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The effect of participatory heat education on agricultural worker knowledge

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Abstract

Objectives: Farmworkers disproportionately experience preventable adverse health effects from heat exposure. We sought to evaluate the effect of participatory heat education on farmworker knowledge.

Methods: We conducted a parallel, comparison group intervention study to investigate the effectiveness of a Spanish/English participatory heat education-based intervention on farmworker heat knowledge in Summer 2019. We used convenience sampling to recruit adult outdoor farmworkers from Central/Eastern Washington State, USA. Crews were randomized to receive the intervention (n=40 participants) versus not receive the intervention (n=43 participants). We assessed changes in heat knowledge, scored on a scale from 0 to 11, between baseline, immediately post-intervention, and post-season, which was approximately three months after baseline, using the Wilcoxon signed-rank test. We compared differences in knowledge scores from baseline to post-season between groups using analysis of variance.

Results: Average knowledge scores improved from 4.6 (standard deviation [sd] 1.5) to 6.3 (sd 2.0) pre to post season in the intervention group ($p<0.001$). There was greater improvement in pre-post knowledge scores in the intervention (average difference 1.6, sd 2.0) versus the comparison group (average difference 0.41, sd 1.7) ($p=0.04$).

Conclusions: Participatory heat training was effective in improving farmworker heat knowledge over the course of a summer season. Results of this study will be used to guide heat prevention efforts for farmworkers.

Trial registration: ClinicalTrials.gov Registration Number: NCT04234802

Keywords

Agricultural health; farmworker; heat stress; heat-related illness; intervention study

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INTRODUCTION

Heat exposure is a preventable cause of death and morbidity among working populations [1]. Working in the heat induces physiological heat strain, and when the body is no longer able to maintain thermal equilibrium, elevated core body temperatures and fatal exertional heat stroke may occur [2]. While classical heat stroke typically affects the elderly and very young, exertional heat stroke can affect young individuals that are otherwise healthy [2]. Other heat-related illnesses (HRIs) include heat rash, heat cramps, heat syncope, heat exhaustion, and rhabdomyolysis [1].

Farmworkers are disproportionately affected by heat exposure. Between 2000 and 2010, United States (US) agricultural workers had an annual average fatality rate of 3.1 per one million workers, which was 35 times the rate of heat-related deaths, compared to workers in all other industries (rate ratio 35.2, 95% confidence interval [CI] 26.3–47.0) [3]. In Washington State (WA), US, from 2006 to 2017, there were 918 HRI workers' compensation claims, and the Agriculture, Forestry, and Fishing (AFF) sector had the second highest July-September HRI claims rate (103/100,000 full-time equivalent [FTE]), after Public Administration [4]. In addition to HRI, heat exposure has been linked to increased risks of traumatic injury [5,6] and to acute kidney injury among US agricultural workers [7–9]. Heat exposure is also hypothesized to contribute to the development of a global epidemic of chronic kidney disease of unknown etiology (CKDu) [10].

Work-related, environmental, and personal factors increase the risk of HRI. Excess heat from a person's own metabolism and non-breathable clothing, which can limit dissipation of heat, contribute to the net heat load (i.e., heat stress) for a worker [11]. Environmental factors such as ambient air temperature, humidity, air movement, and radiant heat (e.g., from the sun) also contribute to heat stress [11]. Modifiable work factors in an agricultural field setting include aspects of tasks, particularly work rate [12] and time performing moderate-to-vigorous activity [13]; payment by the amount of work performed (i.e., piece rate pay), which incentivizes harder and faster work and minimization of breaks; acclimatization; and access to restrooms, beverages, shade, and breaks [1,14]. Outside of the workplace, heat exposure in farmworker housing and community cooling opportunities may influence recovery from heat stress at work and occupational HRI [15,16].

The risk of adverse health effects of heat exposure is likely to increase in the future given the projected increase in frequency and severity of extreme heat [17]. Absent extensive restructuring of agriculture, climate change at its current pace could double crop worker risk of unsafe heat exposure by mid-century [18]. Workers with social and economic disadvantage often are most exposed to heat yet least able to access adequate health care or means to reduce exposure or address health effects [19]. While structural, longer-term solutions are being developed and implemented, effective adaptation to existing heat hazards and prevention of adverse health effects are critical.

There exist approaches and guidance for management of workplace heat stress, including provision of water, rest, and shade, management of work/rest cycles, clothing recommendations, and heat prevention plans [1,11]. California, WA, and Oregon are the only three US states with heat rules intended to protect outdoor agricultural workers [20–22], who are largely foreign-born, Latinx workers. Worker heat education is recommended in heat stress guidance [11] and required in these states' rules [20–22]. The Washington heat rule was implemented in 2008 [20]. However, a survey study conducted in 2013 among WA farmworkers found that only about one third of workers reported receiving heat training in the past year [14], suggesting that training may not always be memorable, effective, or provided. Research from California has reported an increased risk of HRI among agricultural workers even when farms follow California heat rule requirements [23]. Rule provisions and the way in which provisions are implemented for specific working populations needs further study. Few studies have rigorously evaluated HRI prevention approaches using comparison designs [24].

