Comparative Effectiveness of Training Alternatives for the EPA's Worker Protection Standard Regulation Among Immigrant Latino Farmworkers

Joseph G. Grzywacz, PhD, Melinda Gonzales-Backen, PhD, Amy Liebman, MPH, Maribel Trejo, BS, Cecilia Ordaz Gudino, Maria Trejo, Jeannie Economos, Nezahualcoyotl Xiuhtecutli, MS, and J. Antonio Tovar-Aguilar, PhD

Objectives: To determine the comparative effectiveness of two EPA-approved WPS training strategies. **Methods:** Farmworkers in GA and FL blinded to content before training ($N = 339$) were randomly assigned to either a video training ($n = 121$) or a culturally tailored, facilitator-led training ($n = 136$), or an attention-placebo training focused on heat-related illness ($n = 82$). Data were obtained immediately before and after training and 3 months after training. **Results:** Both active interventions increased pesticide knowledge. At the 3-month follow-up, participants in the EPA video lost acquired knowledge. Those in the facilitator-led group retained acquired knowledge and showed greater pesticide safety behavior. **Conclusions:** Standardized training through video improves short-term knowledge, but it is not retained and unable to support desired behavior to reduce pesticide exposure among farmworkers. A culturally tailored, facilitator-led training is more effective in achieving the spirit of the WPS regulation.

Keywords: attention placebo-controlled trial, comparative effectiveness, farmworkers, Latino, Worker Protection Standard

The revised Worker Protection Standard (WPS), a federal regulation designed to protect farmworkers and pesticide applicators from pesticide poisoning (40 CFR 170), is in full effect since 2017 under the purview of the Environmental Protection Agency (EPA). The updated WPS strengthened several components of the original regulation including training requirements, hazard communication (eg, display of safety data sheets), and personal protective equipment.[1] Key enhancements for worker safety were the requirement for annual training, elimination of the grace period requiring farmworkers to be trained before working in an area treated with pesticide and doubling required training content.

There are no published studies of the effectiveness of EPA-approved curriculum designed to meet the revised WPS. Grzywacz and colleagues[2] documented that curriculum reflective of the revised WPS (but not EPA approved) effectively increased knowledge about pesticides and pesticide exposure. They also demonstrated that the training produced changes in attitudes thought to be essential for enacting behaviors that reduce or mitigate pesticide exposure. Together with previous research, there is now a small but consistent body of evidence indicating that curriculum targeting features of the WPS may be beneficial in reducing farmworkers exposure to agricultural pesticide.[2–5]

Nevertheless, critical gaps remain in the evidence underlying the training requirements of the WPS. The training requirements of the WPS, ostensibly like the training requirements for any profession or credential, assume that understanding is an essential prerequisite to behavior change. There are few well-designed studies indicating that pesticide training changes behaviors that minimize pesticide exposure, much less reduce exposure to pesticides. Instead, studies usually focus on changes in knowledge and attitudes using a single sample design,[3,4] or study changes in knowledge or attitudes relative to control group.[2,5] The absence of research linking training with desired outcomes, behavioral or actual exposure, leaves training requirements like those in the WPS vulnerable. Essentially, how can decision-makers continue to justify mandatory training if there is no or limited evidence indicating it yields targeted outcomes? A common complaint by agricultural owners/operators about the WPS is the absence of evidence demonstrating the value of training.

The absence of comparative effectiveness research studying alternative methods for completing required training poses another critical barrier to the purpose of the WPS. Research to date studies a single training approach, typically a popular education curriculum delivered by community health workers (CHW).[6–9] Although studies like these have utility, their interpretation is ambiguous: are observed changes attributed to the curriculum/content, the delivery vehicle (ie, the CHW), or both? The practical casualties following from the absence of cleanly designed comparative effectiveness research cannot be overstated. Farmworker advocates frequently lament that most workers' WPS training is merely putting them in front of a video and instructing them to watch it; a practice that, if true, violates the spirit of the WPS and likely does not meet its requirements. Farmworker advocates further contend that more intensive forms of training, such as the use of an in-person popular education curriculum are easily dismissed because there is no evidence that a such curriculum is better than the usual training (ie, watching a video).[10] Moreover, because an interactive in-person curriculum may require more time, the question can be raised, ''does the added time and effort yield a proportional beneficial effect?''

In short, the relative absence of comparative effectiveness research creates a critical point of vulnerability for the mandatory training requirement of the WPS. In a world driven by ''show me the data,'' the current best-case scenario is that training improves knowledge and attitudes, but it has an unknown effect for reducing pesticide exposure. In a worst-case scenario training is subject to elimination as unnecessarily burdensome because there is insufficient evidence to support its continuation.

