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Promoting Workplace Health, Safety, and Well-Being Among Essential Agricultural Workers Through Vaccine-Preventable Infectious Diseases Training in the Rio Grande Valley

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ABSTRACT

Introduction: Health, safety, and well-being training programs provide essential education on anticipating, identifying, and mitigating exposures like infectious diseases. Gaps in infectious diseases awareness and education became especially apparent during the COVID-19 pandemic and subsequently were exacerbated by mis- and disinformation.

Methods: Vaccine-preventable infectious diseases training (influenza, hepatitis A and B, and tetanus infections, including COVID-19) was developed, delivered, and evaluated among 1,043 farmworkers, bodega workers, and production management in the Rio Grande Valley using mobile-learning technologies. The Kirkpatrick Four-Level Training Evaluation Model was utilized to evaluate training satisfaction (Level 1), effectiveness (Level 2), and effect on behavior (Level 3).

Results: The mean score on the pretest before training was 67.8% (SD 17.5), and the mean score on the same test immediately after the video training was 77.2% (SD 17.9). A paired t-test revealed that knowledge improved significantly from pre- to post-training ($p < .05$). We observed a difference between mean pre- and post-test scores relative to the pooled standard deviation, resulting in an effect size estimate of 0.53 indicative of a medium learning effect.

Conclusion: There is no "silver bullet" for training migrating bodega and farmworkers. Our findings suggest that the utilization of m-learning techniques continues to be a successful mechanism for delivering health, safety, and well-being awareness training content to agricultural workers in remote and challenging work environments. There is a long overdue need for offline capable software with features that allow equitable access to training, even in remote farming regions.

KEYWORDS

Farmworkers and bodega workers; immigrant health; indigenous languages; mobile-learning; occupational health and safety training

Introduction

Occupation is a known social determinant of health that drives morbidity and mortality.[1] A healthy, present, and valued agricultural workforce is crucial for the economic sustainability of modern, fresh produce production in the U.S.[2] As the fresh produce industry expands with increasing reliance on immigrant and H-2A guest visa[3] agricultural workers on farms and bodegas (or "pack houses" where produce is sorted, graded, and packed),[4] the anticipation, identification, and mitigation of worker health needs and occupational exposures becomes paramount.[5] Health, safety, and well-being training programs provide essential education on anticipating, identifying, and mitigating exposures like infectious diseases. Gaps in infectious diseases awareness and education became especially apparent during the COVID-19 pandemic and, subsequently were exacerbated by mis- and disinformation.[6,7] Limited and delayed health care during the COVID-19 pandemic worsened this problem. Agricultural workers were deemed essential non-healthcare workers and continued to work during peak COVID-19 infection periods to provide fresh produce, meats, and dairy products despite national stay-at-home orders.[8,9] Between 2015 and 2016, our team developed, delivered, and evaluated a mobile-learning (m-learning) safety awareness training for U.S. dairy farm workers using tablets

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as a personal learning environment.[10] We learned this delivery modality proved feasible and promising in closing training gaps in the dairy industry – when culturally, literacy, and linguistically appropriate. Building on previous field experiences and lessons learned, our team aimed to adapt and incorporate m-learning technologies into vaccine-preventable infectious diseases training for farmworkers, *bodega* workers, and production management in the Rio Grande Valley (RGV).

The RGV in South Texas is a rural, marginalized, and medically underserved U.S.-Mexico border region with over 92.0% of the population identifying as Hispanic,[11] a quarter of residents living in poverty, >33.0% of residents uninsured, 66.9% with at most a high school level education, and 82.7% speaking Spanish.[11] The RGV is economically sustained by "low-skill," low-wage jobs primarily in seasonal fresh fruit and vegetable farming as well as sorting, grading, and packing produce in "*bodegas*."[12] Agricultural workers residing in the RGV are predominantly immigrant, Hispanic middle-aged males with limited English proficiency (apart from Spanish, speaking indigenous languages such as Tzotzil, Tzeltal, or Nahuatl), limited formal education, and living in poverty.[13–15] Despite making up only 4.7% of the Texas population,[9] by October 2020, the RGV accounted for 16.8% of the state's COVID-19-related deaths.[16,17] The impact of the pandemic on agricultural workers and their multigenerational homes residing in the RGV remains largely unknown.[9,16]