We investigated the effects of a Heat Education and Awareness Tools (HEAT) educational intervention on outdoor farmworkers' knowledge of heat illness identification, prevention, and treatment using a parallel, comparison, group intervention study design. We co-developed the Spanish/English train-the-trainer participatory HEAT education materials with farmworkers and agricultural stakeholders [16]. The HEAT approach is tailored for agriculture, uses a relational and engaged approach, incorporates known science about heat stress and HRI prevention, considers cultural beliefs and practices of Latinx farmworkers, addresses both work and non-work risk factors, and complies with worker education requirements in the WA heat rule [16,20,25]. The HEAT education intervention was designed to last approximately one hour and covers types of heat illness and treatments, risk factors for heat illness, clothing for work in hot weather, staying hydrated at work, and keeping cool in the home and community (see Supplemental materials 1). The education uses an interactive approach with group discussion to learn about and address workers' perspectives. After the group discussion, the facilitator presents content from a facilitator's guide with visualizations to confirm accurate information and discuss misconceptions.

The primary aim of this study evaluated whether heat knowledge changed after completing the HEAT education intervention. We hypothesized that heat knowledge improves after receiving HEAT education. The secondary aim evaluated whether a change in heat knowledge over the course of a summer season was different for workers who received HEAT education versus those that did not (comparison group). We hypothesized that there would be a larger improvement in pre-post season scores in the intervention group compared to the comparison group.

METHODS

Study design & setting

Details of HEAT intervention development and study design have been previously reported [16]. In brief, we conducted a parallel, comparison, group intervention study to evaluate the effectiveness of a multi-level HEAT intervention, consisting of worker education and a supervisor heat awareness mobile application, on reducing adverse heat health effects in farmworkers across a growing season. In this study, we evaluated the effectiveness of HEAT education on outdoor farmworkers' knowledge of heat illness identification, prevention, and treatment. Analyses evaluating the effectiveness of the HEAT intervention on worker HRI symptoms and physiological heat strain will be reported in separate manuscripts. Power calculations were conducted for the heat strain outcome, as previously reported [16], as no prior literature existed upon which to base power calculations for the knowledge outcome. The study took place in Central/Eastern WA, a productive agricultural region, including for tree fruit and grapes, with a largely Latinx workforce. The University of Washington Human Subjects Division (HSD) approved all study procedures, and participants provided written informed consent prior to study participation. This study was registered with ClinicalTrials.gov (Registration Number: NCT04234802).

Recruitment, eligibility, and intervention allocation

We used convenience sampling to recruit and enroll 86 workers from six work crews from four different farms or companies in Central/Eastern WA, as previously described [16]. Agricultural companies were recruited using various approaches, including through the project advisory group and Pacific Northwest Agricultural Safety and Health (PNASH) Center contacts. The research team visited companies that were interested in participating, established an agreement of the company to participate, and obtained information about the company. Once companies were identified, company representatives (i.e., owners, managers) were contacted by phone and/or email, and study researchers shared additional information about the study and recruited workers from work crews for the study. To be eligible, participants were required to be 18 years or older, planning to work in agriculture during the summer season (June-August), and understand Spanish and/or English.

Research staff were trained to randomly allocate crews of participating workers within each workplace to intervention and comparison groups using simple randomization (coin flip). Workers were not aware of which group they are allocated to, but research staff assigning crews to groups were aware of assignments. Workers in the intervention group received HEAT education (Supplemental materials 1) from the same research staff member, and those in the comparison group were offered an alternative education on another topic.

Two participating companies were considered ‘large’ operations, with over 50 full-time employees during the growing season and designated health and safety departments and personnel. Within each ‘large’ company, two crews were randomized to intervention and comparison groups (four crews total). Two farms were considered ‘small’ operations, with under 50 full-time employees during the growing season and no formal health and safety infrastructure. The two small farms were owned by siblings who managed their operations similarly, so the two small farms were collectively considered one company. Each of the small farms had one participating crew (two crews total), one of which was assigned to the intervention and the other to the comparison group. Due to logistical constraints related to the timeline of agricultural work and education administration, the crews from the small farms were not randomized; instead, the first crew to enroll received the intervention, and the second crew to enroll was assigned to the comparison group. The research team did not have a role in selecting specific crews; crews were already formed by the workplace. The research team worked with crew leaders to track crew members over time.

Study procedures, outcome, and flow

After obtaining informed consent, participants were asked to complete a baseline survey and knowledge assessment in Spanish or English [16]. In the baseline survey, we asked participants about demographic, health, work, and community factors that may be related to heat knowledge and HRI. Workplace characteristics, including information about which workers are part of the US H-2A guest worker program were noted by field research staff. The H-2A program allows agricultural employers to hire workers from other countries on temporary work permits for agricultural jobs [26]. We then allocated crews of participating workers to intervention and comparison groups, and workers in the intervention group received HEAT education. Directly after the training, workers in the intervention group completed a post-education knowledge assessment. At the end of the season, which was approximately three months in duration for most participants, workers in both groups completed a post-season knowledge assessment. After the post-season assessment, comparison crews were offered HEAT education. The study took place over one summer (2019).

