



A Case Study of Food Safety Training Delivery Methods in Dairy Processing Plants

ABSTRACT

Computer-based and supervisor-led trainings are the most common approaches to training employees on food safety across the food industry. This study was conducted to evaluate the effect of training format on changes in food safety knowledge, intentions, and compliance. Individualized and group trainings were developed using behaviorism and constructivism learning theories on four food safety topics. The training programs were implemented at 66 dairy processing plants. Pre- and posttest evaluations were received from 793 employees at 22 dairy plants using a validated evaluation method. Data were collected in the form of 14 pre- and posttraining supervisor audits and employee surveys.

Group trainings that involved direct instruction and social learning methods were more effective for increasing knowledge than were individual trainings utilizing programmed instruction. The change in noncompliance associated with receiving training was not significantly different, however, possibly due to the limitations of the study such as the small sample size. Regressions also revealed that

knowledge was a significant positive predictor of compliance, whereas intention was not.

INTRODUCTION

Several studies have been conducted to investigate the relationship between food safety training programs and food safety practices (11–13, 14), and some researchers have observed a gap between food safety knowledge and food safety behaviors or performances (13, 15). In a 2022 global food safety training survey, 88% of respondents indicated “yes” when asked whether they were able to provide the food safety training necessary to drive appropriate, consistent food safety behaviors (7). However, only 40% of the same respondents indicated “yes” when asked whether their employees always follow their food safety program on the plant floor.

Food safety training methods vary from on-the-job training, reading company policies, classroom training delivered by internal managers, classroom training delivered by third party trainers, and computer training (11). The application of learning theories can improve training design

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(4, 11, 15). Direct instruction involves explicit teaching using lectures, whereas programmed instruction uses technology to present structured material in a sequence that allows students to progress through the material at their own speed, and social learning involves learning through observation or imitation of others (17).

This study was conducted to determine the effect of three types of food safety trainings on employee attitudes, personal agency, perceived norms, intention, knowledge, and compliance. Individual e-learning modules, group e-learning modules, and group discussion-based virtual tour trainings were developed and implemented across processing plants of a large dairy company in North America.

METHODS

Training module development

Trainings were developed on four topics: allergen controls, introduction to good manufacturing practices and material controls (GMPs 1), personal responsibility and communicable diseases (GMPs 2), and food defense. Each training module was developed in partnership between an instructional designer and several subject matter experts (including three regional directors of quality, a professor of food science, and a food science graduate student) to ensure that the training material was relevant, effective, and engaging. The modules were designed to take approximately 15 to 25 min to complete. Three training deliveries were evaluated to test three learning theories: direct instruction, programmed instruction, and social and situated learning.

The direct instruction trainings consisted of supervisors or managers guiding a group of employees through the same computer-based training module used in the programmed instruction training. However, these trainings allow employees to interact with each other and with managers to facilitate discussions and questions.

The programmed instruction training was completed by employees individually at their own pace on a company computer at work. It was created using the Articulate Storyline e-learning software (2). Each module began by reviewing the learning outcomes of the module. Each chapter or "page" of the module was accompanied by voiceover narration and had buttons on the bottom of the screen to advance the user to the next page. Each page had graphics or a type of animation requiring user interaction. "Knowledge Check" questions were embedded throughout the module to measure user comprehension, and each module contained 5 to 10 questions. When the questions were answered incorrectly, a narrated page appeared to explain why the chosen answer was incorrect and to inform the user of the correct answer. After completing the computer-based training module, the user's knowledge scores appeared, informing them of whether they had successfully completed the module.

The social and situated learning training consisted of a virtual tour guided by a manager or supervisor and was

performed in a group setting. This training was developed using Panotour virtual tour creation software (8). 360° still images were taken in 10 locations in a dairy processing plant using six GoPro cameras mounted in a Freedom 360 mount. The dairy plant processed both liquid milk and ice cream and therefore was representative of the majority of the company's processing plants, whether those plants processed liquid milk, ice cream, or other dairy products. Each social and situated learning training began in the training room and had a hotspot that opened a 1- to 3-min introductory video or introductory text. Each room within the tour contained hot spots or buttons that could be clicked to reveal informative text and images. Transitional hot spots were also present and allowed the user to progress to the next room or return to the previous room. The social and situated learning trainings were designed to be led by a facilitator, either a plant manager or supervisor, and were accompanied by a facilitator's guide that contained instructions of how to navigate the tour. The facilitator's guide also contained accompanying narration and discussion-based knowledge questions to encourage group engagement and interaction.

