measures by crew and comparison condition. Scores are scaled such that zero represents the lowest possible score and one represents the highest possible score. Mann-Whitney U tests found hydration knowledge ($p=.03$; $r^2=.10$) and rest knowledge ($p=.002$; $r^2=.20$) scores to be higher among workers in the Intervention Crew than among workers in the Comparison Crews. Cronbach's Alpha values for both measures were below 0.7. Attitude measures did not differ significantly between the intervention and comparison conditions.

Table 2 reports crews' working conditions and experiences on the two consecutive study days. On Day 1, Comparison Crew 2 worked a half day at 5.5 hours while Comparison Crew 1 worked 11.25 hours and the Intervention Crew worked 11.5 hours. On Day 2, each crew worked between 13 and 13.5 hours. The Wet Bulb Globe Temperature as measured via the closest stations in the Florida Automated Weather Network (FAWN) climbed to highs of 83°F on Day 1 and 85°F on Day 2 [20]. Ten percent of respondents rated their work as very strenuous on Day 1, and 27 percent rated their work as very or extremely strenuous on Day 2. Despite the high temperatures, three-quarters of participants rated the weather as 'more or less hot' on Day 1, and 40 percent rated the weather as 'more or less hot' on Day 2. Mann-Whitney U tests found perceived heat to be lower in the Intervention Crew on both Day 1 ($p=.04$; $r^2=.09$) and Day 2 ($p=.007$; $r^2=.14$). Most participants reported feeling well or very well, but their well-being was generally worse on Day 2, the hotter and longer of the two workdays for all crews. Mann-Whitney U tests found that Intervention Crew members reported feeling significantly better on Day 2 than Comparison Crew members did ($p=.002$; $r^2=.19$).

Table 3 reports per-hour rates of rest and hydration behaviors during the two workdays by crew and intervention condition. Approximate breaks per hour ranged from zero to 0.35 on

Day 1 and zero to 0.31 on Day 2, with means of 0.14 and 0.13, respectively. Two outliers were winsorized for Day 1 because Comparison Crew 2's values were inflated due to working a half day. Mann-Whitney U tests found that workers in the Intervention Crew had a higher rate of rest breaks on Day 2 than Comparison Crew workers did ($p=.008$; $r^2=.14$). The number of times workers stopped for a drink per hour ranged from 0.18 to 0.73 on Day 1 and from 0.74 to 0.62 on Day 2, with means of 0.45 and 0.40, respectively. Mann-Whitney U tests found higher rates among the Intervention Crew on both Day 1 ($p=.02$; $r^2=.11$) and Day 2 ($p<.001$; $r^2=.29$). The total number of employer-provided, four-ounce, disposable paper cones of water consumed per hour ranged from 0 to 3.20 on Day 1 and from 0.15 to 2.94 on Day 2, with means of 1.03 and 1.11, respectively. Finally, the number of personal drinks (e.g., bottled water, soda, sports drinks, energy drinks) reported per hour ranged from 0 to 0.91 on Day 1 and from 0 to 0.77 on Day 2, with means of 0.40 and 0.34, respectively. T-tests found higher rates of personal drink use among Intervention Crew workers on both Day 1 ($p<.001$; $d=1.14$) and Day 2 ($p=.004$; $d=.88$). Overall, workers in the Intervention Crew tended to report practicing more rest and hydration behaviors during the workday.

Eleven participants (21%) reported HRI symptoms on Day 1, and 15 participants (29%) reported HRI symptoms on Day 2. The symptom most frequently reported was excessive sweating (19% on Day 1 and 23% on Day 2), followed by headaches (6% on Day 1 and 4% on Day 2). Symptoms reported on Day 2 but not on Day 1 included nausea/vomiting (4%), muscle cramps (4%), dizziness (2%), and rapid heart rate (2%). Morning USG measures preshift ranged from 1.011 to 1.039 on Day 1 (mean=1.021) and 1.010 to 1.032 on Day 2, (mean=1.023). Post-workday USG ranged from 1.014 to 1.035 on Day 1 (mean=1.026) and from 1.023 to 1.037 on Day 2, (mean=1.030). The rate of change in USG ranged from -0.009 to 0.018 on Day 1 (mean=0.006) and from -0.008 to 0.019 on Day 2, (mean=0.007). USG values above 1.025 generally indicate dehydration [21]; thus, workers were dehydrated, on average, at the end of each workday. In addition, workers generally became more dehydrated across the day. T-tests found that on Day 1, workers in the Intervention Crew were better hydrated in the morning ($p=.042$; $d=-.614$) but had higher rates of change across the day ($p=.011$; $d=.804$) so that their levels were on par with the Comparison Crews by the end of the day. No other outcomes differed by intervention condition.