Health hazards training, including physical, biological, chemical, psychosocial, and ergonomic hazards, is just one component of a comprehensive safety and health program.[18] Effective training programs are one mechanism to reduce incidents, presenteeism (working while ill, physically or mentally),[19] and absenteeism (absent from work due to health reasons).[20] Over time, increased presenteeism and absenteeism can lead to increased risk of preventable workplace injuries, illnesses, and fatalities,[19,21] high turnover rates,[22] workforce shortages,[23] business productivity losses,[24] and, food shortages.[25] In particular, biological hazards training is essential to identify sources of infectious diseases (e.g., COVID-19 and influenza) and provide interim control measures to protect workers and their families and safeguard minimal disruption to production. The objective of this m-learning project was to develop, deliver, and evaluate a vaccine-preventable infectious diseases training (influenza, hepatitis A and B, and tetanus infections, including COVID-19) among farmworkers, bodega workers, and production management in the RGV.

Methods

Training content development

The COVID-19 pandemic and subsequent emergency declaration (March 13, 2020 – May 11, 2023) increased the request for training and research proposals across all disciplines. The Occupational Safety and Health Administration (OSHA) Susan Harwood Training Grant (2022–2023 application cycle) urged training for special topics in infectious disease, including COVID-19, among vulnerable working populations in the U.S. Through collaborative efforts with the Southwest Center for Occupational and Environmental Health (www.SWCOEH.org) Outreach Program, vaccine-preventable infectious diseases materials were developed using various educational resources from the Centers for Disease Control and Prevention (CDC) Pink Book in Epidemiology and Prevention of Vaccine-Preventable Diseases[26] and the National Center for Farmworker Health (NCFH).[13] The interactive presentation software Prezi™ was used to record training videos in English, Spanish, and Náhuatl (Aztecan language; Central Mexico). Videos were uploaded to (1) the SWCOEH YouTube page, (2) the SWCOEH Outreach Page, and (3) uploaded to the application "Fast Player" for offline viewing on 20 Apple iPad tablets with the intent of enhancing the efficient and effective delivery and sustainability of health and well-being training content to agricultural workers on remote farms and *bodegas*.[10]

Training eligibility and participant sample

A non-random sample of 1,043 (1,006 agricultural workers and 37 production managers) was recruited from farms and bodegas in the RGV between November 2022 and August 2023. Employing the help of local produce associations

and previously established relationships with farm owners, bodega management, and farm labor contractors (FLCs), 26 farms and bodegas were personally called and invited to participate in this training program. All farms and bodegas where trainings took place were privately owned and operated. Each training session was limited to a maximum of 20 workers due to limited tablets and a manageable participant-to-trainer(s) ratio. Before the training, instructors administered a brief survey collecting sociodemographic information regarding their age, race, gender, country of origin, primary language, COVID-19 exposure, and vaccination status. Training program research and evaluation was approved by The University of Texas Health and Science Center at Houston Committee for the Protection of Human Subjects (CPHS) (HSC-SPH-23-0077).

Training and data collection

Training sessions for workers had a duration of one hour, and Question & Answer (Q&A) sessions for produce management had a duration of two hours. Trainings were provided in numerous locations on farms and *bodegas*, including training rooms, conference rooms, warehouses, offices, loading docks, outside under trees and tents, and inside cars during the summer (Figure 1). Free Fast Player app was used to store and view training videos with offline viewing capabilities varying in length from 13 m 51s in English, 14 m 27s in Spanish and 25 m 22s in Nahuatl. Health training content included elementary information about (1) infectious diseases (bacteria vs. virus), (2) types of vaccines, (3) common infectious diseases among agricultural workers, and (4) transmission and mitigation practices. Content was presented using both audio and visual communication resources such as graphics, pictures, cartoons, charts, diagrams; while, avoiding long sentences and clustered wording appropriate for low-literacy adult learners. Table 1 presents detailed health and well-being training topics and durations.

