Journal of Agromedicine

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/wagr20

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To cite this article: M Benoit, E Austin, N Simcox, P Rabinowitz & M Yost (2023) Predictors of Dairy Worker Pre-Test and Post-Test Performance on a Dairy Safety Knowledge Test: Impact of Education Level and Native Language, Journal of Agromedicine, 28:3, 456-469, DOI: 10.1080/1059924X.2022.2140732

To link to this article: https://doi.org/10.1080/1059924X.2022.2140732

JOURNAL OF AGROMEDICINE
2023, VOL. 28, NO. 3, 456–469
https://doi.org/10.1080/1059924X.2022.2140732

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Predictors of Dairy Worker Pre-Test and Post-Test Performance on a Dairy Safety Knowledge Test: Impact of Education Level and Native Language

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ABSTRACT

Background: Efficacy-driven assessments of linguistically appropriate occupational health and safety training (OHS) for dairy workers remain uncommon. This study analyzes predictors of performance on a dairy safety knowledge test using pre-and-post knowledge assessments. The safety training course was delivered by iPad™ to Idahoan dairy workers, managers, and owners.
Objective: To determine the predictors of safety knowledge scores among dairy worker course participants.
Methods: Predictors of pre-test (baseline) scores and change in test scores of n = 1,336 participants were compared, and multivariate iterative linear regressions were used to predict test performance, adjusting for variables such as occupation, years of formal education, native language, and years in dairy work.
Results: Test scores for Spanish and English speakers improved between pre-test and post-test. Years of formal education was the most predictive variable of higher baseline scores and change in test scores among dairy safety course participants, regardless of language.
Conclusion: Dairy worker safety training course results showed improvements in safety knowledge and test scores. Years of formal education of participants appears to be a key determinant of increases in safety knowledge, and therefore safety training programs need to address the learning needs of less educated workers.

KEYWORDS
Adult learning theory; dairy; occupational health and safety; workers

Introduction

Dairy workers experience a twofold higher rate of occupational injuries compared to the national average across all industries (3.3 and 6.6 per 100 full-time workers) – while dairy farms are becoming larger in size and fewer in number, the occupational injury rate of workers in dairy occupations has not changed.[1] Immigrant workers accounted for 51% of all dairy labor.[2]

The US dairy industry, which employs foreign-born, primarily Latinx workers, has a twofold higher injury rate than the national average.[3] The federal government defines Latino/a (used interchangeably with Hispanic or of "Spanish origin") as "a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race".[4] Spanish typically functions as a masculine generic-dominated language, but there are attempts to make the language more inclusive, using the term "Latinx" to describe populations,[5] a term that will be used to describe the population of interest in this research.

Occupational health and safety (OHS) training for dairy workers is not standardized across the country, and little guidance and support is provided to the dairy industry to create and deliver trainings.[6] Additionally, a number of historic exemptions of the agricultural industry[7–9] have allowed for the dairy industry to avoid mandatory implementation of standardized occupational health and safety training programs. Studies on occupational health among farmworkers are especially hard to conduct.[10] One previous scoping review was conducted to identify published reports of occupational safety interventions in the dairy industry, and of 19 articles, none of these studies had a sufficient sample size to compare injury rates as an outcome.[1] As it relates to measuring

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An abstract of this paper will be published as part of the 2022 North American Agricultural Safety Summit hosted by the Agricultural Safety and Health Council of America

injury rates, immigrant workers too often been viewed as a "difficult population to study": epidemiologists and occupational health professionals have frequently excluded immigrant from studies because of their mobility, lack of fluency in the dominant language, cultural differences, and their informal work arrangements.[11]

Trade associations and industry groups such as the Idaho Dairymen's Association (IDA) have worked to provide a safety training program for workers within the state in spite of aforementioned challenges. In July 2017, the IDA created the "Worker and Safety Training Program," a training course that has since provided on-farm occupational safety training modules for thousands of workers on Idahoan dairy farms in native languages such as Spanish.[12] The primary objective of the course is to "promote worker safety, increase safety awareness, and reduce risk of injury and/or fatalities."[13]

Efficacy measurements of training programs are generally divided into the following areas:[14–17] changes in safety knowledge (SKs), changes in safety attitudes and beliefs (SABs), changes in safety behaviors (SBs), or safety and health outcome measurements (HOs).

Past studies indicate that significant changes in SK have been noted in a number of studies involving immigrant worker populations, but only when studies (1) described the process adopted for the design of the training program and (2) used pre-assessment and post-assessments and follow-up assessments *months* beyond the initial test[15] to be impactful.

Training interventions involving farmworkers' families and communities in training programs reported higher effectiveness, particularly in terms of SBs[15]; SABs are most significant in "underserved populations" and use peer educators or community health workers to provide information and provide significant positive effects of training.[15] With regard to SB and SAB, one review found strong evidence for the effectiveness of those training methods classified by Burke[17] as highly engaging, such as peer education.[15]

As previously mentioned, analysis of HOs is sparse in dairy and other sectors[15,17,18] due to challenges of measuring health outcomes over time among the population of interest. In addition to challenges around measuring health outcomes over time in a largely migrant population, Liebman et al.[8] found that immigrant dairy workers underreport work-related injuries out of job loss, deportation, and other stigmatization.