Instrument development

The Integrated Behavior Model (IBM) was used to develop a model for predicting participants' intentions to follow food safety best practices based on their knowledge, attitudes, perceived norms, and personal agencies (1). Because no published studies have included measurements of these constructs in the context of the selected training topics, a draft instrument was developed and beta tested. This 15-min instrument measured employees' attitudes, perceived norms, personal agency, intentions, and knowledge regarding the food safety policies of the associated module with a 7-point Likert scale. The instrument was administered to employees immediately before and after the employees experienced the training.

Supervisor observation audits were also used to collect behavioral data by measuring noncompliance twice 1 month before training implementation and twice after the training had been completed. These observation audits were specific to the training topic being assessed and recorded the level of compliance with various food safety policies covered in the training modules.

Data collection

Training programs were implemented at 66 dairy processing plants across the United States that were owned by a large dairy food company. Sixty-seven quality assurance managers and supervisors were trained via a webinar about how to implement the programmed instruction, direct instruction, and social and situated learning trainings and how to proceed in the data collection process. The webinars were designed to explain the differences between the types of trainings provided and instructions on how to perform

each type of training. Each plant was randomly assigned one training topic as the focus of the evaluations in an effort to reduce the extra workload assigned to each facility and the time taken during the training process.

Employees at each plant were offered a pre- and posttest survey, which they were instructed to place in a sealed “ballot box” created by the human resources department. The pretest survey contained the behavioral intentions instrument, and the posttest survey contained both the behavioral intentions instrument and demographic questions. After training at each location had been completed, the human resources manager shipped the box to researchers at North Carolina State University without breaking the seal on the box. All data collection methods and data collection tools were approved by the North Carolina State University Institutional Review Board before the data were collected (protocol 9494).

Pilot testing

The survey instrument was tested during a pilot study before it was used to collect data. The pilot test was performed at a single processing plant. Data were collected from 20 employees using an online form of the survey. Only the allergen control programmed instruction training delivery was evaluated.

Population and sample validation

Because we could not collect from every processing location or every employee from responding processing locations, a regression analysis was performed with response rate and third party (Safe Quality Foods Institute) audit scores to identify any differences in audit scores between

plants that responded and those that did not respond. The presence of such differences could indicate that the data from responding plants were skewed and not representative. A logistic regression analysis was performed to identify any differences between the third party audit scores of plants that completed and returned supervisor audits and those that did not. No significant difference was found between the audit scores of plants that submitted supervisor audits and those that did not ($P = 0.372$) (Table 1).

Data analysis

All pretest IBM construct questions were tested for reliability and validity by calculating the Cronbach’s alpha scores and the principal components scores.

The trainings were implemented at all 66 of the dairy company’s processing plants. Evaluations were assigned and sent to each location. Only 33% ($N = 22$) of all plants mailed in completed employee surveys (Table 1). When considering the number of workers employed at responding plants ($N = 3,620$), the total response rate of completed surveys was 21.9% ($N = 793$). Also, 21.2% ($N = 14$) of all plants responded with completed supervisor audit data (Table 1).

Pre- and posttest knowledge quizzes were sorted to eliminate those that were < 50% complete. Scores of quizzes with $\leq 50\%$ completion were eliminated to control for inaccurate data due to skipped questions while also allowing for the possibility that some questions may be skipped due to lack of knowledge. For each responding plant, posttest noncompliance results were subtracted from pretest noncompliance results to determine the total change in noncompliance.

TABLE 1. Response rate for training evaluation surveys and audit forms

Training topic	Number of plants contacted	Number of plants responded	Plant response rate (%)	Estimated employees contacted	Employee surveys received	Estimated response rate (%)	Supervisor audits received	Supervisor audit response rate (%)
Introduction to good manufacturing practices and material controls	20	9	45.0	1,742	380	21.8	5	25.0
Personal responsibility and communicable diseases	19	6	31.6	791	165	20.9	3	15.8
Allergen control	13	3	23.1	224	99	44.2	4	30.8
Food defense	14	4	28.6	863	224	17.3	2	14.3
Total	66	22	33.3	3,620	793	21.9	14	21.2

Using SPSS software (6), the IBM construct data, knowledge scores, and audit data were tested for normality with a Shapiro-Wilk test, which indicated that all of the data were nonparametric. As a result, all pre- and posttest comparisons of noncompliance, IBM constructs, and knowledge were made using either a Wilcoxon test or a sign test, which compare medians rather than means. Kruskal-Wallis H tests were used to measure the effects of training type, experience, and demographics on changes in compliance and knowledge (6).