Table 4 reports participants' self-reported ratings of six different potential influences on their heat safety behaviors in the field. The item workers most frequently reported as influencing their behavior was how they felt physically in the field (27% 'a little influence' and 44% 'a lot of influence'). They also frequently reported being influenced by their productivity level (33% 'a little influence' and 27% 'a lot of influence') and learning new information about heat safety (25% 'a little influence' and 35% 'a lot of influence'). Less than half of participants reported being influenced by their supervisors (25% 'a little influence' and 13.5% 'a lot of influence'). Participants reported being less influenced by their coworkers on their crew (31% 'a little influence' and 8% 'a lot of influence') and by their roommates (29% 'a little influence' and 6% 'a lot of influence'). However, Mann-Whitney U tests found that workers in the Intervention Crew attributed a significantly higher influence to their coworkers ($p=.003$; $r^2=.17$), roommates ($p<.001$; $r^2=.22$), and supervisor ($p=.02$; $r^2=.11$).

Social Network Structures of Heat Safety Reminders

Network structures varied noticeably by crew and behavior but were similar across the two days. As shown in Figures 1 & 2 and Appendix C (<http://links.lww.com/JOM/B931>), the Intervention Crew exchanged more reminders than both Comparison Crews. In addition, hydration reminders were more common than rest reminders across all crews. As shown in Figure 2, the Intervention Crew also had more repeated and/or reciprocal ties between pairs of workers, often aligned with the buddies they had selected during training. Relatedly, the Intervention Crew had fewer isolates—workers who were ‘left out’ of the crew’s network structure—than the Comparison Crews. As shown in Figure 1, this pattern was particularly notable regarding rest reminders.

Characteristics of Workers Giving and Receiving Reminders

In the full sample (comprised of all three crews), the main factor clearly related to giving reminders was the intervention. Mann-Whitney U tests found that Intervention Crew members gave significantly more reminders overall ($p=.002$; $r^2=.18$), for hydration ($p=.014$; $r^2=.12$), and for rest ($p=.005$; $r^2=.15$). In this full sample, giving reminders to rest also had several other significant associations. The total number of rest reminders combined across the two days was related to education levels ($p=.04$; $\eta^2=.10$) and hydration knowledge ($p=.04$; $\eta^2=.09$), but post-hoc pairwise comparisons fell short of significance. Among the single-day variables, giving reminders to rest was more common among workers who perceived their work as less strenuous on Day 1 ($p<.001$; $\rho=-.47$) and among workers who perceived less heat on both Day 1 ($p=.007$; $\rho=-.38$) and Day 2 ($p=.008$; $\rho=-.37$). This could possibly be a result of more experienced workers habituating to the working conditions, but workers’ years of experience in agriculture and the number of months they had spent on the farm that season were not significantly related to giving reminders.

In the full sample (comprised of all three crews) analysis investigating possible associations with receiving reminders, there was one significant relationship on Day 1 but several on Day 2. On Day 1, the only significant relationship was that those who received more total reminders reported feeling better ($p=.016$; $\rho=.33$). On Day 2, the total reminders received (both hydration and rest reminders) was positively associated with the rate of taking rest breaks ($p=.005$; $\rho=.39$). Those who received more reminders to rest reported taking more frequent breaks ($p<.001$; $\rho=.52$), longer breaks ($p=.010$; $\rho=.36$), and more frequent pauses for a drink ($p=.016$; $\rho=.34$). There was also a non-monotonic relationship between the total reminders received and personal beverage use ($p=.04$; $\eta^2=.09$) whereby workers who received two reminders reported more personal beverage use than those who only received one ($p=.03$).