The primary outcome for this analysis was the knowledge assessment score (0–11). There were 12 questions on the knowledge assessment (see Supplemental materials 2), but one question (#7) was excluded from this analysis because of an error in the Spanish version of the question. Questions covered symptoms and treatments for HRI, methods to decrease the risk of HRI such as staying hydrated and wearing appropriate clothing, and how to stay cool at home and work. The knowledge assessment was completed by participants on a paper or computer tablet form in Spanish or English, depending on the participant's preference. For low literacy participants, Spanish/English bicultural/bilingual study staff members were available to read the questions and response choices to the participants. Ninety-nine percent of participants completed the assessment in Spanish. Participants in both groups completed assessments at the beginning of the study (pre-season, Test 1), participants in the intervention group completed assessments directly after education (immediate post-intervention, Test 2), and participants in both groups completed assessments at the end of the study (post-season, Test 3).

The study flow is shown in Figure 1. Eighty-seven participants were assessed for eligibility, and one participant was less than 18 years of age and was excluded. Eighty-six participants were randomized, with 43 participants allocated to the intervention group and 43 to the comparison group. Three participants did not receive the allocated intervention. Three participants were missing baseline knowledge assessments in the intervention group, and eight participants were missing baseline knowledge assessments in the comparison group. Six and 12 participants were missing post-season knowledge assessments in the intervention and comparison groups, respectively. Forty and 43 participants in the intervention and comparison groups, respectively, that had a knowledge assessment at one or more time points were included in the analysis.

Statistical Analysis

We conducted univariate descriptive analyses and generated box plots to describe study variables. We examined the relationship between integer-valued variables (test scores and age) and categorical variables using the Mann-Whitney U test (for categorical variables with two levels) and the Kruskal-Wallis H test (for categorical variables with more than two levels). We also examined the relationship between categorical variables using the Fisher's exact test. We used an intention-to-treat analysis approach. For our first Aim, we tested the null hypothesis that there is no improvement in overall knowledge scores from Test 1 to Test 2 and from Test 1 to Test 3 in the intervention group using the Wilcoxon signed-rank test. By question, we tested the null hypothesis that knowledge question scores did not change from pre- to post-season in the intervention and comparison groups using the exact McNemar test.

The second aim concerns difference scores from Test 1 to Test 3. These differences were judged to have distributions that were sufficiently symmetric to be addressed using conventional linear models or analysis of variance (ANOVA) tests. We tested the null hypothesis that the difference in overall knowledge scores from Test 1 to Test 3 is the same in the intervention and comparison groups. The study design calls for an ANOVA model with three factors: the binary indicator for the intervention and comparison groups, the three-level company level variable (Small, Large-1, Large-2), and a three-level 'English reading level' factor derived from the baseline survey question: "How well can you read in English?", as this variable was identified to be associated with Test 1 scores in our descriptive analyses (see Supplemental materials 3). The three different companies were in different geographic locations, had different crops, different management strategies, and different types of employees. Analyses were conducted using RStudio Server Version 1.4.1717 [27].

RESULTS

Participant characteristics by intervention versus comparison group are shown in Table 1. The mean (standard deviation) age of participants is 44 (16) years. 65% of study participants are male, and 51% of participants reported an education level of primary school or less. The majority (59%) or participants reported living in the US for more than 10 years, and 94% reported their country of origin as Mexico. Thirty-five percent of participants reported working in agriculture in the US for less than one year, and 45% reported working in agriculture in the US for 10 or more years. Most workers (77%) reported starting work outdoors before May, and 69% reported receiving HRI training in the past year. Twelve percent of participants reported skills at reading Spanish as not very well or not at all, and 72% reported skills at reading English as not very well or not at all. Twenty-two percent of participants reporting having been told by a healthcare provider about a diagnosis of high blood pressure, 7% about overweight/obesity, and 8% about diabetes mellitus. Thirty-four percent of participants are H-2A workers. Compared to the non-H2-A participants, the H2-A workers are all male and generally younger (mean age 29 versus 51 years). H2A workers tended to have less experience; for 96% of H-2A workers, this was their first year working in agriculture in the US. H2-A workers lived in employer-sponsored (Large-1) housing.

In general, groups are well-balanced by participant characteristics. There is a higher percentage of males and participants reporting receiving HRI training in the past twelve months in the intervention group. A lower percentage of participants report reading in English very or fairly well in the intervention group. Aside from English reading level and intervention group, no other variables are significantly associated with knowledge test scores in our bivariate descriptive analyses.

Table 2 and Figure 2 show knowledge assessment scores by time point and group. The intervention and comparison groups have similar mean Test 1 scores. The mean Test 2 score is higher in the intervention group compared to the mean Test 1 score. Test 3 scores are higher than Test 1 scores for both the intervention and comparison groups. The mean (standard deviation) Test 3 – Test 1 score difference is 1.6 (2.0) in the intervention group and 0.4 (1.7) in the comparison group.

In the intervention group, there is a statistically significant difference between Test 1 and Test 3 knowledge scores (median [range] Test 3 – Test 1 score difference of 2 [−2, 6], P<0.001) and Test 1 and Test 2 scores (median [range] Test 2 – Test 1 score difference of 1 [−3, 5], P<0.001) using the Wilcoxon signed-rank test. Participants in the intervention group significantly improved on answering questions about treatments for HRI and HRI risk factors (see Table S2).