From the Florida State University, Department of Family & Child Sciences (Dr Grzywacz, Dr Gonzales-Backen, Ms Trejo, Ms Ordaz Gudino, and Ms Trejo); Migrant Clinicians Network, Division of Environmental and Occupational Health (Ms Liebman); Farmworker Association of Florida (Ms Economos, Mr Xiuhtecutli, and Dr Tovar-Aguilar).

This research was supported by a grant to the Southeastern Coastal Center for Agricultural Health and Safety (U54 OH011230).

None of the authors have financial, consultant, institutional, and other relationships that might lead to bias or a conflict of interest.

Clinical significance: Improvements in pesticide-related knowledge after Worker Protection Standard (WPS) training under the revised standard, was comparable regardless of training type. However, pesticide knowledge acquired from video training was lost 3 months later. Farmworkers trained using a facilitator-led curriculum retained acquired knowledge and demonstrated more advocated pesticide safety behaviors.

Supplemental digital contents are available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.joem.org).

Address correspondence to: Joseph G. Grzywacz, PhD, Norejane Hendrickson Professor of Family & Child Sciences, 120 Convocation Way, Tallahassee, FL, 32306 (jgrzywacz@fsu.edu).

DOI: 10.1097/JOM.0000000000002368

The goal of this study was to determine the effectiveness of two EPA-approved WPS curricula in the immigrant Latino farmworker community. The study had three specific aims. The first aim was to document changes in pesticide-related knowledge from pretest to post-test and subsequent knowledge after 3 months comparing training using either an EPA-approved video or a tailored EPA-approved curriculum delivered by a trainer. The second aim was to determine if receipt of EPA-approved training resulted in improvements in behavior believed to reduce pesticide exposure, and to delineate variation in behavior between the two training strategies (ie, video versus trainer-delivered). The final aim was to test the proposed theory of action that changes in knowledge and attitudes are essential for observing behavior change.

METHOD

This study used an attention placebo-control design.[11,12] The attention-placebo was culturally, and contextually tailored heat-illness curriculum delivered by trained facilitators. There were two ''active'' treatments: a culturally and contextually tailored facilitator-led WPS curriculum, and a WPS video. The facilitator-led WPS curriculum was from the *PISCA* project.[2] The *PISCA* (*Entrenamiento de Pesticidas e Insolación que es Culturalmente Apropiada*) WPS and heat-illness curricula were tailored to accommodate cultural (eg, aspects of humoral medicine), linguistic (ie, conversational Spanish), and practical (eg, piece-rate employment) impediments to comprehension of lesson content or uptake of advocated behavioral practices. The facilitators were well-trained (bachelors degree or higher) professionals fluent in English and Spanish, not CHWs. Both active interventions are EPA-approved under the revised WPS and delivered in Spanish. All participants received one safety education curriculum (ie, WPS trainer-led, EPA video, or trainer-led heat illness). Participants receiving either pesticide curricula should show greater increases in and retention of pesticide-related knowledge and behaviors than those receiving the heat-illness curricula because everything received (ie, attention from investigators, expectations of potential benefit from training) is similar. The main distinction is the express content (ie, pesticide safety versus heat illness), thereby serving as an attention-placebo control.[11] The use of two active interventions also allows comparisons of theoretical changes in knowledge, attitudes and behaviors attributed to curricula delivered in-person relative to video-delivered content. Participants completed surveys before the training, directly after the training, and after 3 months. All study procedures were approved by a federally recognized Institutional Review Board.

Recruitment

Study participants were recruited through a two-stage community-based procedure among farmworker communities in Florida and Georgia. Community Advisors, individuals known in the farmworker community and employed by the research project, operated within their social networks to invite participants to a free safety education event. Community Advisors did not know which curricula would be featured at each safety education event. Participants knew that they might be invited to participate in a study as part of the safety education event, and that they would receive $30 total ($5 at pre-test, $10 at post-test, and $15 at 3-month follow-up) if they enrolled and completed the study. Twenty-one safety education events were completed between April 2018 and May 2019, with an average of 16.8 farmworkers participating in each lesson.

Strategies for locating farmworkers and directing them to attend the free safety event varied across time and segments of the farmworker population. Locating farmworkers grew easier over the study recruitment period as full implementation of the revised WPS took effect. That is, Community Advisors could access farm establishments and explain to crew leaders and owners that farmworkers could receive *free* mandatory WPS training. This method was beneficial for recruiting from larger establishments reliant on H-2A workers. Our team would work with those establishments to time a safety lesson that corresponded with the arrival and intake of new H-2a workers.