RESULTS

Reliability and validity

The Cronbach's alpha score for each construct for each training topic was > 0.7, and the principal components analysis factor loadings were ≥ 0.420 , with only one principal component per factor loading. Therefore, all evaluation questions were deemed reliable and valid (5).

Effect of training on food safety compliance

In aggregate, there was an observed increase in compliance (i.e., decrease in noncompliance) among the 11 plants that

provided supervisor audit data (aggregate pretest median = 0.500, pretest mean = 3.364, posttest median = 0.667, posttest mean = 1.651) (Fig. 1). The significance of each of the statistical analyses was limited because of the small sample sizes. However, when comparing the pre- and posttest average noncompliance results in aggregate, the one-tailed comparison *P*-value was 0.08 for the comparison of the pre- versus posttest aggregate data. Increases in compliance were also observed for the introductory lesson on GMPs and materials controls and food defense but not the lessons on personal responsibility and communicable diseases or allergen controls.

Effect of training on employees' food safety knowledge

There was a significant difference in pretest (median = 75.00, mean = 74.82, standard deviation [SD] = 19.68) and posttest (median = 83.33, mean = 80.06, SD = 18.62) knowledge scores for all training topics analyzed in aggregate ($P < 0.000$) and individually except for allergen controls (Fig. 2).