In the primary ANOVA model (Table 3), the mean difference in scores from Test 1 to Test 3 is significantly higher in the intervention than in the comparison group, after accounting for company and English reading level (P=0.04). In a post-hoc secondary analysis, we also include interactions between covariates, but the main finding does not change. When we exclude English reading level from the ANOVA model with interactions (as none of the terms involving English reading level are nominally significant), we find a significant interaction between company and intervention assignment (p=0.03). The difference between Test 1 and Test 3 scores is greater for the intervention group in one large company (Large-2) compared to other companies (Table 4 & Figure 3).

DISCUSSION

In this study of Washington State, US, farmworkers, participatory HEAT education was effective in improving farmworker heat knowledge across the course of a summer season. We found improvements in knowledge scores in the intervention group between Test 1 (pre-season) and Test 2 (immediately post-education) and between Test 1 (pre-season) and Test 3 (post-season). We also found improvement in both groups from pre- to post-season, but improvement was greater in the intervention group compared to the comparison group. Our findings are consistent with another study that reported a greater increase in HRI knowledge and behavioral intentions for farmworkers receiving culturally appropriate and agriculture-tailored education compared to attention placebo-control pesticide education [24].Several elements of HEAT education design and development may have contributed to its effectiveness [16]. HEAT education development was guided by advisory groups that included farmworkers and managers, in addition to technical advisors and agricultural stakeholders, and grounded in an approach that centers farmworkers and farmers as innovators and experts in agriculture [28]. In addition, HEAT training was developed using a relational and engaged approach. Relational approaches encourage sharing of information and perspectives, and engaged approaches involve participatory activities and active participation, which has been shown to be more effective for health and safety training [29].

Compared to our 2013 study, in which only about one third of WA farmworkers reported receiving heat training in the past year [14], about two thirds of WA farmworkers in the present study reported receiving heat training in the past year at baseline. Although this is an improvement, approximately one third of workers still reported not receiving training in the past year. We were not able to determine whether this was because of a lack of training or because training was not memorable or effective. A higher percentage of participants reported receiving HRI training in the past year in the intervention group, but baseline mean knowledge scores were similar in both groups and receipt of prior training was not significantly associated with test scores.

The overall improvement in scores in the intervention group appears to have been driven by improvement in knowledge about HRI treatment and personal and behavioral risk factors for HRI (Table S2). There were some topics, such as clothing and consequences of not identifying HRI, that may have been covered within other trainings workers previously received. Participants may have already had a high level of knowledge and awareness of these topics, consistent with high baseline scores, with less room for improvement in scores post-season. We do not have detailed information about specific prior trainings.

Further study is needed to determine how changes in knowledge interact with other workplace heat stress controls to influence physiological heat strain and the risk of HRI. The effectiveness of the HEAT intervention on physiological heat strain in our study will be reported in a separate manuscript. Though training is required by California, WA, and Oregon heat rules [20–22], training is only one component of an effective heat stress management program, which should also include provisions for hydration, work/rest cycles, and clothing, and heat prevention and emergency response plans. Further, knowledge alone may not maximize individual behavior change to prevent HRI. The Health Belief Model posits that optimal behavior change is achieved if intervention approaches target perceived barriers, benefits, susceptibility, and threats [30]. While tailored participatory education could influence perceived susceptibility, benefits, and barriers, education must be done in combination with other aspects to comprehensively influence factors that affect the likelihood of behavior.

Though improvement in knowledge scores was greater in the intervention group, there was improvement in both groups from pre- to post-season. Improvements in the comparison group may be attributed to training provided by employers outside of our study's HEAT education or heat prevention information provided to agricultural communities over the radio, internet, and other sources. We were not able to track and account for these other potential sources of information.

The difference in improvement between groups may be an underestimate. We found a significant interaction between company and intervention group assignment, indicating that differences in scores varied by company. At one large company (Large-2), we worked with two crews that were geographically separated and did not interact. At the other large company (Large-1), we worked with two crews that had separate crew leaders, but the crews sometimes worked together and lived together. There was greater improvement over the season for the intervention compared to the comparison group within the company that had geographically separated crews (Large-2). It is possible that the interaction within the company with the crews that lived together led to a reduction in intervention effectiveness because crews may have discussed what they learned with each other. We analyzed our results by intention-to-treat, so potential cross-over could have led to more conservative estimates of the effectiveness of the training, with a larger *per protocol* improvement in knowledge expected from the training in the absence of cross-over.

Though we initially identified an association between Test 1 scores and English reading level, the intervention effect persisted after adjustment for English reading level. We additionally assessed for effect modification by English reading level on the effect of the education intervention on knowledge scores. We did not find evidence of effect modification by English reading level, although adequate assessment of interaction by English reading is hampered by the small sample size of participants who reported having a high level of English reading skill. Educational resources have been more widely available in English until relatively recently, so we had included English reading level as a proxy for access to resources and information. We posited that participants who were less comfortable reading prior heat prevention resources in English may have been more likely than those with more English reading skill to show improvement with our Spanish HEAT education.