Engaging non-H-2A workers, many of whom were undocumented, was more complex. Our team mapped ''neighborhoods'' and ''enclaves'' where significant numbers of farmworkers dwelled. Many of these neighborhoods and enclaves were found based on references from local owners or personnel in Tiendas (ie, Mexican Stores), local restaurants, outreach workers from a migrant health clinic, and other community members. Approximately 3 to 4 weeks in advance of a safety education event, Community Advisors would visit selected neighborhoods and enclaves, share information about the training, and encourage attendance. If a farmworker expressed interest in attending, the Community Advisor obtained the individual's name and cell phone number and would call the individual in the days leading up to the safety education lesson. The Community Advisor would arrange transportation if needed. As with the H-2A workers, the possibility of free mandatory WPS training was valuable to non-H-2A workers. All farmworkers who received either of the WPS training were given a ''Training Completion'' wallet card to prove to a prospective employer their ability to begin work immediately.

At the ''check-in'' for each safety event, participants who self-identified as Latino and reported having worked in agriculture in the previous week were invited to participate. Study staff explained the study in detail and obtained verbal informed consent.

Data Collection

All data were collected via small group (eg, 3 to 5) interviewer-assisted survey questionnaires. Study staff provided each participant of the small group with a copy of the assessment in the participant's preferred language (all selected Spanish) and explained that she/he would read each question, and participants would mark the most appropriate response. While participants were marking their response, the staff member observed participants recording their answer to the question just asked. Participants completed surveys just before the training (T1), directly following the training (T2), and 3 months after the training (T3). Staff contacted participants by phone to complete the T3 survey. Retention at the 3-month follow-up was 62%.

Measures

Pesticide knowledge was assessed with 27 true/false questions tapping several domains covered by the WPS curriculum. Questions included those related to knowledge of pesticides (eg, ''The most common symptom of pesticide poisoning is vomiting.'') primary routes by which pesticides enter the body (eg, ''The main way that pesticides get into a farmworker's body is through the skin.''), and health threats of pesticide exposure (eg, ''Dizziness, skin rashes, and eye irritation are symptoms of pesticide exposure.''). Items also assessed familiarity with standard re-entry interval signs, common field sanitization strategies for reducing pesticide exposure (eg, ''Showering after work is a good way to decrease pesticide exposure to you and your family.''), and legal requirements of pesticide training (eg, ''Your employer or contractor must make pesticide information available to all workers without requiring workers to request that information.''). Like in previous research,[2] items were scored such that ''correct'' answers were coded one, zero otherwise, and summed such that higher values indicated greater *pesticide knowledge*.

Behavioral intentions about pesticides were assessed with six items used in previous research.[2] The items asked, ''In the next week, how likely is it that you will. . ...'' with items like ''wash your hands before eating?'' and ''take a shower and wash your hair immediately after finishing work?.'' Response options were ''not at all,'' ''a little,'' and ''a lot.'' At the 3-month follow-up interview,

pesticide exposure prevention behaviors were measured with the same items, but the item stem was changed to ''In the past week how often did you. . .'' Response options were ''never,'' ''sometimes,'' and ''always.'' Items were averaged with higher scores indicating greater *behavioral intention/protective behaviors*. Participants who were not actively working in farm work at the 3-month follow-up interview were not asked the behavioral questions.

Analytic Plan

Path analysis with maximum likelihood estimation with robust standard errors (MLR) in MPlus Version 8.4[13] was used to test all hypotheses. The type = complex command was used to adjust standard errors given the clustered nature of these data (ie, workers within trainings). The core model was specified to test differences in change from pre-test (T1) to post-test (T2) and retention at 3-month follow-up (T3) in pesticide safety knowledge and behavioral intentions/behaviors between the three conditions. The path model was specified such that (1) T2 pesticide safety knowledge and behavioral intentions were regressed on condition (WPS versus EPA and heat-illness combined) and T1 pesticide safety knowledge and behavioral intentions, respectively and (2) T3 pesticide safety knowledge and protective behaviors were regressed on condition and T1 knowledge and behavioral intentions, respectively. Knowledge and behavioral intentions/behaviors were free to covary within time point. Additional specifications were added to test if differences in knowledge and behavioral outcomes existed between those assigned to the culturally tailored facilitator-led curriculum relative to the EPA video. Finally, to test the theory of action, the indirect path from condition to T3 pesticide safety behaviors via T3 pesticide exposure safety knowledge was estimated using the MODEL INDIRECT command. All analytic models controlled for gender and years in farm work.

RESULTS

Study participants ($N = 339$) were Latino farmworkers attending safety education sessions, the content for which was unknown to participants prior to the event and randomly assigned. Consequently, study participants were unevenly distributed across the two active conditions (ie, $n = 136$ received the culturally tailored facilitator-led curriculum, $n = 121$ received the EPA video) and the remainder received attention-placebo control ($n = 82$). The demographic profile of the entire sample and the subsamples receiving distinctive curricular is in Table 1.