Before training delivery, bilingual (English and Spanish) and culturally proficient instructors provided a verbal introduction on the purpose and objectives of the training, as well as tablet user navigation instructions. All participants were given new disposable earbuds to create a personal learning environment with the tablet, minimize distractions, and prevent hygiene risks. Instructors were available throughout the entire training for technical support and guidance. Upon training completion, participants received a personalized training certificate. Additionally, producers and produce management received a thorough report of the training content, effectiveness, and attendance for their records.

We utilized the Kirkpatrick Four-Level Training Evaluation Model[27] to evaluate training satisfaction, effectiveness, and effect on behavior. Figure 2 shows the chronology of the infectious diseases training delivery. Using the Qualtrics^{XM} survey application with offline capabilities, Level 2 pre-test was administered at baseline before the training video; and, Level 2 post-test was administered after the training video. Each pre- and post-test included 10 questions with "True" or "False" and

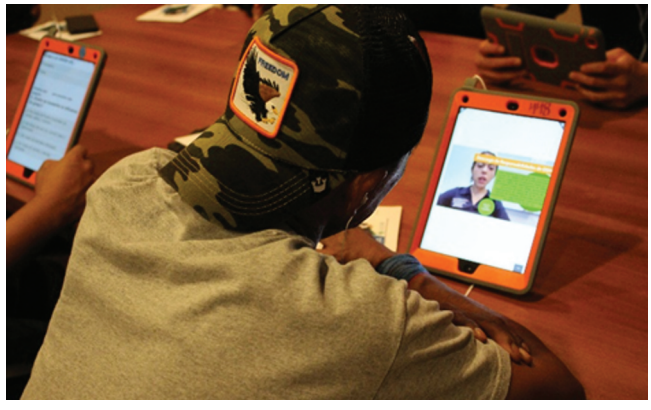

Figure 1. Training environment on different farms and packhouses.

Table 1. Workplace infectious diseases health, safety, and well-being training topics.

(1) **Occupational health, safety, and well-being (0-1:11 m)**
   a. Essential workforce
   b. Importance of health
   c. Employer commitment to health and safety
(2) **What are infectious diseases? (1:12 – 2:00 m)**
   a. Bacteria vs. viruses
   b. Antibiotics vs. antivirals
   c. Vaccine-preventable infectious diseases
(3) **What are vaccines? (2:00 – 2:26 m)**
   a. Active immunity (*natural vs. vaccine-induced*)
   b. Disease prevention vs. disease severity
(4) **Workplace infectious diseases (2:27 – 12:56 m)**
   a. Influenza*
   b. Tetanus*
   c. Tuberculosis (TB)*
   d. Hepatitis A*
   e. Hepatitis B*
   f. Coronavirus (COVID-19)*
      (i) Vaccine myths & facts
   g. Monkeypox*
(5) **Prevention and mitigation (12:57 – 13:51 m)****
   a. Personal hygiene
   b. Sick time off
   c. Personal protective equipment (PPE) usage
   d. Disinfecting techniques (*at work and home*)
   e. Disease mitigation at work and home
   f. Vaccine and booster schedules for adults

*Each infectious disease section talked about what is the disease, how it spreads, what are the symptoms, how can it be diagnosed, how is it treated, and how to prevent it.
**Based on English training video length of 13 minutes and 51 seconds.

multiple-choice question variability addressing training content presented in Table 1. Level 2 evaluations are included in Supplementals.

Training personnel were always available during training sessions to monitor and help participants with any questions or clarifications needed. After completing the Level 2 post-test, participants were asked to complete the Level 1 satisfaction evaluation. Level 1 included seven questions using "happy sheets" (green smiley face = "Yes," yellow neutral face = "Maybe," and red frowning face = "No"), which are ideal for adult learners with limited literacy.[27]

To assess training effect on worker health and well-being behavior, training personnel returned to farms and bodegas 3 to 6 months later and randomly selected previous participants to complete a Level 3 evaluation. This self-report questionnaire included seven questions administered in-person by the same training instructors using conventional "yes" and "no" answer choice bank to collect information on iPad tablets. The following questions were presented in the pre- and post-tests:

(1) *A tetanus infection is considered a medical emergency.*
   a. ***True***
   b. *False*
(2) *What should you do if you feel sick?*
   a. ***Stay home and rest***
   b. *Go to work sick*
   c. *Not wear a mask around others*
   d. *All of the above are correct*
(3) *How is influenza (or the flu) transmitted?*
   a. *Through bodily fluids*
   b. ***Through the air***
   c. *Through infected animals*
   d. *Through infected foods and drinks*

Statistical analysis

The statistical analyses included descriptive statistics of demographic characteristics, COVID-19 experiences, vaccination status, test score results, and training effectiveness evaluations. ANOVA and paired t-tests were used to assess knowledge improvement from pre- to post-training. Hedges' g estimate was used to compute effect size by comparing pre- and post-test mean scores relative to pooled variances.[28] We conducted bivariate analyses to examine differences between variables using both the chi-square test and the nonparametric Kruskal-Wallis test. All statistical analyses were performed using Stata/SE 17.0.[29]

Results

The mean age of participants was 41.7 (SD 14.7) years, with a wide range of 18–97 years, and 61.8% were male (Table 2). While the large majority of workers identified as Hispanic (97.4%), 31.9% were born in the United States, in particular in the state of Texas (90.5%), where the training was delivered, and 66.7% originated from Mexico from the U.S.-Mexico border states of Tamaulipas (43.0%) and Nuevo Leon (15.5%). On average,

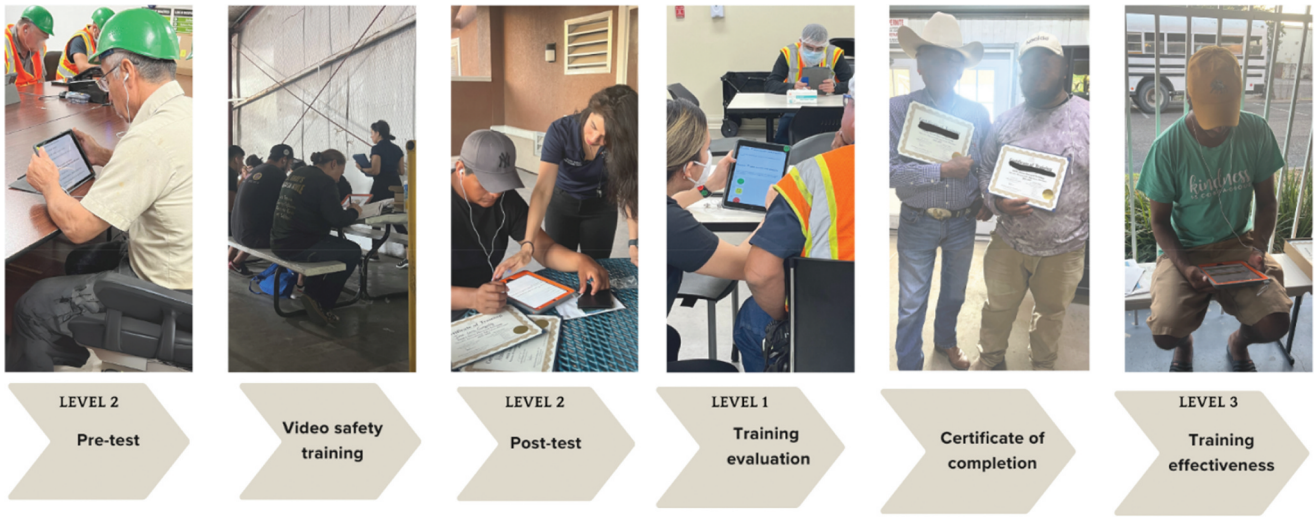

Figure 2. Chronology of vaccine-training. Training delivery, level 1 & 2 evaluations, and certificate of completion were conducted on the same day. Level 3 evaluation was conducted 3-6 months post-training.

Table 2. Sociodemographic and health characteristics of agricultural workers in the Rio Grande Valley (*n = 995*).