Discussion

Participants in this study were mostly young adult males from more than five different Mexican states. At the end of a four-week program delivered to one crew, all three crews participated in a knowledge and attitudes survey as well as daily surveys and urinalysis across two consecutive workdays. Each of the workdays was hot (with a WBGT reaching 82.5°F on Day 1 and 85.4°F on Day 2) and very long, except for one of the Comparison

Crews who worked a half day on Day 1. Day 2 was particularly long for each crew, who worked a range of 13 to 13.5 hours. Almost a third of workers rated their work as very or extremely strenuous that day, even though OSHA guidelines recommend that even acclimatized workers should not have been performing greater than moderate activity in those weather conditions [22]. Nevertheless, many workers rated the temperatures as ‘more or less hot,’ indicating that these conditions were not abnormal for what these workers have experienced. This finding aligns with qualitative research indicating a normalization of heat as just ‘part of the job’ [13]. It also supports other research highlighting the need for a more proactive approach to heat safety because workers may not recognize that their risk for serious HRI is elevated until it is too late [e.g., 23].

Rest breaks were very infrequent among these workers. Some workers reported taking no rest breaks, and the average was about one rest break every eight hours or so (not including lunch). This result is alarming but not surprising, as the avoidance of rest both at the behest of supervisors or due to an internal drive to increase earnings is well documented [8, 10–14]. This may also explain why, across all three crews, giving reminders to rest was less common than giving reminders to hydrate. Correspondingly, pausing work to take a drink was more frequent than taking rest breaks, yet the average was still only about once every two and a half hours or so (including lunch). This is far less frequent than NIOSH’s recommendation of drinking eight ounces of liquid every 15–20 minutes [24]. We cannot reliably report how much total liquid workers consumed during their work pauses because 1) we relied on self-report and recall, and 2) it was not practical to account for the different sizes and compositions of personal drinks. However, workers reported consuming an average of about one 4-oz cup of employer-provided water per hour and an average of a little over a third of a personal drink per hour. Workers’ urine specific gravity values—which indicated that workers, on average, became more dehydrated across each workday—show these hydration rates were insufficient. This finding aligns with results from California measuring dehydration via changes in body weight across the day [25] and another study in Florida measuring pre- and post-shift USG [26].

Post-intervention data provide evidence suggesting that the intervention had some positive influences on heat safety. First, knowledge scores were higher for the Intervention Crew than the Comparison Crews. In addition, Intervention Crew workers reported higher rates of rest-taking on Day 2, more stops for a drink on both days, and more personal beverage use. Intervention Crew members also tended to perceive less heat and felt better than the Comparison Crews did on Day 2. Workers in the Intervention Crew attributed a significantly higher influence on their heat safety behaviors to their coworkers, roommates, and supervisor. This finding was aligned with the patterns in crews’ social networks for exchanging reminders. Workers in the Intervention Crew exchanged reminders more frequently than the Comparison Crews, especially for rest breaks. Across the two days, none of the workers in the Intervention Crew were completely left out of the social network of exchanging reminders, while both Comparison Crews had isolates. The fact that many of the reciprocal ties between workers mirrored the “buddy system” from the initial training suggests that this was one mechanism contributing to the differences between crews.

We used social network analysis to explore the possible predictors and effects of engagement in each crew's social network of heat safety reminders. While participation in the intervention was the clearest predictor of giving reminders, we also found that workers who perceived less heat and/or a less strenuous workload on a specific workday tended to give more reminders during that day. Future research should further investigate this finding; other studies have found associations between experience working in agriculture and both higher heat safety knowledge scores [9] and lower risk of elevated core body temperature [27].

Regarding the potential effects of receiving reminders, we found that 1) on Day 1, people who received more reminders felt better; 2) on Day 2, people who received more rest reminders reported taking more frequent breaks, longer breaks, and more frequent pauses to take a drink; and 3) workers who received two reminders on Day 2 reported more personal beverage use than those who only received one. These positive correlations suggest that including a social component—particularly a “buddy system”—into heat safety interventions is worthwhile. These findings add to intervention studies that have identified benefits of peer health promotion to include, for instance, acceptance of community-embedded peers as informational resources [28] and improved knowledge and biomarkers related to pesticide exposure [29].

The social and behavioral patterns did not translate to clear impacts on symptoms or hydration levels, however. Workers' reports of HRI symptoms and the more severe symptoms were more common on the hotter and longer of the two days. Symptoms did not differ by crew. On average, workers ended Day 1 dehydrated and ended Day 2 severely dehydrated. While workers in the intervention crew were better hydrated in the morning on Day 1, they reached the comparison workers' dehydration levels by the end of the day. No other physiological outcomes differed by intervention condition. These findings align with mounting evidence suggesting that training alone is insufficient to address heat risk among farmworkers [3, 13, 23].