Strengths & limitations

This is the first study of which we are aware that has evaluated the effect of heat prevention education on worker knowledge using a controlled, comparison design. Study strengths also include conduct of the study in actual agricultural field settings and follow-up through the course of a summer season. The study has several important limitations. First, the study had a sample size that did not permit adjustment for many factors in our ANOVA model. However, participant characteristics across the intervention and comparison groups were relatively well balanced. Second, knowledge questions were not validated. We considered several existing question sources in the development of our knowledge questions [31,32] but were unable to find a previously published validated heat knowledge assessment. The questions ranged in difficulty in an attempt to increase variability in responses and were field tested with our Spanish/English bicultural, bilingual staff, who are familiar with the study population. However, it is possible some questions were not challenging enough for participants while others were more challenging. Third, we used convenience sampling to select companies and workers. We would expect workers at companies who did not participate to potentially have less heat awareness and a greater potential for improvement in heat knowledge from HEAT education, and thus our estimates of effectiveness may be conservative. Fourth, we were unable to address potential cross-over between intervention and comparison groups, which may have led to more conservative estimates of the effectiveness of the training. Finally, our study was conducted in a US State with a heat rule [20], and our findings may not be generalizable to all agricultural populations.

CONCLUSION

HEAT training was effective in improving Washington farmworker HRI knowledge across the course of a summer season. Results of this study will be used to guide heat illness prevention efforts for farmworkers. Although our study supports the premise that tailoring heat prevention education to specific working populations contributes to the effectiveness of education, education should still be combined with other heat stress management program elements and policies that support workplace health and safety for all workers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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DATA AVAILABILTY:

De-identified data and statistical code will be made available upon request from the corresponding author.

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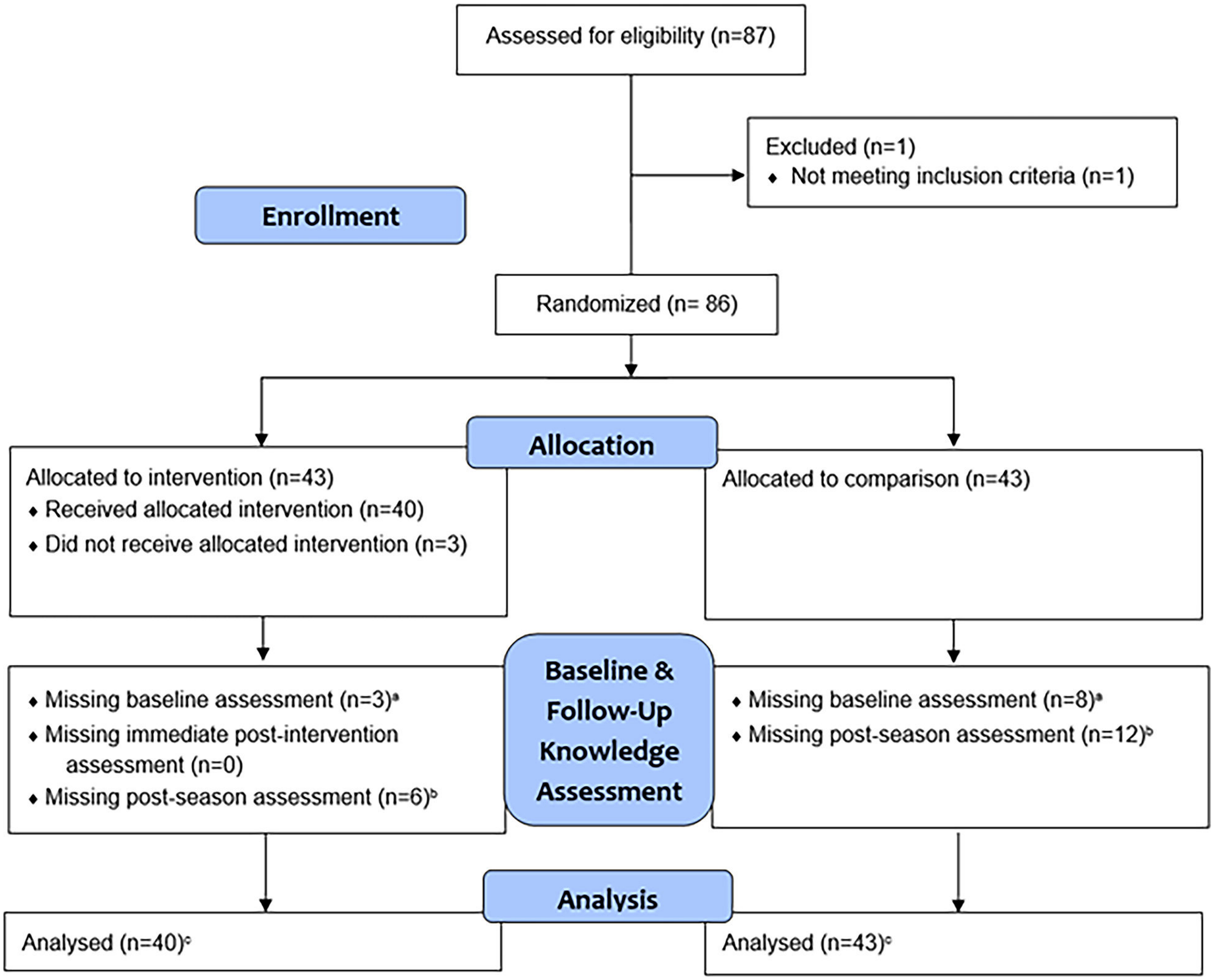