Like most farmworker samples, participants were primarily male (15.1% female). All but two participants (0.6%) were born outside of the United States with 89.4% born in Mexico and the

TABLE 1. Descriptive Statistics for PISCA Study Participants, By Exposure to Curricula

	Sample		WPS Curricula ($n = 136$)		EPA Video ($n = 121$)		Heat-Illness Curricula ($n = 82$)	
	N	%	*N*	%	*N*	%	*N*	%
Personal characteristics								
Age								
18–25	143	40.1	62	45.6	53	43.8	25	30.5
26–35	127	35.6	54	39.7	42	34.7	31	37.8
36–45	46	12.9	14	10.3	19	15.7	12	14.6
46–55	21	5.9	4	2.9	6	5.0	11	13.4
55+	20	5.6	2	1.5	1	0.8	3	3.7
Sex								
Male	287	80.4	118	86.8	101	83.5	65	79.3
Female	54	15.1	18	13.2	19	15.7	16	19.5
Country of birth								
Mexico	319	89.4	133	97.8	108	89.3	74	90.2
Other	20	5.7	2	1.5	11	9.1	7	8.5
Educational attainment								
Primary (<6th grade)	76	21.3	21	15.4	31	26.2	24	29.3
Secondary (7th–9th grade)	140	39.2	63	46.3	42	35.6	34	41.5
Preparatory (10th–12th grade)	95	26.6	37	27.2	36	30.5	19	23.2
Some college or higher	28	7.8	15	11.0	9	7.6	4	4.8
English-speaking fluency								
Little or none	310	86.8	123	90.4	107	88.4	76	92.7
More or less/conversational	19	5.3	8	5.9	6	5.0	5	6.1
Bilingual	6	1.7	4	2.9	2	1.7	0	0.0
Work-related characteristics								
Years in US farm work								
<3 years	193	54.1	84	61.8	68	56.2	37	45.1
3–5 years	94	26.3	40	29.4	27	22.3	27	32.9
6–10 years	19	5.3	4	2.9	9	7.4	6	7.3
>10 years	51	14.3	8	5.9	17	14.0	12	14.6
Type of worker								
Migrant	177	49.6	81	59.6	65	53.7	30	36.6
Seasonal	160	44.8	53	39.0	53	43.8	51	62.2
Training in the past year								
WPS	98	27.5	31	22.8	35	28.9	30	36.6
Heat-related illness	92	25.8	28	20.6	38	31.4	24	29.3

EPA, Environmental Protection Agency; WPS, Worker Protection Standard.

remaining 8.5% born in other Central and South American countries (five participants did not provide country of birth). Participants average 29.4 ($SD = 9.1$) years old and had been working in farm work for an average of 3.7 years ($SD = 4.9$). Most participants had an H2A visa (80.4%) and about half self-classified as a migrant worker (49.6%). Most had not had a work safety training in the past year (59.1%). Of the 122 participants who reported participating in a worker safety training in the past year, 27.5% reported having a WPS training and 25.8% reported having a heat stress safety training in the past year.

Preliminary analyses examined differences in demographics and T1 knowledge and behavioral intentions for pesticide and heat-illness safety. Participants assigned to the WPS condition were more likely to have an H2A visa, $\chi^2(2) = 15.20$, $P < 0.01$, compared to those in the EPA video and heat stress conditions. Compared to the WPS and EPA video groups, participants assigned to the heat stress condition were less likely to be migrant workers, $\chi^2(2) = 11.46$, $P < 0.01$. Participants assigned to the heat stress condition were older compared to those in the WPS and EPA video conditions, $F(2, 334) = 9.86$, $P < 0.001$. Participants in the heat stress condition reported significantly more years in farm work relative to the WPS condition, $F(2, 329) = 3.98$, $P < 0.05$. Participants assigned to the heat stress condition reported significantly more T1 pesticide safety knowledge, $F(2, 335) = 3.33$, $P < 0.05$, and more T1 heat stress safety knowledge, $F(2, 333) = 3.57$, $P < 0.05$, compared to participants assigned to the EPA video condition. Finally, participants assigned to the EPA condition reported more T1 heat stress safety behavioral intentions compared to participants assigned to the WPS condition, $F(2, 332) = 3.77$, $P < 0.05$. Due to these limitations in the randomization, we included H2A visa status, worker type (ie, migrant versus seasonal worker), and years in farm work as covariates in addition to gender.