	Agricultural workers (*n* = 995)	Self-reported COVID-19 case, ever* (*n* = 306)	No known COVID-19 (*n* = 581)	P-value
Characteristics	Mean (SD) or n (%)			
Age (*Range 18 - 97*)	41.7 (14.7)	45.3 (13.8)	40.8 (15.0)	.0001
Gender				<.0001
Male	609 (61.8)	160 (52.3)	389 (67.2)	
Female	377 (38.2)	146 (47.7)	190(32.8)	
Nationality				<.0001
United States	315 (31.9)	123 (40.2)	156 (26.9)	
Texas	229 (90.5)			
Mexico	659 (66.7)	181 (59.2)	416 (71.6)	
Tamaulipas	266 (43.0)			
Nuevo Leon	96 (15.5)			
Veracruz	57 (9.2)			
Mexico	49 (7.9)			
Chiapas	32 (5.2)			
Hispanic	962 (97.4)	287 (93.8)	574 (98.8)	<.0001
Primary language spoken				<.0001
English	310 (31.4)	130 (42.5)	150 (25.8)	
Spanish	676 (68.4)	175 (57.2)	429 (73.8)	
Years living in the U.S. (*Range 1 month – 65 years*)	18.2 (14.2)	23.1 (11.1)	16.9 (15.0)	.0001
Education				<.0001
No formal	23 (2.3)	2 (0.7)	18 (3.1)	
Elementary	197 (19.9)	52 (17.0)	124 (21.3)	
Middle school	234 (23.7)	59 (19.3)	143 (24.6)	
High school	419 (42.4)	124 (40.5)	260 (44.8)	
College/Graduate/Professional	115 (11.6)	69 (22.6)	36 (6.2)	
General Health				<.0001
Excellent	330 (33.4)	71 (23.2)	226 (38.9)	
Very Good	285 (28.9)	95 (31.1)	166 (28.6)	
Good	322 (32.6)	125 (40.9)	165 (28.4)	
Fair	35 (3.5)	12 (3.9)	15 (2.6)	
Poor	16 (1.6)	3 (1.0)	9 (1.6)	
Tuberculosis diagnosis, ever	11 (1.1)			
Seasonal influenza (*past 12-months*)	115 (11.6)	65 (21.2)	43 (7.4)	<.0001
Vaccinations (*past 12-months*)	691 (70.0)	225 (73.5)	404 (69.5)	.2130
COVID-19	599 (60.2)	180 (58.8)	365 (62.8)	.2450

(*Continued*)

Table 2. (Continued).

Characteristics	Agricultural workers ($n = 995$)	Self-reported COVID-19 case, ever* ($n = 306$)	No known COVID-19 ($n = 581$)	P-value
	Mean (SD) or n (%)			
Influenza (flu)	245 (24.6)	102 (33.3)	129 (22.2)	<.0001
Tetanus, diphtheria, pertussis (Tdap)	77 (7.7)	20 (6.5)	53 (9.1)	.1830
Measles, mumps, rubeola (MMR)	1 (0.1)			
Hepatitis A	8 (0.8)			
Hepatitis B	11 (1.1)			

**COVID-19 diagnosis, ever (March 2020 – August 2023).*
***Cuba, El Salvador, Guatemala, Honduras, Puerto Rico, Venezuela.*

workers had 18.2 (SD 14.2) years residing in the U.S., ranging from 1 month to 65 years. Spanish (68.4%) was reported as the primary language spoken, and most workers had an elementary/middle school education (45.9%). No Nahuatl monolingual native speakers were encountered during our training.

The intake survey also included a short self-reported health assessment section. The majority of workers described their general health as "Excellent" (33.4%) and "Good" (32.6%). Most workers reported no known history of diagnosed tuberculosis (98.9%), whereas 11.6% had been diagnosed with seasonal influenza in the past 12-months. Almost three-fourths of trained workers reported vaccination(s) in the past 12-months, with 60.2% reporting receiving a dose(s) or booster of the COVID-19 vaccine, 24.6% the seasonal influenza vaccine, and 7.7% the tetanus, diphtheria, pertussis (Tdap) booster.