The IDA specifically utilized changes in SK (quantified as differences between baseline and posttest scores) to assess the efficacy of their dairy safety training course[19] rather than measure changes in SBs or SABs. Such comparisons of SK have frequently used paired *t*-tests to assess statistical significance in changes between pre-and-post -test scores to measure efficacy in OHS dairy safety training courses.[20–22] However, some studies have indicated that the use of SK to measure efficacy is problematic, especially in cases of very young migrant workers, and when training materials were only provided in a non-native language.[23] Several researchers[20,21,24,25] have underscored the importance of the delivery of linguistically appropriate OHS training for Latinx dairy workers.

There is a need to analyze the results of training programs such as the IDA's to assess determinants of SK and provide feedback to improve the effectiveness of training efforts.

Methods

IDA training course structure

The IDA conducted a dairy safety training course (see APPENDIX for full details regarding course curriculum, objectives, and test questions) to promote worker health and safety of workers, owners, and managers on dairy farms in Idaho. This dataset was collected between August 14, 2017, and February 14, 2020. The full dairy curriculum was originally developed by the National Dairy FARM Program funds.[12] The Worker and Safety Training Program served as "the intervention" and was provided to participants by individual iPad™ using several video vignettes (training modules) in Spanish or English via Articulate Storyline™ within a 1.5-hour-long training. Course content was broken into two parts: Part I focused on General Farm Safety, such as ATV and chemical

safety, ear and eye protection, and ergonomics, while Part II focused on Animal Handling Techniques and largely focused on stockmanship (see APPENDIX for full list of topics). Training sessions contained, on average, about 12 workers. All workers on dairy farms were encouraged to take the training course. Both a pre- and post-test was administered to the course participants before and after the training intervention in written form on personal iPads™. Bilingual (English and Spanish speaking) trainers offered technical support, answered worker questions during the training, assisted participants who required clarification of pre-and-post test questions, and finally, collected demographic data from course participants. The pre- and post-tests were administered using the Qualtrics Mobile Survey Software® application, and each test consisted of 15 unique questions. Test questions were a combination of multiple-choice and true or false questions; the pre- and post-test were each worth 100 points.

Dataset collection and preparation

Bilingual course trainers collected the following demographic information from dairy workers after completing the post-test: age, gender, position or occupation in dairy work, years in dairy work, years of formal education, country of origin, and native language, which were then matched to the participant's pre-and-post test scores. The original dataset consisted of 1,668 entries and was provided to the University of Washington in raw form. Further data cleaning and classification of variables then took place after all entries were removed which did not include (at minimum): pre-test score, post-test score, and native language (Figure 1).

The data for native language were originally coded to include four groups: Bilingual (in both Spanish and English), Dutch, English, and Spanish. "Bilingual" referred to participants who self-identified as speaking both English and Spanish. Participants who self-identified as speaking English and Spanish were labeled as "Bilingual". Dutch speakers (n = 2) were removed from the analysis because the training modules were not offered in their native language and because results from such a small sample size could not be inferred.

Education level attained was also consolidated. "No education," "None," "No," and other responses designating no formal education were consolidated and categorized as "No Formal Education or Elementary School". Participants reporting education levels as "professional", or "college" were combined into one category, "College". National origin was also consolidated – dairy workers originating from El Salvador, Honduras, Peru, and Puerto Rico were combined and labeled as "Other" (n = 125).

Positions on dairy farms (i.e., primary job title/duty) were also consolidated. Positions on dairy farms selected by fewer than 20% of participants were combined under a new label "Other" (see descriptions of positions included in the analysis in APPENDIX). All occupations were then further grouped into four groups: "Cattle" (including Calves, Herdsmen, Maternity, and all positions who worked directly with cattle), "Farm" (General, Other, Outside, Shop, or all positions who did not work closely with cattle), "Milker" and "Owner" for analysis. Ultimately, the final analysis dataset included only participants who had completed both the pre-test and post-test and had native language information recorded, bringing the final number of participants eligible to be analyzed to n = 1,336.

Model building

Twenty-seven linear regression models were used to identify and explore bivariate relationships between pre-and-post-test scores and the demographic data collected from course participants. A final regression model was created based on the significance of each coefficient and the entire model and higher multiple and adjusted R^2 values. A "full model" was used to explore relationships between pre-test and post-test scores and demographic variables of course participants: years in dairy, occupation, years of formal education, and native language were included in the model. Nationality was not included in the full model because it was not significant during bivariate analysis. The "full model" was also stratified by language for English-speaking (n = 157) and