Considering the NIOSH hygiene hierarchy of controls, these findings underscore the importance of implementing more effective engineering controls in addition to administrative controls [4]. Possible engineering controls include adding shade structures or vehicles equipped with fans or air conditioning for rest and lunch breaks [5]. For these measures to be widely and effectively adopted within the agriculture industry, intervention efforts will need to target multiple levels of influence simultaneously. We echo the conclusion by Bush et al. [28] that “the formidable structural barriers facing the community reinforce the need for integrated, multi-level approaches, despite the inherent challenges in implementing them.” If we are to achieve the clear improvements in hydration status and HRI prevalence that we hope to see, stronger labor protections for workers at the industry and policy levels are urgently needed.

Strengths and Limitations

This study enabled us to investigate specific social and behavioral mechanisms beyond just whether a worker was in the intervention crew. However, some study limitations should be noted. Because we did not collect pre-intervention baseline data for each crew, we

could not control for baseline scores in estimating the effect size of the intervention. The study design likewise does not account for a potential placebo effect arising from simply giving attention to a safety issue. It is also important to note the small sample size and the fact that participants in the three work crews are not representative of the farmworker population as a whole. In addition, access is restricted by employers, and the protocol and findings on one farm are not necessarily representative; this work warrants broader dissemination to test reproducibility. Research with farmworkers in their occupational settings is always challenging due to employer controlled access, housing circumstances, and mistrust of outsiders. Also, the behavioral variables rely exclusively on worker recall and self-report, which are not always reliable. USG may not be the most accurate measure of overall hydration status, though its simplicity makes it an important tool for field research [30]. Finally, most of the measures have not yet been systematically validated with this population.

Conclusion

This study uses social network analysis to investigate potential mechanisms by which peer health promotion through behavioral reminders may improve on-farm heat safety. Results indicate that establishing a “buddy system” may help cultivate a within-crew work climate that normalizes pausing work to hydrate and rest. This could help workers to feel more comfortable implementing the heat safety practices recommended in worker trainings. However, the lack of a clear impact on the outcome measures of symptoms and hydration status underlines the need for interventions designed to generate broader structural change. The fact that these outcome measures more closely corresponded to the length of the workday further emphasizes this point. Crew-level intervention is important but not nearly enough to reduce the mounting heat risk farmworkers are facing.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability:

The authors do not have permission to share the data.

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Learning Outcomes

- Assess the importance of heat safety training among agricultural workers.
- Evaluate the outcomes of an intervention that utilized a “buddy system” to promote heat safety within crews.

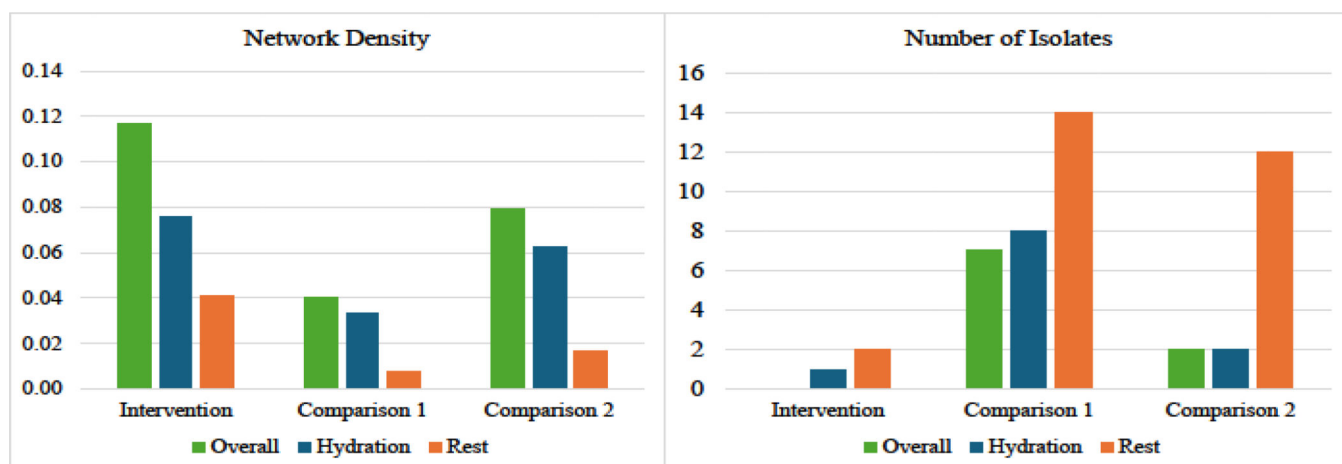
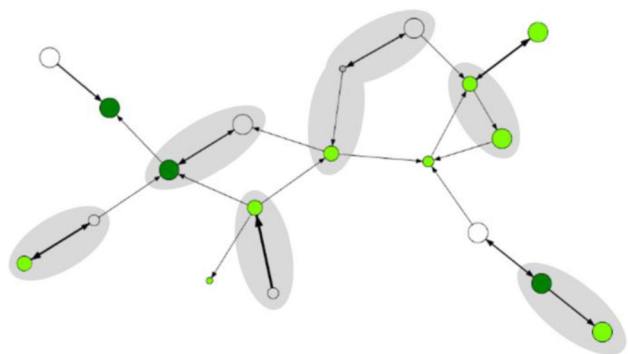