Figure 1:
Study flow

[a]Participant declined to take assessment, test was lost, or participant did not have time to complete

[b]Participant declined to take assessment, lost-to follow-up, test was lost, or participant did not have time to complete

[c]Participants for which knowledge assessment was available at least one time point

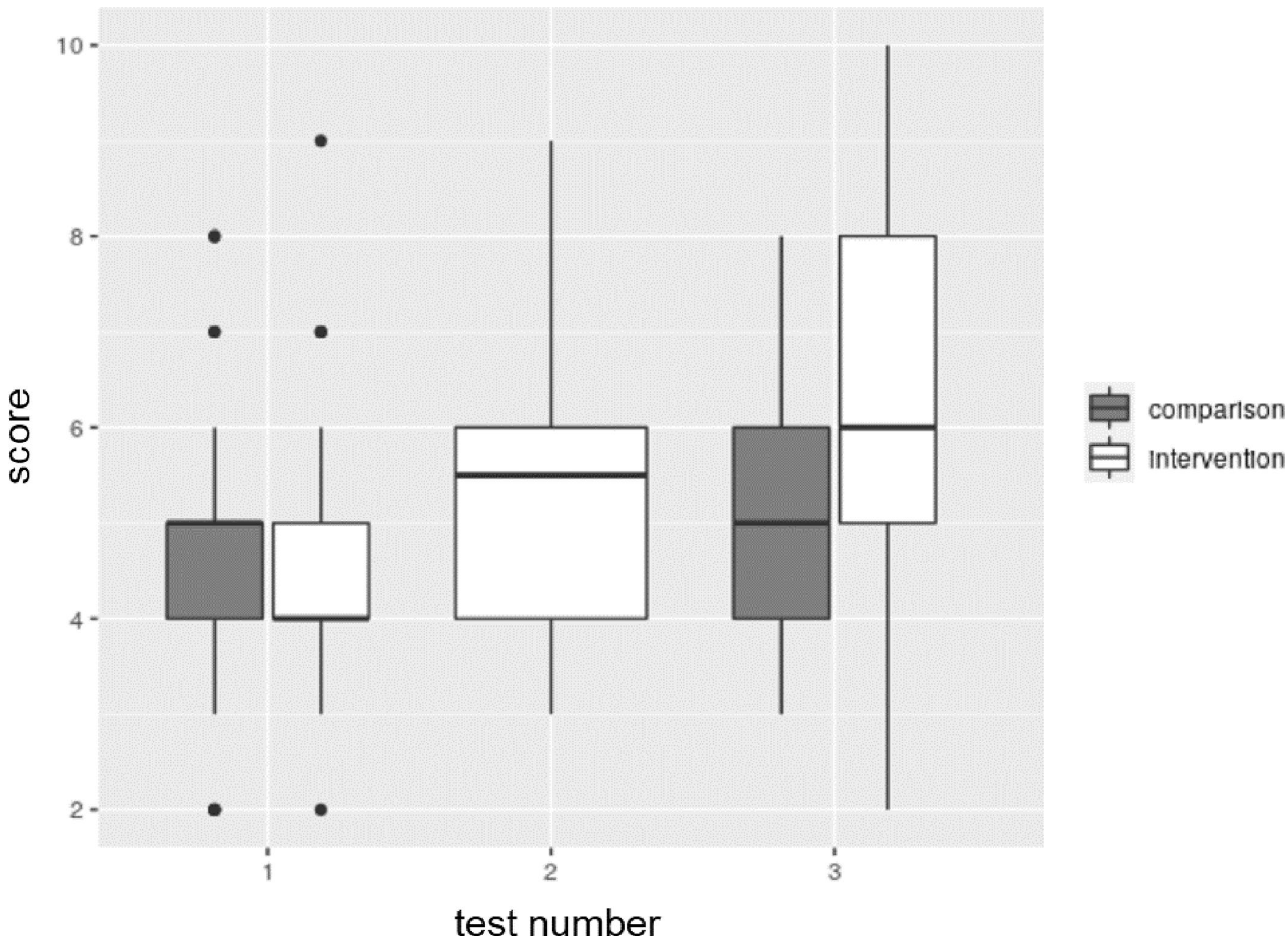

Figure 2.
Knowledge test scores by time point and group

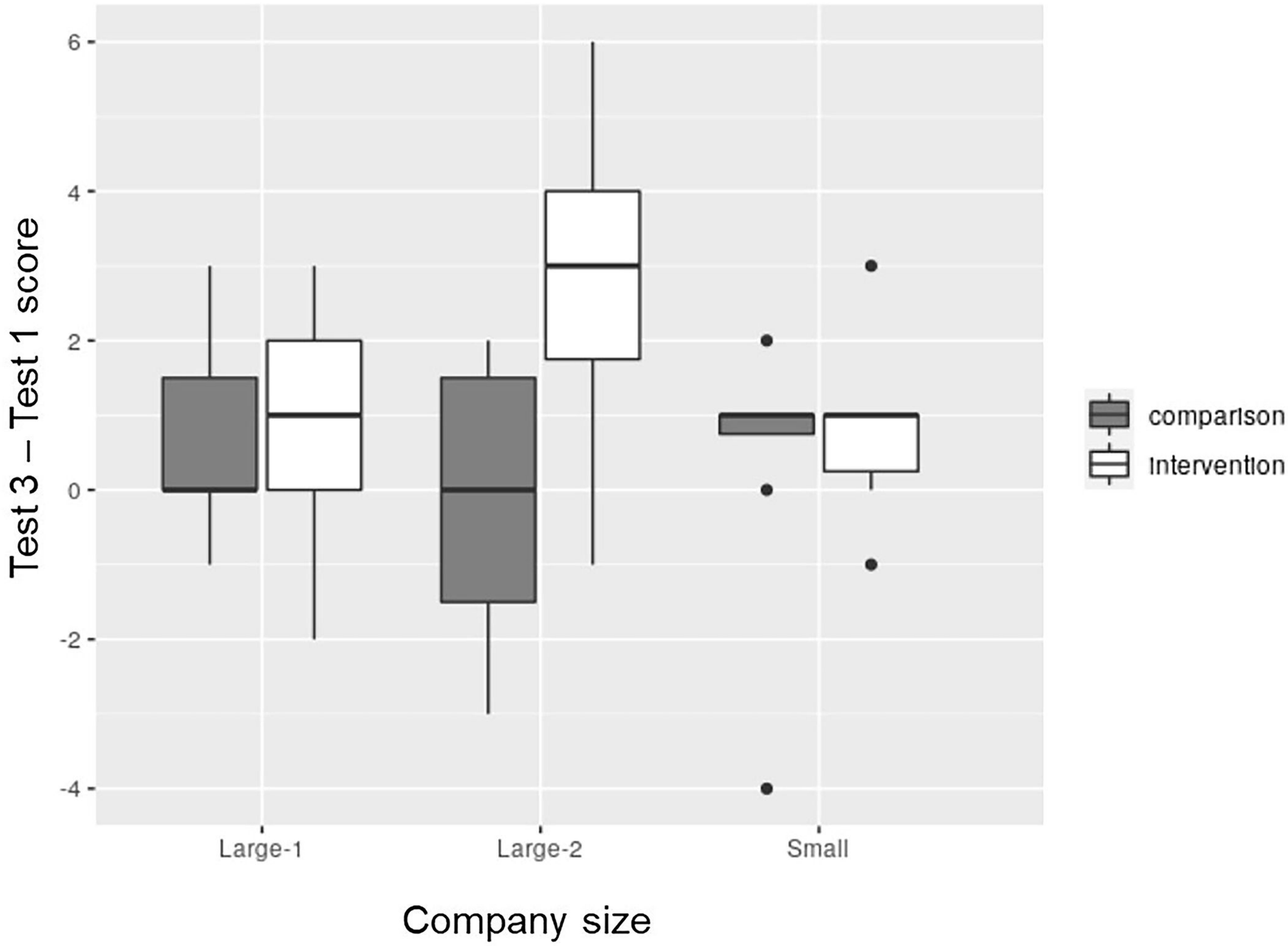

Figure 3.
Knowledge test scores by company size and group

Table 1.

Participant characteristics by intervention versus comparison group, n (%)

	All (n=83)	Comparison (n=43)	Intervention (n=40)
Age			
18–24	12 (14%)	6 (14%)	6 (15%)
25–44	31 (37%)	15 (35%)	16 (40%)
45–64	31 (37%)	17 (40%)	14 (35%)
Older than 64	9 (11%)	5 (12%)	4 (10%)
Sex			
Male	54 (65%)	24 (56%)	30 (75%)
Female	29 (35%)	19 (44%)	10 (25%)
Spanish reading			
Very well	48 (58%)	24 (56%)	24 (60%)
Fairly well	25 (30%)	13 (30%)	12 (30%)
Not very well	6 (7%)	4 (9%)	2 (5%)
Not at all	4 (5%)	2 (5%)	2 (5%)