The no known COVID-19 group had statistically significantly lower mean knowledge scores than those in the self-reported COVID-19 case, ever group. The no known COVID-19 group was more likely to be younger, Mexican, Spanish-speaking males with, at most, a middle school level education. They were more likely to perceive their general health as "Excellent" and report a lower prevalence of seasonal influenza diagnosis in the past 12-months. In contrast, the self-reported COVID-19 case, ever group was more likely to have a high school education, perceive their general health as "Good," and report a higher prevalence of seasonal influenza diagnosis in the past 12-months.

Table 3 presents the results of the different evaluation levels delivered during and after training. A total of 992 completed Level 1, 987 Level 2 (pre-test), 992 Level 2 (post-test), and 124 completed Level 3 evaluations. Level 1 evaluation, which assessed learner experiences with training, revealed that 93.6% of participants reported ease of use of iPad devices, 96.0% enjoyed watching the training videos, and 95.3% liked where the training was conducted. Despite the reiteration of COVID-19 information in mainstream media and social media, 92.0% reported having more knowledge of COVID-19 than before the training.

Level 2 evaluation measured how training participants improved their knowledge of vaccine-preventable infectious diseases on farms and *bodegas*. The mean score on the pretest before training was 67.8% (SD 17.5), and the mean score on the same test immediately after the video training was 77.2% (SD 17.9). A paired *t*-test revealed that knowledge improved significantly from pre- to post-training ($p < .05$). We observed a difference between mean pre- and post-test scores relative to the pooled standard deviation, resulting in an effect size estimate of 0.53 indicative of a medium learning effect. There were statistically significant ($p < .05$) differences between and within pre and post-test scores across gender, all education levels (except "No education"), language, ethnicity, and COVID-19 case, ever (March 2020–August 2023).

Level 3 evaluation measured training effect on worker health and well-being behavior after training delivery. A subsample ($n = 124$) of training participants was surveyed three to six months after completing the training. Results indicated that of these, 94.4% of participants reported that they had applied the health and well-being techniques that they learned from the training, and 97.6% had taken steps to prevent transmission of infectious diseases (e.g., COVID-19, flu) among themselves and their families because of this training. In addition, since completing the training,

Table 3. Levels 1-3 training effectiveness evaluations among agricultural workers in the Rio Grande Valley.

Level 1 training satisfaction ($n = 992$)	Yes (%)	Maybe (%)	No (%)
1. Was it easy to use the iPad?	93.6	5.3	1.1
2. Did you enjoy watching the training videos?	96.0	3.7	0.3
3. Was the training video easy to understand?	94.1	5.3	0.5
4. Did you like where the training was conducted?	95.3	4.0	0.7
5. Do you think you will apply what you learned in this training in your workplace?	94.5	2.0	0.3
6. Do you think you will apply what you learned in this training in your home?	94.9	1.7	1.7
7. Do you think that after this training you have more knowledge of COVID-19 than you had before the training?	92.0	0.2	0.2

Level 2 training effectiveness evaluation	Pre-test (SD) ($n = 987$)	Post-test (SD) ($n = 992$)	p-value
All participants*	67.9 (17.5)	77.2 (17.9)	<0.0001
Gender*			
Female	68.6 (14.5)	80.4 (15.1)	<0.0001
Male	67.4 (19.1)	75.4 (19.1)	<0.0001
Highest education level achieved			
No education	60.0 (16.9)	68.7 (18.9)	0.0635
Elementary school*	59.7 (19.6)	68.4 (10.0)	<0.0001
Middle school*	70.9 (14.6)	76.3 (15.1)	<0.0001
High school*	69.5 (17.9)	80.6 (18.3)	<0.0001
Higher education*	71.2 (12.3)	84.0 (13.8)	<0.0001
Language*			
English	70.4 (16.9)	83.4 (18.3)	<0.0001
Spanish	66.7 (17.6)	74.5 (16.9)	<0.0001
Ethnicity*			
Non-Hispanic	68.1 (14.4)	92.3 (12.4)	<0.0001
Hispanic	67.9 (17.6)	76.9 (17.8)	<0.0001
Self-reported COVID-19 case, ever*			
No	65.9 (17.5)	76.5 (17.7)	<0.0001
Yes	71.9 (17.2)	80.0 (18.2)	<0.0001