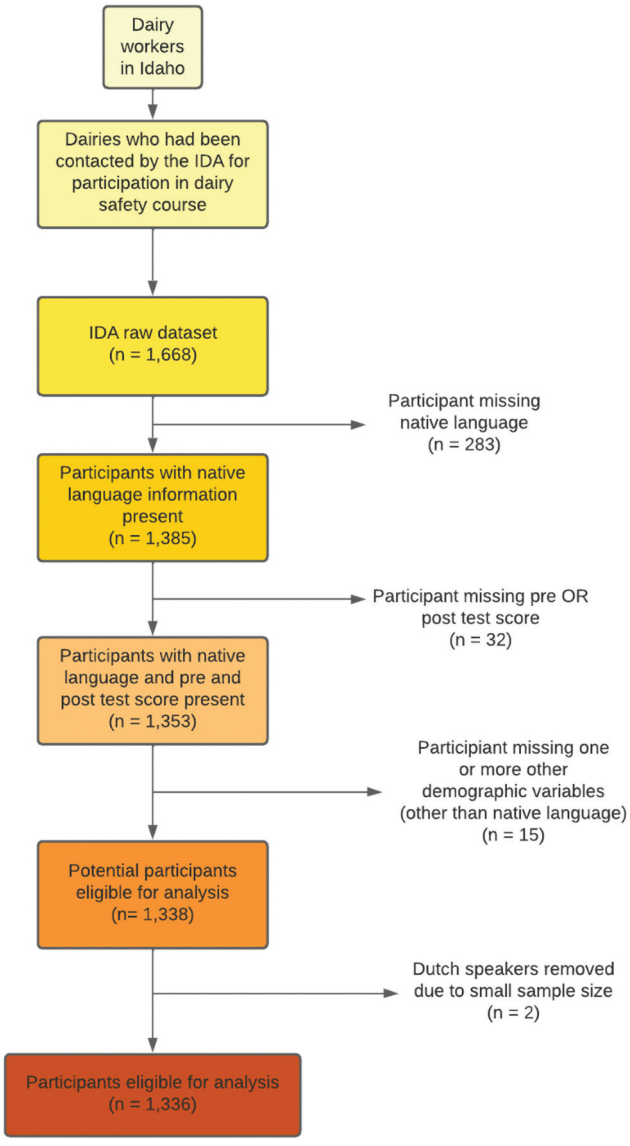

Figure 1. Participant inclusion criteria for analysis.

Spanish-speaking participants (n = 1,165). In addition to these regression models, a Wilcoxon rank sum test was used to determine if post-test scores were higher than baseline test scores, thus demonstrating improvement via changes in SK for English speakers and Spanish speakers only, with effect size and magnitude examined.

Results

The demographic characteristics of the study participants are shown in Table 1. Of the study participants, 83.7% were male, with a mean age of 36.1 years; 74.5% of respondents were originally from Mexico (Table 1). Most participants in this study identified as Spanish speaking (87.2%), and almost 70% of course participants who spoke Spanish had a middle school education or less and worked as milkers (44.9%) from Mexico (84.7%), with an average of 8.3 years of experience in the dairy industry. In contrast, course participants who identified as English speakers had the highest number of years in the dairy industry (16.3 years on average) and almost 90% of English speakers had a high school education or greater. Additionally, all course participants who identified as dairy "owners" by occupation in the study were English speaking (n = 22). Self-identified Bilingual speakers (those who spoke English and Spanish) made up about 1% of the study population (n = 14). Bilingual speakers tended to be younger than English and Spanish speakers on average (24.1 years of age) and all participants identified as having a high school education (100%).

English speakers had the highest baseline test scores (79.9) when summarizing pre-test (baseline), post-test and improvement (difference) in test scores by language group (Table 2). The results from the Wilcoxon rank sum test indicated Spanish speakers improved the most (median score improvement of 27.0) but had the lowest mean baseline test scores (61.3) (Tables 2 and 3).

Both Spanish- and English-speaking groups experienced significant improvement by Wilcoxon rank sum test between pre- and post-test scores (Tables 2 and 3). The difference between pre-test and post-test scores (changes in SK) was significant in both English speakers and Spanish speakers (CI 95% CI, *P*-value <2.2e-16), with large magnitudes, and large effect sizes for both language groups (Table 3).

During original bivariate analyses, mean baseline test score showed a stepwise linear progression as compared to level of education achieved by course participants (Figure 2).

Years of formal education was the primary driver of differences in baseline test performance when accounting for preferred and native language in multivariate models. Irrespective of language, participants with a middle school education scored almost 9.0 points higher than those with an elementary school education or

Table 1. Demographics of dairy workers by language group (n = 1,336).