PISCA Effectiveness

Results from a path model indicate the effectiveness of the PISCA culturally tailored curriculum in predicting change in pesticide safety knowledge and behavioral intentions and retention at the 3-month follow-up (Fig. 1). The model was an adequate fit to the data, $\chi^2(14) = 20.492$, $P = 0.12$, RMSEA = 0.04, CFI = 0.98, TLI = 0.95, explaining 44.0% and 22.5% of the variance in pesticide safety knowledge for T2 and T3, respectively, and 22.9% and 6.2% of the variance in pesticide safety behavioral intentions at T2 and pesticide safety behaviors at T3, respectively. The model indicates that pesticide safety knowledge and pesticide safety behavioral intentions at T2 did not differ between the WPS condition relative to the combined EPA and heat stress illness conditions. However, the results demonstrated that participants randomized to the WPS condition reported greater retention of pesticide safety knowledge compared to the other two conditions combined ($\beta = 0.22$, $P < 0.01$).

The intervention effect on pesticide knowledge is summarized in Figure 2; that is, the PISCA curriculum and EPA video had comparable effects on knowledge improvement from before to after the training, but only PISCA participants retained that knowledge. Further, participants randomized to the WPS condition reported greater pesticide safety behaviors at T3 relative to the combined EPA and heat stress illness conditions, controlling for T1 pesticide safety behavioral intentions ($\beta = 0.18$, $P < 0.01$). Appendix A, http://links.lww.com/JOM/A983 presents the complete results for all the paths in the model.

Fitting the identical model to only those farmworkers who received an EPA-approved curriculum resulted in a better model, and clearer evidence of the benefit of a culturally tailored training approach. The model was an excellent fit to the data, $\chi^2(14) = 15.693$, $P = 0.33$, RMSEA = 0.02, CFI = 0.99, TLI = 0.99. The model explained 43.2% and 25.6% of the variance in pesticide safety knowledge for T2 and T3, respectively, and 24.0% and 5.0% of the variance in pesticide safety behavioral intentions at T2 and pesticide safety behaviors at T3, respectively. Results from this model are also presented in Figure 1, but in italicized font. Participants randomized to the WPS condition reported significantly more T3 pesticide safety knowledge compared to those randomized to the EPA condition ($\beta = 0.27$, $P < 0.001$). Additionally, T3 pesticide safety behaviors were greater among participants in the WPS condition relative to those in the EPA condition ($\beta = 0.18$, $P < 0.05$). Appendix B, http://links.lww.com/JOM/A984 presents the complete results for all the paths in the model.

Theory of Action

A path model specifying our theory of action wherein acquired knowledge enables behavior change (Fig. 3) provided an excellent fit to the data, $\chi^2(6) = 3.44$, $P = 0.75$, RMSEA = 0.00, CFI = 1.00, TLI = 1.00. The model explained 20.5% and 14.3% of the variance in T3 pesticide safety knowledge and T3 pesticide safety behaviors, respectively. T3 pesticide safety knowledge explained 12.2% of the variance in T3 behaviors. Results indicated that participants randomized to the WPS condition reported significantly more T3 pesticide safety knowledge relative to the EPA and heat stress conditions combined ($\beta = 0.21$, $P < 0.01$). Further, T3 pesticide safety knowledge

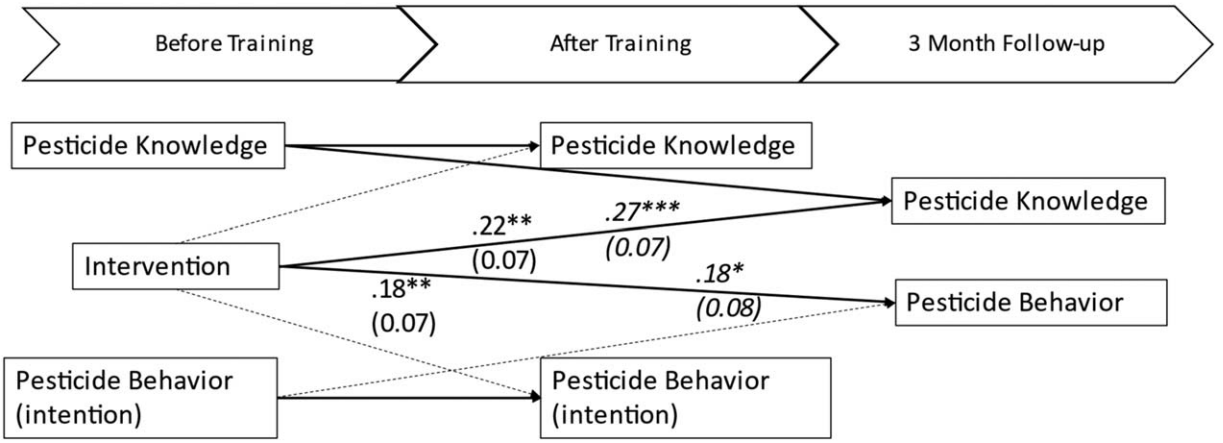

FIGURE 1. Summary of results from a path model illustrating the effects of the PISCA culturally tailored WPS curriculum compared to control conditions in predicting change in pesticide and behaviors that prevent/minimize pesticide exposure among immigrant Latino farmworkers.