Level 3 training effect on health behavior ($n = 124$)	Yes (%)	No (%)
1. Did you take the training on vaccine-preventable infectious diseases using the iPad device?	124 (100.0)	–
2. Have you applied the health and well-being techniques that you learned from the training?	117 (94.4)	7 (5.7)
3. Have you taken steps to prevent the transmission of infectious diseases (like COVID-19, flu) among yourself, coworkers, or family members because of this health and well-being training?	121 (97.6)	3 (2.4)
4. Since taking the training have you received any vaccines? If "Yes," which vaccines?	37 (29.8)	87 (70.2)
COVID-19 (1_{st}, 2_{nd}, booster)	30 (24.2)	
Influenza	23 (18.6)	
Tetanus (Tdap booster)	5 (4.0)	
Knowledge check	**Correct (%)**	
5. What causes infectious diseases?	106 (85.5)	
6. What are ways to prevent COVID-19?	111 (89.5)	
7. What should you do if you feel sick?	114 (91.9)	

**Statistically significant ($p < .05$) differences between and within pre- and post-test scores across gender, education level, except "no formal education," primary language, Hispanic ethnicity, and self-reported COVID-19 case, ever (March 2020 – August 2023).*

29.8% reported that they had received a vaccine(s), including a dose or booster of COVID-19 (24.2%), influenza (18.6%), and Tdap (4.0%). A quick knowledge check, asking three previously administered questions from the Level 2 pre-post assessments, revealed a mean score of 89.0%.

Time, budgetary restraints, and the migratory (seasonal) nature of farm work precluded Level 4 evaluation which measures outcomes and the impact of training and reinforcement by the organization (employer). These tangible measures can be, but are not limited to, decreased COVID-19 or influenza cases, presenteeism,[19] and absenteeism.[20]

While collecting information on the prevention of the spread of disease was not feasible, training personnel collected anecdotal information on the praise, effectiveness, and benefits of the training program delivered. Examples include emails from participating producers:

> Training today was truly exceptional, and I must say, captivated the audience effortlessly. The smiles and laughter from everyone indicated just how much they enjoyed the program. Thank you!

> We would like to express our deepest gratitude for all the help and support you provided to [company

name left out for confidentiality] employees in accessing the training program. Your efforts have made a significant difference in the lives of our employees during these challenging times.

Discussion

In the United States (U.S.), over two-thirds of undocumented immigrant workers were deemed essential workers during the pandemic.[30,31] Yet, most immigrant workers, including agricultural workers, were excluded from basic needs, including paid sick time off, priority access to vaccines, emergency relief social efforts, access to health care services, or workplace training on disease prevention and mitigation.[8,9] These exclusions and systematic barriers often lead to increased self-reliant attitudes and dependence on social media platforms for "reliable" and "trustworthy" health information,[7] culturally rooted self-healing home remedies,[32] and self-medication using affordable medication acquired from Mexico without medical guidance.[33–35] The pandemic materialized the consequences of historical neglect and the exclusion of agricultural workers from public health literacy and practices, voting and political participation, unwavering growth of economic inequalities, health care access, social support, and occupational health, safety, and well-being training.[8,9,36–38]

Training participants and learning needs

Consistent with Texas Census data,[11] our intake survey found that farm and bodega workers who participated in our training program were largely Hispanic (97.4%) males (61.8%) with at most an elementary/middle school education (45.9%) and reported Spanish as their primary language (68.4%). Most striking was the range of ages captured, from 18 to 97 years. Further analyses of the age distribution found that 14.7% of active bodega and farmworkers were ≥60 years of age, and of those, 16.6% were ≥70 years of age. In 2023, the U.S. Social Security Administration reported that 62 years was the median retirement age.[39] Yet aging farmworkers in their late 60s and 70s continue to work in incredibly hazardous,[40] physically demanding, and precarious, low-wage jobs without retirement benefits.[41] From cradle-to-grave, farmworkers are stuck in a multi-generational cycle of poverty with limited lifetime savings and access to social benefits. There is little to no alternative but to work well beyond retirement age.[41]