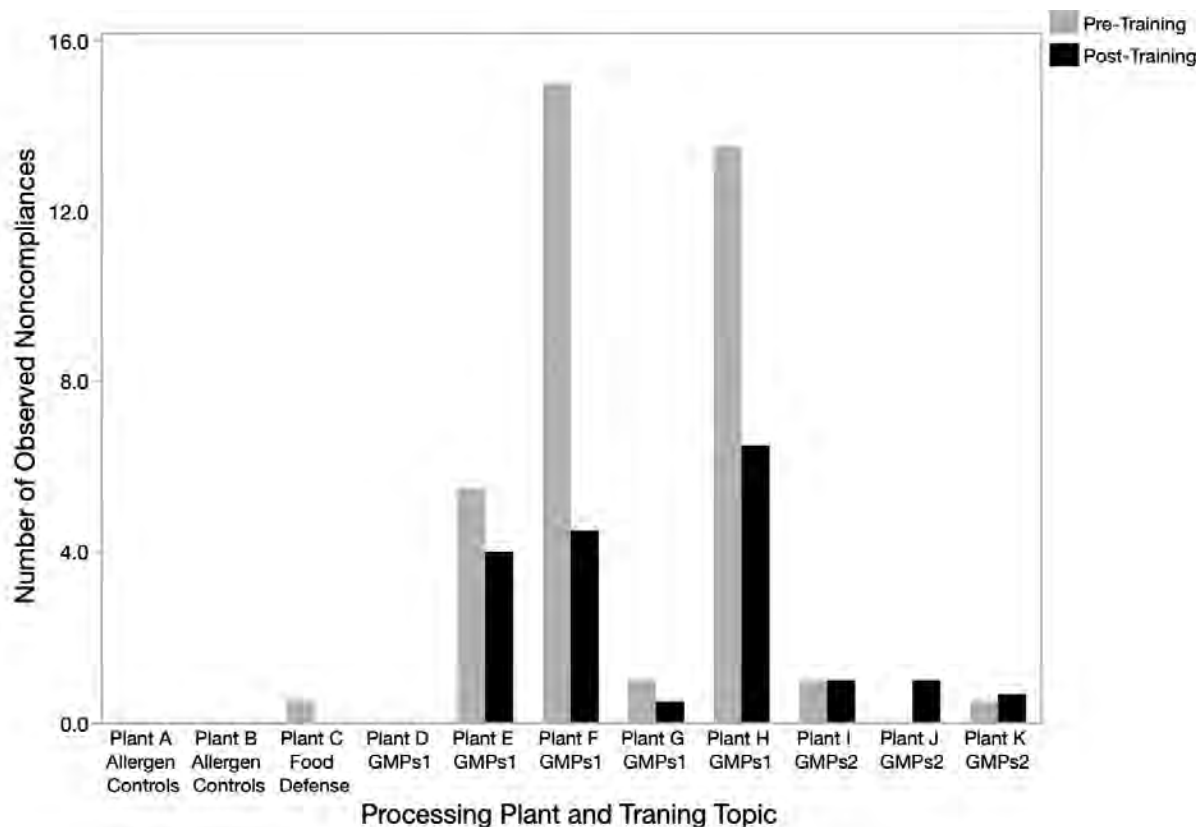


Figure 1. The Effect of Food Safety Training on Observed Noncompliances Across 11 Separate Dairy Processing Facilities. GMPs 1 training covered introduction to good manufacturing practices (GMPs) and material controls. GMPs 2 training covered personal responsibility and communicable diseases.

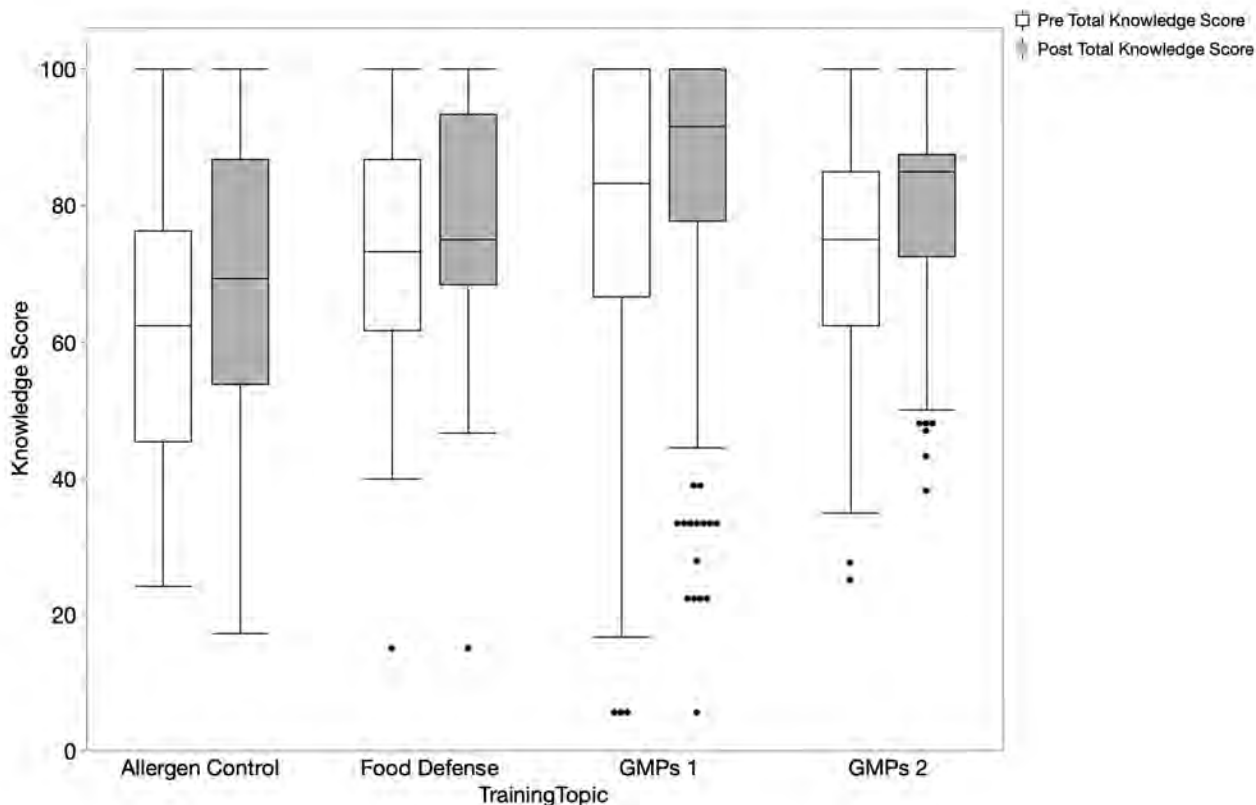


Figure 2. The Effect of Food Safety Training on Knowledge Scores for Aggregate Data and by Training Topic. GMPs 1 training covered introduction to good manufacturing practices (GMPs) and material controls. GMPs 2 training covered personal responsibility and communicable diseases. Box plots with standard error bars are shown.