	English (n = 157)	Spanish (n = 1165)	Bilingual (n = 14)	Overall(n = 1336)
Age				
Mean (SD)	35.4 (16.3)	36.7 (15.8)	24.1 (6.7)	36.1 (11.7)
Median [Min, Max]	32.0 [7.0, 77.0]	36.0 [14.0, 80.0]	24.0 [14.0, 37.0]	35.0 [7.00, 80.0]
Missing	2 (1.3%)	6 (0.5%)	0 (0%)	8 (0.6%)
Gender				
Female	26 (16.6%)	190 (16.3%)	2 (14.2%)	218 (16.3%)
Male	131 (83.4%)	975 (83.7%)	12 (85.8%)	1118 (83.7%)
Education Level				
Elementary School/None	8 (5.1%)	333 (28.6%)	0 (0.0%)	341 (25.5%)
Middle School	9 (5.7%)	480 (41.2%)	0 (0.0%)	489 (36.5%)
High School	79 (50.3%)	286 (24.5%)	14 (100%)	379 (28.3%)
College	61 (38.9%)	61 (5.2%)	0 (0.0%)	124 (9.3%)
Missing	0 (0.0%)	5 (0.4%)	0 (0.0%)	5 (0.4%)
Occupation				
Calves	7 (4.5%)	54 (4.6%)	2 (14.3%)	63 (4.7%)
General	6 (3.8%)	40 (3.4%)	0 (0.0%)	46 (3.4%)
Herdsman	11 (7.0%)	12 (1.0%)	0 (0.0%)	23 (1.7%)
Maternity	2 (1.3%)	25 (2.1%)	0 (0.0%)	27 (2.0%)
Milker	23 (14.6%)	523 (44.9%)	4 (28.6%)	550 (41.2%)
Other or Missing	32 (20.4%)	54 (4.6%)	1 (7.1%)	88 (6.6%)
Outside	49 (31.2%)	442 (37.9%)	6 (42.9%)	497 (37.2%)
Owner	22 (14.0%)	0 (0.0%)	1 (7.1%)	22 (1.6%)
Shop	5 (3.2%)	15 (1.3%)	1 (7.1%)	21 (1.6%)
Nationality				
Guatemala	0 (0.0%)	32 (2.7%)	0 (0.0%)	32 (2.4%)
Mexico	4 (2.5%)	987 (84.7%)	5 (35.7%)	996 (74.5%)
Other	0 (0.0%)	125 (10.7%)	0 (0.0%)	125 (9.4%)
US	153 (97.5%)	21 (1.8%)	9 (64.3%)	183 (13.7%)
Years in Dairy				
Mean (SD)	16.3 (18.8)	8.3 (8.0)	7.3 (8.3)	9.2 (10.2)
Median [Min, Max]	8.00 [0, 77.0]	6.00 (0, 60.0)	4.5 [0, 30.0]	6.00 [0, 77.0]
Missing	6 (3.8%)	5 (0.4%)	0 (0%)	11 (0.8%)

Table 2. Pre-test (baseline) score, post-test score, and difference in test scores by language group.

	English (n = 157)	Spanish (n = 1165)	Bilingual (n = 14)	Overall (n = 1336)
Baseline Test Score				
Mean (SD)	79.9 (13.9)	61.3 (18.5)	69.9 (16.2)	63.6 (18.9)
Median [Min, Max]	80.0 [20.0, 100.0]	64.0 [0.0, 100.0]	66.7 [33.0, 93.0]	66.7 [0.0, 100.0]
Post-Test Score				
Mean (SD)	96.1 (6.43)	88.0 (11.6)	90.0 (10.7)	89.0 (11.4)
Median [Min, Max]	100.0 [60.0, 100.0]	93.0 [13.0, 100.0]	93.3 [67.0, 100.0]	93.3 [13.0, 100]
Difference in Score				
Mean (SD)	16.2 (13.0)	26.7 (17.1)	20.1 (11.3)	25.4 (16.9)
Median [Min, Max]	13.0 [−7.00, 73.0]	27.0 [−26.0, 100.0]	26.6 [1.00, 33.4]	26.6 [−26.0, 100.0]

Table 3. Wilcoxon rank sum test results for comparisons of baseline and post-test performance.

English Speakers	n	Median	IQR
Baseline	157	80	20
Post-Test	157	100	7
Effect Size and Magnitude: large, 0.698 ***P*-value**: <2.2e-16 **V**: 9566.5			
Spanish Speakers	**n**	**Median**	**IQR**
Baseline	1165	64	26
Post-Test	1165	93	20
Effect Size and Magnitude: large, 0.698 *P*-**value**: < 2.2e-16 **V**: 627,280.0			

no education (95% CI, *P*-value = 3.20e-13); participants with a high school education scored almost 16.0 points higher than those with an elementary school or no education (95% CI, *P*-value <2e-16); and participants with a college level education scored almost 19.0 points higher than those with an elementary school or no education (95% CI, *P*-value <2e-16) on baseline tests (Table 4a).

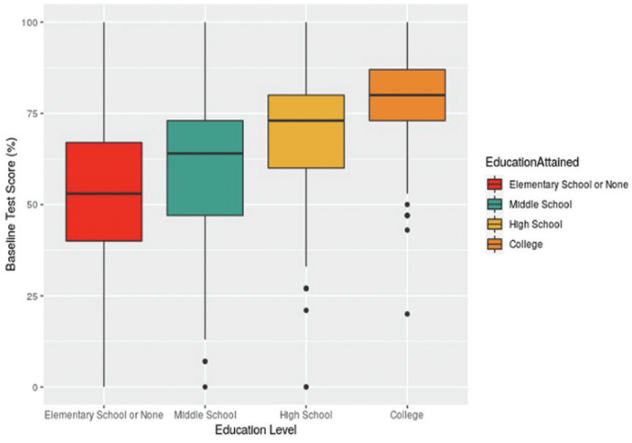

Figure 2. Boxplots illustrating relationship between education level and baseline test scores.