The general health status of most of the participants in our study was either "Excellent" (33.4%) or "Good" (32.6%). These percentages are similar to data from dairy farmworkers in the Texas Panhandle[4] and better than results from the 2020 Texas Behavioral Risk Factor Surveillance Survey (BRFSS), which is representative of the general state population (18.5% "Excellent" and 28.6% "Very Good").[42] The differences can be attributed to the known "healthy worker effect" (HWE), that is, on average, people in the workforce are generally healthier than those not in the workforce.[43] Additionally, agricultural workers may have higher levels of protective resiliency,[44] including adaptability to physically strenuous and psychosocially stressful jobs as well as unknown general health status.[4]

Our training program reinforced the need to consider variables associated with lower pre- and post-test mean knowledge scores, such as being male, having less than a middle school education, speaking Spanish, and identifying as Hispanic. Learning needs and barriers to content comprehension and knowledge retention should be considered when creating a culturally, literacy, and linguistically appropriate training program.

Training and study limitations

In our 2015 program,[10] we experienced a software challenge that is *still* a challenge in 2023. Large agricultural regions in the U.S. and Texas continue to experience limited internet, cellular, and hotspot service.[45] Training software with offline capabilities has limiting functions that impede the development of continuous and self-sustainable training. While functional, the integration of two different software applications disrupted the flow of training by the need for training personnel to manually transition from the QualtricsXM survey app (used for intake and Levels 1–3 evaluations) to the Free Fast Player app (used to store and view training videos) and back to the Qualtrics^{XM} survey app. After our pilot training session, our team

decided to host all evaluations and videos on the Qualtrics^{XM} survey app because of prolonged training delivery durations due to frequent disruptions to transition between apps. While continuous and offline on the Qualtrics^{XM} survey app, on occasion, the size of the videos caused the app to slow down, shut off, or restart altogether. There is a long overdue need for offline capable software with features that allow trainee interactions (e.g., pop quizzes, interactive images for hazard identification), pre- and post- evaluations with voice-over in different languages, video playing functions, and data management for employer records.

Preparation of the training resources included dubbing ("language replacement") our training video to meet the needs of Mexican Náhuatl speakers. Based on the NCFH community assessment of Hidalgo County in the RGV, we anticipated that some of the workers in our target population would be speaking this native language.[13] In fact, an unforeseeable challenge faced during our 2015 training program for dairy farm workers was some of the workers spoke Guatemalan K'iche', but the training vignettes were not available in that language. We also anticipated low literacy levels, which led us to create voice-over options for all Levels 1–3 evaluations in English, Spanish, and Náhuatl. Voice-over options on the Qualtrics^{XM} survey app could be replayed as many times as possible, eliminating the need for training personnel to assist participants who struggled with reading comprehension. This, in turn, allowed training personnel to monitor, answer questions, and help with technical difficulties. Voice over options also avoided singling out or intimidating participants with limited literacy levels by reading to them in front of coworkers.

Unlike the dairy industry, the fresh fruit and vegetable produce industry is seasonal. In particular, farm work is heavily dependent on weather, and therefore, so is packing, sorting, and grading at bodegas. Every season looks different. Recruitment and scheduling trainings proved challenging for this reason. Some employers preferred training during the enrollment season, from late September to early December, while others did not. The challenge with training during the enrollment season is that workers who are mentally fatigued from orientation and paperwork, are also pressed for time to return to work or family matters. In addition, workers migrate to follow the different produce seasons. This makes it difficult to follow-up with farmworkers for Level 3 evaluations of self-reported training effect on behavior. Additionally, some workers are missed or unaccounted for because of transient work at different farms or bodegas.

Practice implications and conclusions

There is no "silver bullet" for training migrating bodega and farmworkers. Workplace vaccine-preventable infectious diseases training is simply one comprehensive health, safety, and well-being training program module. Our findings suggest that the utilization of m-learning techniques continues to be a successful mechanism for delivering health, safety, and well-being awareness training content to agricultural workers in remote and challenging work environments. There is a long overdue need for offline capable software with features that allow equitable access to training, even in remote farming regions.

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