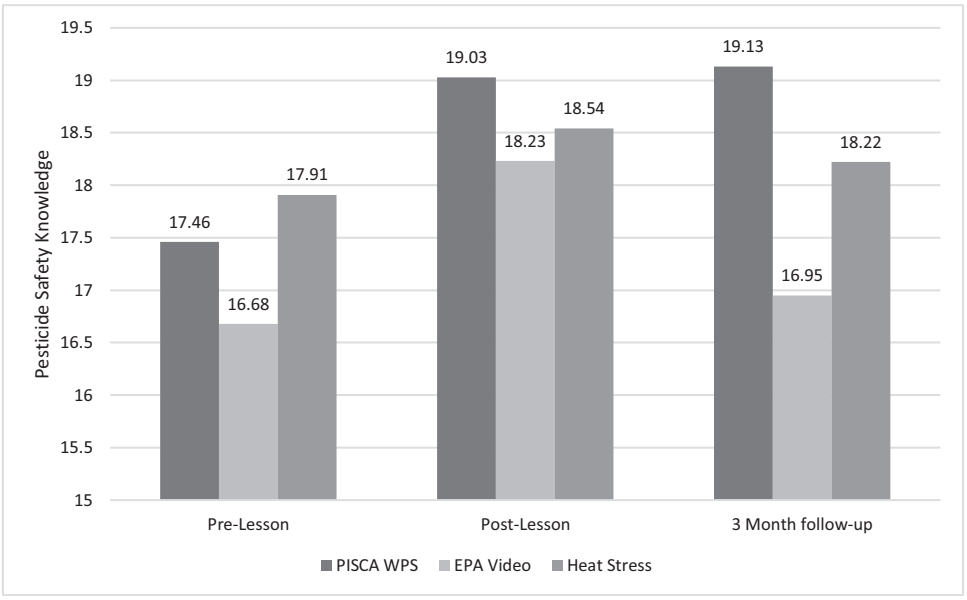

FIGURE 2. Marginal means of pesticide knowledge across time by treatment.

significantly predicted T3 pesticide safety behaviors ($\beta = 0.33$, $P < 0.001$). Findings supported Theory of Action such that condition predicted T3 pesticide safety behaviors via T3 pesticide safety knowledge ($\beta = 0.07$, $P < 0.05$). Put differently, participants randomized to the WPS condition reported greater retention of pesticide safety knowledge at the 3-month follow-up compared to the combined EPA and heat stress illness conditions and T3 pesticide safety knowledge in turn predicted more T3 pesticide safety behaviors. Appendix C, http://links.lww.com/JOM/A985 presents the complete results for all the paths in the model.

DISCUSSION

The revised WPS is the most recent federal regulation designed to protect farmworkers and pesticide applicators from pesticide poisoning (40 CFR 170). Despite full implementation in 2017, the evidence-base surrounding the effectiveness of training for facilitating changes that can lessen pesticide exposure is weak. Weak evidence makes the WPS vulnerable to arguments that mandatory training is an unnecessary weight for employers. Therefore, the goal of this study to determine the effectiveness of two EPA-approved WPS curricula in enhancing knowledge and promoting pesticide safety behaviors among immigrant Latino farmworkers. The results of this rigorous attention placebo-controlled design make several contributions to the literature.

The most significant contribution of this study is demonstration that pesticide-specific training does produce more frequent practice of behaviors advocated for reducing pesticide exposure. Specifically, the results of this study indicated more frequent practice of behaviors advocated by the WPS to reduce pesticide exposure among individuals who received the WPS curriculum than those who received the attention-placebo control. The current results extend previous studies demonstrating beneficial effects of WPS or WPS-like training for farmworker knowledge and attitudes.[2–5] Further, the results parallel the one previous study of behavioral outcomes. That is, Quandt and colleagues[8] showed improvements in practices on the part of women in farmworker families that reduce para-occupational exposure to pesticides, many of which are derived from the WPS. When combined with the results of previous research, the results of this attention placebo-controlled design provide the strongest evidence to date that WPS