English reading			
Very well	7 (8%)	5 (12%)	2 (5%)
Fairly well	7 (8%)	5 (12%)	2 (5%)
Not very well	16 (19%)	7 (16%)	9 (23%)
Not at all	44 (53%)	21 (49%)	23 (58%)
Don’t know/refused/missing	9 (11%)	5 (12%)	4 (10%)
Education level			
Primary school or less	42 (51%)	22 (51%)	20 (50%)
Some or all of middle school	10 (12%)	6 (14%)	4 (10%)
Some or all of high school	24 (29%)	11 (26%)	13 (33%)
More than high school	6 (7%)	4 (9%)	2 (5%)
Don’t know/refused/missing	1 (1%)	0 (0%)	1 (3%)
Years living in US			
Less than 1 year	25 (30%)	12 (28%)	13 (33%)
3–10 years	7 (8%)	2 (5%)	5 (13%)
More than 10 years	49 (59%)	28 (65%)	21 (53%)
Don’t know/refused/missing	2 (2%)	1 (2%)	1 (3%)
Country of origin			
United States	3 (4%)	1 (2%)	2 (5%)
Mexico	78 (94%)	41 (95%)	37 (93%)
Don’t know/refused/missing/other	2 (2%)	1 (2%)	1 (3%)
Years working in agriculture in the US			
Less than 1 year	29 (35%)	16 (37%)	13 (33%)
1 to 5 years	10 (12%)	5 (12%)	5 (13%)
6 to 9 years	7 (8%)	2 (5%)	5 (13%)
10 or more years	37 (45%)	20 (47%)	17 (43%)