Table 4a. Prediction of baseline test scores for all course participants (n = 1,336) (English language, owner as occupation and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	65.75	<2e-16
Native Language: Bilingual	−7.79	.10
Native Language: Spanish	−8.52	9.31e-07
Occupation: Cattle	−5.88	.17
Occupation: Farm	−3.54	.38
Occupation: Milker	−7.92	.05
Education Level: Middle School	8.83	3.20e-13
Education Level: High School	15.88	<2e-16
Education Level: College	18.59	<2e-16
Years in Dairy	0.16	<.01

Multiple ***R2***: 0.23
Adjusted R^2: 0.22
F-statistic: 38.39
***P*-value**: <2.2e-16

Table 4b. Prediction of baseline test scores: Spanish speakers only (n = 1,165)(Milker and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	48.44	<2e-16
Occupation: Cattle	0.71	.72
Occupation: Farm	4.12	<.001
Education Level: Middle School	9.30	2.57e-13
Education Level: High School	16.19	<2e-16
Education Level: College	19.86	5.42e-16
Years in Dairy	0.25	<.001

Multiple ***R2***: 0.1378
Adjusted R^2: 0.13
F-statistic: 30.71
P-value: <2.2e-16

Table 4c. Prediction of baseline test scores: English speakers only (n = 157) (Owner and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	71.31	<2e-16
Occupation: Cattle	−4.77	.23
Occupation: Farm	−6.31	.04
Occupation: Milker	−12.42	<.001
Education Level: Middle School	5.29	.48
Education Level: High School	14.96	.02
Education Level: College	16.99	.01
Years in Dairy	0.03	.65

Multiple ***R2***: 0.19
Adjusted R^2: 0.14
F-statistic: 4.65
P-value: <0.001

When analyzing baseline test score contributors for Spanish speakers only, increasingly greater number of years of formal education were highly correlated to higher baseline test scores when comparing those with an elementary school education or less to those with middle school and high school level educations (Table 4b). When analyzing baseline test score contributors for English speakers only, higher baseline test scores were somewhat correlated to a greater number of years of formal education (Table 4c).

Years of formal education once again played a role in driving predictions of significant changes in test scores by education group. Irrespective of language, and relative to course participants who achieved an elementary school level of education, those with a middle school education were predicted to have, on average, a 1.5-point change in test score, on average (95% CI: *P*-value = .03) when looking at all language groups (Table 5a).

Additionally, among course participants of the same baseline test score, native language, occupation, and years in dairy, those with a high school level of education were predicted to have, on average, a 3.0-point change in test score, on average (95% CI: *P*-value <.001) (Table 5a). When examining change in test score for Spanish speakers only, those with a high school education predicted to have, on average, an approximately 3.2-point change in test score, on average (95% CI: *P*-value <.001) (Table 5b). The model for predictions of change in test score was not as significant for English speakers (Table 5c).

Table 5a. Prediction of change in test scores for all course participants (n = 1,336) (English language, owner as occupation and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	73.16	<2e-16
Native Language: Bilingual	−3.66	.20
Native Language: Spanish	−1.94	.06
Occupation: Cattle	1.28	.61
Occupation: Farm	1.09	.65
Occupation: Milker	−0.16	.95
Education Level: Middle School	1.57	.03
Education Level: High School	3.00	<.001
Education Level: College	2.79	.02
Years in Dairy	0.01	.81
Baseline Test Score	−0.76	<2e-16

Multiple ***R2***: 0.66
Adjusted R^2: 0.65
F-statistic: 229.3
***P*-value**: <2.2e-16

Table 5b. Prediction of change in test scores: Spanish speakers only (n = 1,165), (Milker and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	70.99	<2e-16
Occupation: Cattle	1.39	.28
Occupation: Farm	1.31	.05
Education Level: Middle School	1.55	.05
Education Level: High School	3.24	<.001
Education Level: College	2.19	.14
Years in Dairy	0.00	.93
Baseline Test score	−0.76	<2e-16

Multiple ***R2***: 0.63
Adjusted R^2: 0.63
F-statistic: 285.9
***P*-value**: <2.2e-16

Table 5c. Prediction of change in test scores: English speakers only (n = 157) (Owner and elementary school or no formal education as reference categories).

	Estimates	*P*-value
Intercept	82.50	<2e-16
Occupation: Cattle	1.42	.48
Occupation: Farm	1.17	.46
Occupation: Milker	0.05	.98
Education Level: Middle School	−2.08	.58
Education Level: High School	−2.34	.47
Education Level: College	−0.94	.78
Years in Dairy	0.02	.42
Baseline Test score	−0.83	<2e-16

Multiple ***R2***: 0.77
Adjusted R^2: 0.75
F-statistic: 57.87
***P*-value**: <2.2e-16

Discussion

This study used a large dataset of dairy safety training records to assess predictors of test performance. Ultimately, the goal of this dairy safety training course was to verify that dairy workers who participated in the OHS training intervention were able to significantly improve their dairy safety knowledge scores (measurements of SK) between baseline and post-test scores.[13] The demographic characteristics of dairy workers, owners, and managers in this study are directly in line with demographic information collected from past studies.[1,7,20–22,24] All language groups (English, Spanish, and Bilingual) statistically improved between baseline and post-test scores. The demographic information collected further corroborates prior findings – many dairy workers speak English as a second language who may be from another country,[26] and have fewer years of experience with cattle than their English-speaking counterparts.[27]

In terms of OHS course efficacy, both English and Spanish speakers statistically improved between baseline and post-test scores, indicating greater improvements in SK of the participants in the course. It is important to note that Spanish speakers experienced the greatest differences between baseline and posttest scores, yet their baseline test scores were the lowest of any language group. There is evidence to suggest that pre-test performances of dairy workers were closely related to language group. The IDA indicated that between 10% and 20% of participants were illiterate, or struggled to read,[13] which is likely associated with the aforementioned fewer years of formal education in the Spanish-speaking group. Therefore, assessments of efficacy (such as using changes in SK as the standard) may need to be re-evaluated to ensure that the assessments of efficacy are best suited to the population of interest.