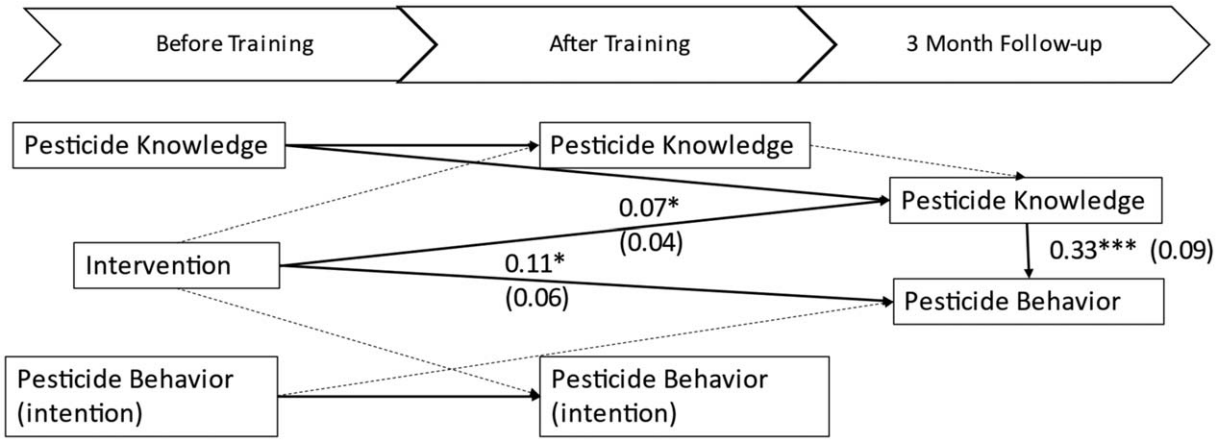

FIGURE 3. Summary of results from a path model testing PISCA's theoretical model of change wherein a culturally tailored WPS curriculum, relative to the EPA-approved video, changes immigrant Latino farmworkers' pesticide-related behavior by strengthening pesticide knowledge. EPA, Environmental Protection Agency.

training can promote behavior change essential to reducing pesticide exposure.

Equally significant are findings related to the mode of intervention. The results of this study demonstrated that both EPA-approved trainings resulted in significant changes in knowledge from pre-intervention to post-intervention. However, farmworkers who were trained through the EPA-approved video did not retain that acquired knowledge, such that 3-month follow-up knowledge levels about pesticide were comparable to those who received the attention placebo-control intervention (heat illness). Only farmworkers who receive the culturally and contextually tailored EPA-curricula in conversational Spanish delivered by a facilitator retained acquired knowledge over time. These results are consistent with longstanding arguments that effective training must accommodate farmworkers' preferred language, cultural beliefs, and acquired knowledge.[9,14] Further, the results of this study provide needed evidence to support more engaging training methods, like led by a trained facilitator using best-practice adult education techniques, over token video-based training violates the spirit of the WPS and likely does not meet its requirements.

The third and final contribution of the study is, perhaps, the first evidence to support the theory of action underlying the WPS. That is, the WPS-like all mandated training programs assume that training and the resultant knowledge obtained from training is essential for facilitating behavior change. The results from the study support this theory of action; approximately 12.2% of the observed difference in pesticide safety behavior was attributed to knowledge gained and retained by those who received the culturally and contextually tailored curricula. Previous results have shown cross-sectional associations between pesticide-related knowledge and greater practice of some WPS-advocated behaviors.[15,16] But this study provides the first evidence that effective WPS training facilitates growth and retention of pesticide-related knowledge that can be drawn upon to support more frequent use of behaviors believed to minimize pesticide exposure over time.

The contributions of study require recognition of its limitations. Foremost, the measure of pesticide safety behavior was based on self-report and is therefore subject to social desirability and recall bias. Next, the unbalanced composition of each condition group, particularly as it relates to farmworker age and years in agriculture, may have affected the results. Third, approximately one-third of the sample was lost to attrition. Although previous studies of farmworkers observed comparable loss,[17] threats to external validity may be greater in intervention studies relative to cohort designs. Finally, the sample for this study was from a narrow geographic region, and participants were not randomly selected for participation. However, the threat to validity from non-random selection is partially offset by the random assignment of study groups to conditions.

Limitations notwithstanding, the results of study are invaluable. Scientifically, the results of this study provide the first and most rigorous evidence that WPS training is useful in promoting behaviors widely believed to reduce farmworkers' exposure to pesticide. However, as is frequently the case, all training is not equal. The results of this study suggest that only training that is culturally and contextually tailored and delivered by a facilitator produced knowledge gain and retention, and that knowledge enabled desired behavior. These results, obtained from a strong attention-placebo controlled design, provide needed evidence demonstrating the value of the strengthened worker training requirements of the revised WPS. Moreover, the results of this study begin to provide needed evidence to both agribusiness and farmworker advocates justifying deliberate and engaging forms of training over passive video-based training. Although the essential question of whether training and subsequent behavior change reduces farmworker exposure to pesticide awaits future research, the results of this study clearly indicate the value of culturally and contextually tailored curricula for promoting safety behavior among Latino farmworkers.