	All (n=83)	Comparison (n=43)	Intervention (n=40)
H-2A status			
H-2A worker	28 (34%)	14 (33%)	14 (35%)
Not H-2A	55 (66%)	29 (67%)	26 (65%)
Company			
Small	19 (23%)	10 (23%)	9 (23%)
Large - 1	28 (34%)	14 (33%)	14 (35%)
Large - 2	36 (43%)	19 (44%)	17 (43%)
Started working outdoors this year			
Before May	64 (77%)	33 (77%)	35 (88%)
During May	4 (5%)	2 (5%)	2 (5%)
During the first half of June	9 (11%)	6 (14%)	3 (8%)
Don’t know/refused/missing	2 (2%)	2 (5%)	0 (0%)
Receive HRI training in past year			
Yes	57 (69%)	26 (60%)	31 (78%)
No	24 (29%)	16 (37%)	8 (20%)
Don’t know/refused/missing	2 (2%)	1 (2%)	1 (3%)
Informed by healthcare provider about selected personal health conditions [a]			
Diabetes mellitus	7 (8%)	5 (12%)	2 (5%)
High blood pressure	18 (22%)	10 (23%)	8 (20%)
Heart disease	3 (4%)	2 (5%)	1 (3%)
Overweight or obese	6 (7%)	2 (5%)	4 (10%)

[a]Categories not mutually exclusive

Table 2.

Knowledge test scores by time point and group (N=83, 43 comparison, 40 intervention)

	n	mean (sd)	median	min	max
Test 1 [a]					
Intervention	37	4.6 (1.5)	4	2	9
Comparison	35	4.7 (1.6)	5	2	8
Test 2 [b]					
Intervention	40	5.6 (1.7)	5.5	3	9
Test 3 [c]					
Intervention	34	6.3 (2.0)	6	2	10
Comparison	31	5.0 (1.4)	5	3	8

[a] 3 intervention and 8 comparison tests missing because participants declined, test was lost, or participant did not have time to complete

[b] Only intervention group completed Test 2 (immediately following heat education)

[c] 6 intervention and 12 comparison tests missing because participants declined, dropped from study, test was lost, or participant did not have time to complete

Table 3.

ANOVA results with main effects and interactions

Primary analysis: Company, English reading, and intervention assignment					
	df	**SS**	**MS**	**F**	**P-Value**
Company	2	18.4	9.2	2.5	0.10
English reading	2	8.9	4.5	1.2	0.31
Intervention group	1	15.9	15.9	4.3	0.04 *
Residuals	45	173.4	3.9		
Secondary analysis: Company, English reading, and intervention assignment with interactions					
Company	2	18.4	9.2	2.8	0.07
English reading	2	8.9	4.5	1.4	0.27
Intervention group	1	15.9	15.9	4.9	0.03 *
Company*English reading	3	17.5	5.8	1.8	0.17
Company*Intervention group	2	18.1	9	2.8	0.08
English reading*Intervention group	2	3.2	1.6	0.5	0.62
Company*English reading*Intervention group	1	7.9	7.9	2.4	0.13
Residuals	37	121.0	3.3		
Secondary analysis: Company and intervention assignment with interaction					
Company	2	13.7	6.9	2.2	0.12
Intervention group	1	16.7	16.7	5.3	0.03 *
Company*Intervention group	2	23.3	11.6	3.7	0.03 *
Residuals	52	163.2	3.1		

SS = Sum of Squares; MS = Mean Square

* P values < 0.05

Note: There are no workers in the small company with English reading level “not very well,” in the large-1 company with “very/fairly well” in the intervention group, or in the large-2 company with “very/fairly well” in the comparison group.

Table 4.

Comparison of the difference between Test 3 and Test 1 knowledge scores in intervention and comparison groups, overall and stratified by company

	Intervention			Comparison			All		
Company size	**n**	**mean (sd)**	**median**	**n**	**mean (sd)**	**median**	**n**	**mean (sd)**	**median**
Large-1	13	0.85 (1.6)	1	12	0.75 (1.5)	0	25	0.80 (1.5)	1
Large-2	12	2.80 (2.2)	3	7	−0.14 (2.0)	0	19	1.70 (2.5)	2
Small	6	0.83 (1.3)	1	8	0.38 (1.9)	1	14	0.60 (1.6)	1
All	31	1.61 (2.0)	2	27	0.41 (1.7)	1	58	1.05 (2.0)	1