Figure 1.
Comparisons of number of reminders exchanged and isolates across behavior and crew.

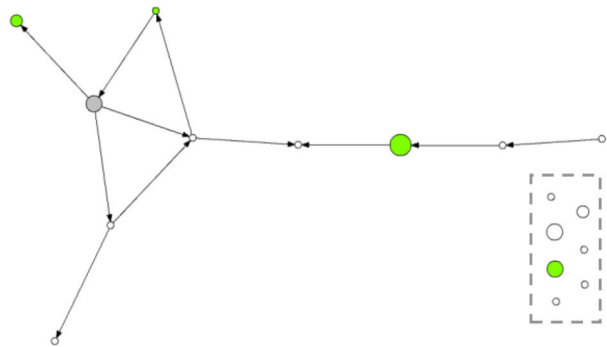
Intervention



Legend

- Gray oval:** Buddies
- Rectangle outline:** Isolates
- Node color:** Influence of coworkers on heat safety behaviors (dark green=max)
- Node size:** Intervention exposure index (largest=max)
- Arrow weight:** Number of reminders specified between alters (largest=4)

Comparison 1



Comparison 2

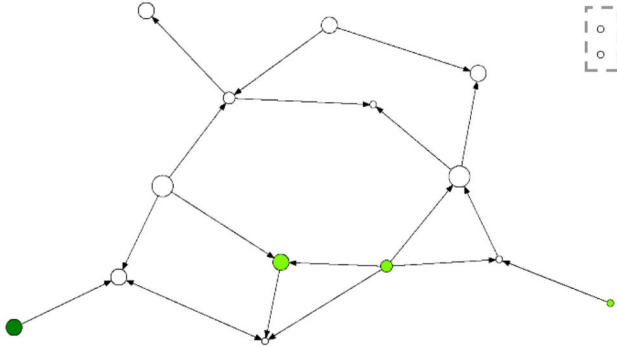


Figure 2.
Overall network structures across crews

Table 1.
Knowledge and attitude composite measures by crew and intervention condition

		Intervention	Combined	Comparison	
				C1	C2
	α	M (SD)	M (SD)	M (SD)	M (SD)
Hydration knowledge *	0.685	0.78 (.281)	0.66 (.236)	0.63 (.225)	0.70 (.250)
Rest knowledge **	0.550	0.88 (.276)	0.73 (.191)	0.68 (.213)	0.79 (.154)
Risk perception	0.751	0.68 (.287)	0.69 (.194)	0.65 (.140)	0.73 (.237)
Competing priorities (r)	0.602	0.40 (.184)	0.32 (.220)	0.35 (.154)	0.30 (.277)
Self efficacy	0.858	0.77 (.286)	0.80 (.175)	0.73 (.186)	0.88 (.122)
Buy-in	0.835	0.83 (.184)	0.85 (.194)	0.84 (.131)	0.85 (.249)

* Difference between intervention conditions is significant at $p < .05$

** Difference between intervention conditions is significant at $p < .010$ (r) Scale is coded such that lower scores are more favorable for heat safety

Table 2.