As Arcury et al. reported, limited education among agricultural workers may affect safety training in several ways including (1) limited

literacy, (2) limited development of learning skills, and '(3) limited ability to learn complex concepts.[28] Prior research has noted an inverse relationship between education and English as a first language and self-efficacy, while education and language were highly correlated, language was a more important predictor of self-efficacy as it relates to OHS training.[29]

Years of formal education was explicitly the main driver of higher baseline test scores – all education variables were moderately or highly statistically significant in prediction of baseline test score for all languages and similar trends emerged when relationships between baseline test scores among Spanish speakers only were examined. This indicates that the role of years of formal education is *imperative* to consider and understand for Spanish speakers to predict gains in SK, while change in scores for English speakers may be more driven by other factors. Additionally, when examining all course participants (regardless of language), change in test scores were primarily driven by higher baseline test scores and most remarkably, years of formal education as well.

One of the biggest limitations of this study was inability to quantify illiterate participants for further analysis. The IDA indicated that between 10% and 20% of participants were illiterate.[13] It has been well described that the population of interest has fewer years of formal education[3,7,8,30–33] and low levels of literacy, and this study population is well aligned to previous findings. For future analysis, knowing the actual number of illiterate participants would be of exceptional importance so that it can be appropriately represented in future models. Additionally, there is a possibility that workers may have taken the safety training course more than once, as turnover in this industry is high and workers were not given permanent unique identifiers.

Another limitation of the study was that the post-test score (the only outcome) was measured only one time immediately after completion of the course. While these measurements may indicate knowledge gains (improvements in SK) over the short term, it is impossible to know how much knowledge is *retained* by course participants in the long run, unless additional post-tests (on the scale of weeks, months, or even years.

Furthermore, further exploration of the effects of training on Bilingual speakers was somewhat limited in this research due to a small sample size (n = 14); further definition of what constitutes as "Bilingual" could be expanded upon in future research. The scope of this question should be examined when presenting the question to course participants.

The biggest strength of the primary analysis is the robust sample size (n = 1,336) of the study. Past research indicates that small sample sizes of Latinx dairy workers are the norm rather than the exception[21,24] – the extensive data which the IDA was able to collect is invaluable in its rarity, and should be viewed as an achievement for the industry. Of note, the importance of quantifying and measuring outcomes of interest (in this case, improvements in SK) to inform efficacy of the training course provided by the IDA should not be understated. The generalizability of the study is also good in that methods and analysis used to analyze and predict test scores by language group in this study could be applied to dairy workers in other areas of the United States.

There are several implications from this study and suggestions to be made to continue to improve the OHS training course:

1. Quantify and characterize participant illiteracy as a variable of interest. The illiteracy frequency of the study population needs to be quantified, and that literacy levels (in general) should be assessed in the study population – this would be the first step for future studies and for further improvements to the OHS course, especially if changes in SK are to continue to be measured as indicators of course efficacy. It is worth noting that while SK improvement was observed in a substantial number of research articles, highly significant increases in SK were seen especially among *highly educated participants* when using computer-based training software.[15] For the dairy course participants, it is a benefit that the IDA presents information to dairy workers in native and preferred languages,[13] but assumptions that course participants can read and write in their native language is not always the case,[34] and may ultimately limit sound efficacy evaluations of the safety training course. Participants who are English speaking and originate from the United

States may also have an advantage in the ability to simply take traditional written tests as opposed to their Spanish-speaking counterparts, resulting in higher baseline test scores in English speakers.

2. Consider measuring changes in SABs or SBs in contrast or in addition to measurements of SK; ultimately, seek to measure changes in HOs as the "gold standard", despite challenges. Longitudinal efficacy assessments of dairy workers in an occupational space are rare[35] chiefly due to time constraints surrounding training,[20,21,30] high rates of turnover of dairy workers,[36] and a lack of formal classroom space which can ultimately lead to discontinuation of pre-and-post assessments of SK and efficacy.[21,25] Studies have indicated that significant SK gains have been noted in studies where pre-assessment and post-assessment tests are used *weeks, months, or even years* beyond the initial assessment[15,37] to measure behavioral changes (SBs) due to applied knowledge gained in work activities.[37] In the context of this safety training course, additional measurements of SK within the research population would be more powerful if subsequent knowledge tests were taken weeks or months after the initial training course to demonstrate efficacy; as mentioned, this might prove challenging on dairy farms with many immigrant workers.