REFERENCES

1. Environmental Protection Agency (EPA). Agricultural Worker Protection Standard (WPS) Comparison of the Revised Protections to the Previous Protections. Published online January 2017. Accessed May 5, 2021. https://www.epa.gov/sites/production/files/2017-01/documents/comparison_chart_wps_011117_cwpb.pdf.
2. Grzywacz JG, Gonzales-Backen M, Liebman A, et al. Attending to pesticide exposure and heat illness among farmworkers: results from an attention placebo-controlled evaluation design. *J Occup Environ Med*. 2019;61:735–742. DOI 10.1097/JOM.0000000000001650.
3. Anger WK, Patterson L, Fuchs M, Will LL, Rohlman DS. Learning and recall of Worker Protection Standard (WPS) training in vineyard workers. *J Agromed*. 2009;14:336–344. DOI 10.1080/10599240903042057.
4. LePrevost CE, Storm JF, Asuaje CR, Arellano C, Cope WG. Assessing the effectiveness of the pesticides and farmworker health toolkit: a curriculum for enhancing farmworkers' understanding of pesticide safety concepts. *J Agromed*. 2014;19:96–102. DOI 10.1080/1059924X.2014.886538.
5. Vela Acosta MS, Chapman P, Bigelow PL, Kennedy C, Buchan RM. Measuring success in a pesticide risk reduction program among migrant farmworkers in Colorado. *Am J Ind Med*. 2005;47:237–245. DOI 10.1002/ajim.20136.
6. Liebman AK, Juarez PM, Leyva C, Corona A. A pilot program using promotoras de salud to educate farmworker families about the risk from pesticide exposure. *J Agromed*. 2007;12:33–43. DOI 10.1300/J096v12n02_04.
7. Forst L, Lacey S, Chen HY, et al. Effectiveness of community health workers for promoting use of safety eyewear by Latino farm workers. *Am J Ind Med*. 2004;46:607–613. DOI 10.1002/ajim.20103.
8. Quandt SA, Grzywacz JG, Talton JW, et al. Evaluating the effectiveness of a lay health promoter-led, community-based participatory pesticide safety intervention with farmworker families. *Health Promot Pract*. 2013;14:425–432. DOI 10.1177/1524839912459652.
9. Quandt SA, Arcury TA, Austin CK, Cabrera LF. Preventing occupational exposure to pesticides: using participatory research with Latino farmworkers to develop an intervention. *J Immigr Health*. 2001;3:85–96. DOI 10.1023/A:1009513916713.
10. Brennan K, Economos J, Salerno MM. Farmworkers make their voices heard in the call for stronger protections from pesticides. *New Solut J Environ Occup Health Policy*. 2015;25:362–376. DOI 10.1177/1048291115604428.
11. Popp L, Schneider S. Attention placebo control in randomized controlled trials of psychosocial interventions: theory and practice. *Trials*. 2015;16:150. DOI 10.1186/s13063-015-0679-0.
12. Gross D. On the merits of attention-control groups. *Res Nurs Health*. 2005;28:93–94. DOI 10.1002/nur.20065.
13. Muthén L, Muthén B. Mplus User's Guide. Eighth Edition. Published online 2017 1998. Accessed May 5, 2021. https://www.statmodel.com/download/usersguide/MplusUserGuideVer_8.pdf.
14. Quandt SA, Arcury TA, Pell AI. Something for everyone? A community and academic partnership to address farmworker pesticide exposure in North Carolina. *Environ Health Perspect*. 2001;109(Suppl 3):435–441.
15. Salvatore AL, Bradman A, Castorina R, et al. Occupational behaviors and farmworkers' pesticide exposure: findings from a study in Monterey County, California. *Am J Ind Med*. 2008;51:782–794. DOI 10.1002/ajim.20622.
16. Walton AL, LePrevost C, Wong B, Linnan L, Sanchez-Birkhead A, Mooney K. Observed and self-reported pesticide protective behaviors of Latino migrant and seasonal farmworkers. *Environ Res*. 2016;147:275–283. DOI 10.1016/j.envres.2016.02.020.
17. Quandt SA, Preisser JS, Arcury TA. Mobility patterns of migrant farmworkers in North Carolina: implications for occupational health research and policy. *Hum Organ*. 2002;61:21–29. DOI 10.17730/humo.61.1.7ndbyxnqd56vatd7.