Effect of training delivery and demographics on employees' food safety knowledge

Overall, there were significant increases in knowledge scores from pre- to posttest for employees who received the social and situated learning ($P = 0.001$) and direct instruction trainings ($P < 0.001$) but not those who received the programmed instruction training ($P > 0.05$) (Fig. 3). Therefore, group training had an effect on employees' knowledge, and individual training did not.

English as a primary language, gender, length of time worked for the company, and ethnicity did not have significant effects on the change in knowledge experienced by employees ($P > 0.05$; data not shown).

Effect of training on change in intentions

In aggregate, there was a significant increase in employee intentions from pretest to posttest ($z = -2.013$, $P = 0.007$) after receiving training. Within the training delivery methods, there was a significant difference in intention for only the direct instruction training from pretest to posttest (Fig. 4). The intentions distributions were negatively skewed (pretest skew = -1.93 , posttest skew = -2.9), and the mode for both the pre- and posttest distribution was 7.

Regressions of intentions and compliance

Pretest attitude, perceived norms, and personal agency explained 37.4% of the variance in pretest intention scores ($F(3, 711) = 142.951$, $P < 0.000$, $R^2 = 0.374$), and each of these constructs were significantly positive predictors of pretest intention (attitude: $B = 0.128$; perceived norm: $B = 0.406$; personal agency: $B = 0.283$; $P < 0.000$) (Fig. 5). No significant effect was found for change in attitudes, personal agency, and perceived norm on change in intentions ($P > 0.05$). When all training topics were analyzed in aggregate, pretest knowledge and intentions explained only 7.8% of the variance in pretest scores. Pretest knowledge was a significant positive predictor of compliance ($B = 0.275$, $P < 0.000$), whereas intentions were not ($P > 0.05$).

Posttest attitude, perceived norms, and personal agency explained 35.7% of the variation in the posttest intention scores (Fig. 6). The individual predictors were examined further and indicated that posttest perceived norm ($B = 0.255$, $P < 0.001$) and personal agency ($B = 0.399$, $P < 0.001$) were significant predictors of intention, but posttest attitude was not ($P > 0.05$). When the training topics were analyzed in aggregate, posttest knowledge and intentions explained