Moving away from the format of a written pre-and-post assessment as indicators of success and replacing with alternative assessments of OHS program efficacy (changes in SBs, SABs) may be more beneficial for the population of interest. Group-based or community-based approaches as it applies to workers demonstrates significant changes in SBs.[15] SABs are most significant in underserved populations when using peer educators or community health workers.[16] The course format (maybe eventually moving away from iPad video vignettes over time) might need to shift to better evaluate SBs and SABs.

For example, changes in SB could be measured by observing PPE usage compared with a baseline or control group who received iPad training and compared to a group who received training from a trained peer educator or community member[15] in a pilot study. Similarly, changes in SAB could be measured by collecting data about participants' attitudes towards safety at work via surveys (quantitative) or group discussion (qualitative) before and after training, a common method[16] while utilizing iPads for training or expanding upon a more interactive safety training course.

Measuring a reduction in occupational injuries and illness (HOs) should still be considered the gold standard will still be challenging to implement among dairy workers unless health-care delivery and public health programs be tailored to the needs of immigrant workers: this includes legal frameworks that enable health care for migrants.[38]

3) Further utilization of bilingual trainers in "hands-on" training to make the dairy safety course more interactive and thus more tailored to the population of interest. The bilingual trainers in the Worker and Safety Training Course were essential because of the linguistic support provided during the safety training course. Bilingual trainers could (and did) read pre-and-post-test questions aloud to combat barriers of illiteracy among the study population. Additionally, trainers could offer support with content comprehension and stimulate deeper thinking about course questions, in addition to continuing to provide technical and other support during the training course.

Exploration of bilingual trainers in more of a "hands-on" teaching role during the Worker and Safety Training Program should be considered. While utilizing iPads for viewing video vignettes for training is convenient,[12] generally, as training methods became more engaging (i.e., requiring trainees' active participation), workers demonstrated greater knowledge acquisition, and reductions were seen in accidents, illnesses, and injuries.[17] Additionally, changing the course format could enable multiple measures of efficacy. For example, previous research supported that community-based interventions,[39,40] based on discussions and demonstrations supported by field safety promoters, videos, and printed materials (flipcharts and brochures) resulted in both SK *and* SB advancement.[15] Other methods could include playing games to review course content, using visuals, multiple-choice questions with pictures and oral checklists

or hands-on demonstrations[16] to make the course more interactive and potentially improve safety of the workers as well as efficacy measurements.

Conclusion

Continuing to verify the efficacy of the IDA Worker and Safety Training Program curriculum and other OHS training programs is crucial to meeting ultimate course goals: to provide training which prevents and lower the rates of illness and injury in dairy workers. The importance of culturally and linguistically appropriate training for Latinx dairy workers needs to continue to be a priority for occupational health and safety researchers within the dairy industry. Incorporation of worker perspective and having cultural representation in the development of training will in turn more effectively protect workers.[7]

Acknowledgments

Special thank you to the Idaho Dairymen's Association for use of their data and The Northwest Center for Occupational Health and Safety for supporting this research. Thank you also to Brian High of the University of Washington for R coding assistance.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Research reported in this thesis was supported by the National Institute for Occupational Safety and Health (NIOSH) under Federal Training Grant T42OH008433. The content is solely the responsibility of the author and does not necessarily represent the official views of NIOSH.

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APPENDIX

Dairy Safety Questions Pre-Test Questions, English and Spanish

Question	English	Spanish
Question 1	"Cattle feel calmer when:"	"Las vacas están más tranquilas cuando:"
Question 2	"When treating animals for wounds or injections, handlers should make sure to:"	"Al administrar inyecciones o curar heridas, los trabajadores deben de:"
Question 3	"When entering a pen with a bull, an animal handler should:"	"Al entrar al corral de un toro, el trabajador debe de:"
Question 4	"Milkers should always watch out for kicking."	"Los ordeñadores pueden ser pateados por las vacas."
Question 5	"Workers should follow all directions on labels when using chemicals."	"Los trabajadores deben de seguir todas las direcciones en las etiquetas de los productos químicos."
Question 6	"When working with heavy machinery, one should:"	"Cuando el trabajador trabaja con maquinaria pesada debe de:"
Question 7	"Waste lagoons are dangerous because:"	"Las lagunas de desechos pueden ser muy peligrosas porque:"
Question 8	"Good animal handling practices will lead to:"	"Buenas prácticas del manejo del ganado pueden:"
Question 9	"Walking besides a cow, in the same direction, will slow her down."	"Si caminas a lado de la vaca en la misma direccion, ella acelerará su paso."
Question 10	"Cows have good hearing. You shouldn't have to yell, whistle or bang on things to get a cow's attention."	"Las vacas tienen buena audición (oído). No es necesario gritar, chiflar, o golpearlas para tener su atención."
Question 11	"Good animal handling helps build negative associations with cows."	"El buen manejo del ganado crea asociaciones negativas con ellas."
Question 12	"The best way to move a cow is to:"	"La mejor manera de mover una vaca es:"
Question 13	"Handlers should use the ____ to move cows without stressing them."	"Los trabajadores deben de usar la_____ para mover las vacas sin estresarlas."
Question 14	"Needle stick injuries are minor and can NOT be serious."	"Las lesiones por piquetes de agujas son menores y no pueden ser graves."
Question 15	"Preventing needle stick injuries is important. What should you do as an employee?"	"Piquetes con agujas pueden ser muy peligrosos. ¿Qué debe hacer como empleado para prevenir lesiones por piquetes de agujas?"
Dairy Safety Questions Post-Test Questions, English and Spanish		
Question 1	"When moving cattle, handlers should:"	"Al mover vacas en el corral, los trabajadores deben de:"
Question 2	"The flight zone is the animal's personal space or comfort zone."	"La 'zona de fuga' es el espacio personal del animal."
Question 3	"Milkers should avoid being loud in the milking barn."	"Los ordeñadores deben de evitar ser ruidosos en la sala de ordeño?"
Question 4	"Which protective gear should be worn in the milking parlour?"	"¿Qué equipo de protección debe ser usado en la sala de ordeño?"
Question 5	"After working with chemicals workers should … "	"Después de trabajar con químicos peligrosos los trabajadores deben de … "
Question 6	"Workers should be especially careful to:"	"Los trabajadores deben de tener mucho cuidado y … "
Question 7	"When working around silage piles, be aware of the danger of falling debris."	"Cuando trabaje alrededor de las pilas de ensilaje (silo), debe tener cuidado con desechos que pueden caer encima de usted mismo o sus compañeros."
Question 8	"To safety move cattle, you should:"	Para mover el ganado efectivamente, los trabajadores deben de …
Question 9	"How can you move a group of cows?"	"¿Qué técnica puede usar un trabajador para mover un grupo de vacas?"
Question 10	"You can tell you have a cow's attention by:"	"Un trabajador puede confirmar que una vaca le está prestando atención … "