Working conditions during two consecutive study workdays by crew and intervention condition

	Intervention	Combined	Comparison	
			C1	C2
Day 1	7:00a-7:00p	-	7:00a-6:45p	7:00a-12:30p
	M (Range)	M (Range)	M (Range)	M (Range)
WBGT during work hours	78.0 (65.4–82.5)	-	78.1 (65.4–82.5)	76.4 (65.4–81.8)
Perceived heat *	1.68 (0 – 3)	2.00 (0 – 3)	1.94 (1 – 2)	2.06 (0 – 3)
Work strenuousness	1.53 (0 – 3)	1.73 (0 – 3)	1.88 (1 – 3)	1.56 (0 – 3)
Well-being	4.37 (4 – 5)	4.12 (2 – 5)	4.06 (3 – 5)	4.19 (2 – 5)
Day 2	7:00a-8:45p	-	7:00a-9:00p	7:00a-8:30p
	M (Range)	M (Range)	M (Range)	M (Range)
WBGT during work hours	78.8 (64.3–85.4)	-	78.7 (64.3–85.4)	78.9 (64.3–85.4)
Perceived heat **	1.89 (0 – 4)	2.55 (1 – 4)	2.35 (1 – 3)	2.75 (1 – 4)
Work strenuousness	1.78 (0 – 3)	2.27 (1 – 4)	1.88 (1 – 3)	2.69 (2 – 4)
Well-being **	4.29 (3 – 5)	3.64 (2 – 5)	3.71 (3 – 5)	3.56 (2 – 4)

Perceived heat and strenuousness scales: 0 = Not at all; 1 = A little; 2 = More or less; 3 = Very; 4 = Extremely**Well-being scale:** 1 = Very bad; 2 = Bad; 3 = Neither good nor bad; 4 = Good; 5 = Very good* Difference between intervention conditions is significant at $p < .05$ ** Difference between intervention conditions is significant at $p < .010$

Table 3.

Self-reported rates of rest and hydration behaviors by day, crew, and intervention condition

	Intervention	Combined	Comparison	
			C1	C2
Day 1	M (SD)	M (SD)	M (SD)	M (SD)
Breaks per hour	0.18 (.117)	0.12 (.100)	0.10 (.076)	0.13 (.120)
Stops for a drink per hour *	0.57 (.146)	0.39 (.188)	0.46 (.164)	0.31 (.184)
Employer provided drinks per hour	1.16 (.869)	0.95 (.809)	1.13 (.849)	0.78 (.754)
Personal drinks per hour ***	0.57 (.216)	0.31 (.242)	0.37 (.218)	0.24 (.255)
Day 2	M (SD)	M (SD)	M (SD)	M (SD)
Breaks per hour **	0.16 (.103)	0.11 (.078)	0.09 (.069)	0.13 (.084)
Stops for a drink per hour ***	0.50 (.143)	0.34 (.155)	0.42 (.122)	0.26 (.140)
Employer cones per hour	1.25 (.732)	1.03 (.601)	1.29 (.673)	0.79 (.412)
Personal drinks per hour **	0.45 (.208)	0.29 (.180)	0.28 (.211)	0.29 (.147)

* Difference between intervention conditions is significant at $p < .05$

** Difference between intervention conditions is significant at $p < .010$

*** Difference between intervention conditions is significant at $p < .001$

Table 4.

Self-reported influences on heat safety behaviors

	Intervention	Combined	Comparison	
			C1	C2
	M (SD)	M (SD)	M (SD)	M (SD)
Coworkers**	0.83 (.707)	0.28 (.523)	0.25 (.447)	0.31 (.602)
Roommates***	0.78 (.647)	0.22 (.491)	0.19 (.403)	0.25 (.577)
Supervisor *	0.88 (.781)	0.39 (.667)	0.38 (.619)	0.40 (.737)
New information about heat safety	1.25 (.931)	0.91 (.818)	0.81 (.834)	1.00 (.816)
Productivity	1.06 (.827)	0.84 (.808)	0.81 (.834)	0.88 (.806)
How they felt in the field	1.35 (.862)	1.16 (.808)	1.44 (.727)	0.88 (.806)

Scale: 0 = Not at all; 1 = A little; 2 = A lot* Difference between intervention conditions is significant at $p < .05$ ** Difference between intervention conditions is significant at $p < .010$ *** Difference between intervention conditions is significant at $p < .001$