(*Continued*)

(Continued).

Dairy Safety Questions Pre-Test Questions, English and Spanish

Question	English	Spanish
Question 11	"Cattle can see almost 360 degrees around them but have a small blind spot:"	"Las vacas pueden ver casi 360 grados alrededor de ellas, pero tienen un punto ciego … "
Question 12	"For the cow, the milking parlour should be a stress-free and familiar place."	"La sala de ordeño debe ser un lugar libre de estrés para las vacas."
Question 13	"With much practice, good animal handling techniques will become very effective and reduce stress and injuries."	"Aplicándolas cada día, las buenas prácticas del manejo del ganado pueden prevenir estrés y lesiones."
Question 14	"The best way to prevent needle stick injuries is to:"	"La mejor manera de prevenir piquetes con agujas es … "
Question 15	"Needle stick injuries can be very serious, from allergic reactions to hospitalizations. What is one way to prevent this type of injury?"	"Los piquetes con agujas pueden ser muy peligrosos. ¿De qué forma puede un trabajador prevenir este tipo de lesión?"

Responsibilities associated with position in dairy work as described by the Idaho Dairymen's Association

Title	Responsibilities associated with title
Calves	Feeds and cares for young calves
General	Completes a variety of tasks on the dairy (milking, feeding, caring for calves, shop work, operates equipment)
Herdsman	Oversees cows' health, reproduction, & milk production
Maternity	Works with cows that are calving and newborn calves
Milker	Participates in the milking process in the milking parlor
Other	Included various positions constituting less than 20% of participants: Agropur, Books/Owner, Breeder, Calf Manager, Family, Farm, Feeder, Hospital, IDA, Irrigation, Manager, Mechanic, Nutritionist, Office, Pusher, Truck, Veterinarian
Outside	Completes tasks outside the milking barn (feeding, operating equipment, herds cows to the barn for milking, hoof trimming, etc.)
Owner	Owns and manages the dairy operation
Shop	Works on projects involving mechanics & welding (typically in a large shop)

Idaho Dairy Worker Training and Safety Program Curriculum

Part I: General Dairy Farm Safety

- ATV safety
- Cattle flight zone
- Chemical safety
- Eye and ear protection
- Milking barn safety
- Moving cattle safely
- Proper cattle immobilization
- PTO safety
- Safety around bulls
- Electrical safety
- Ergonomics
- Livestock-handling and treatment chutes
- Safety around heavy equipment
- Safety around the silage pile
- Safety in the machine room
- Understanding how cattle see
- Waste lagoon safety
- Working with self-locking stanchions

Part II: Animal Handling Techniques

- **Using Predictable Animal Behavior to Increase Milk Production**
  - Stockmanship (animal handling)
  - Reducing animal stress
  - Positive impacts on cows and handlers
- **How a Cow Uses Her Senses**
  - Sight, hearing, smell as senses
    - Setting the tone for interaction
  - Forming good habits
- **Working with the Pressure Zone**
- Establishing clear directions for cattle
- "Flight Zone" & "Pressure Zone"
- Adjusting pressure & behavior
- **Moving Cows More Effectively**
  - Using the herd-effect
    - Using the blindspot
  - Moving in parallel directions
    - Zig-zag pattern to move herds
- **Making the Milking Parlor a Happy Place**
  - Avoiding loud noises and stress
- **Preventing Needlestick Injuries on Dairy Farms**
    - Seriousness of needlestick injuries
  - Properly administering injections
    - Properly disposing of used needles