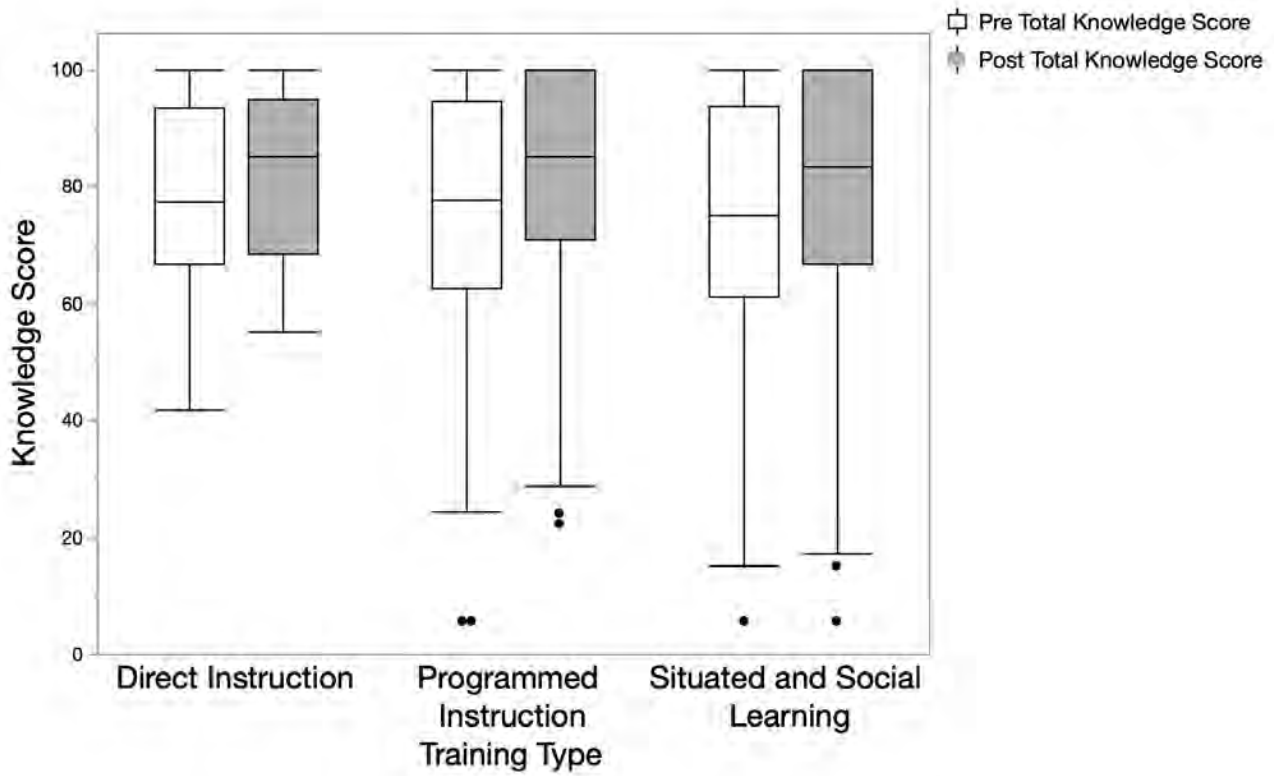


Figure 3. Effect of training delivery on change in aggregate food safety knowledge.

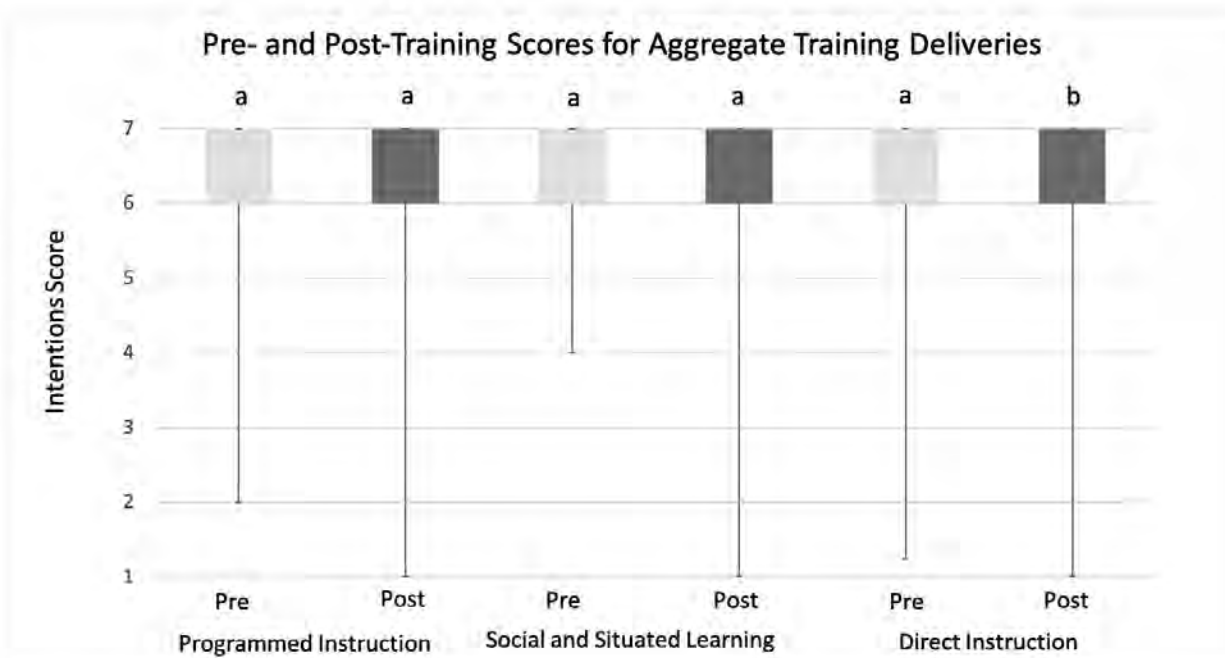


Figure 4. Effect of food safety training delivery on self-reported intentions.

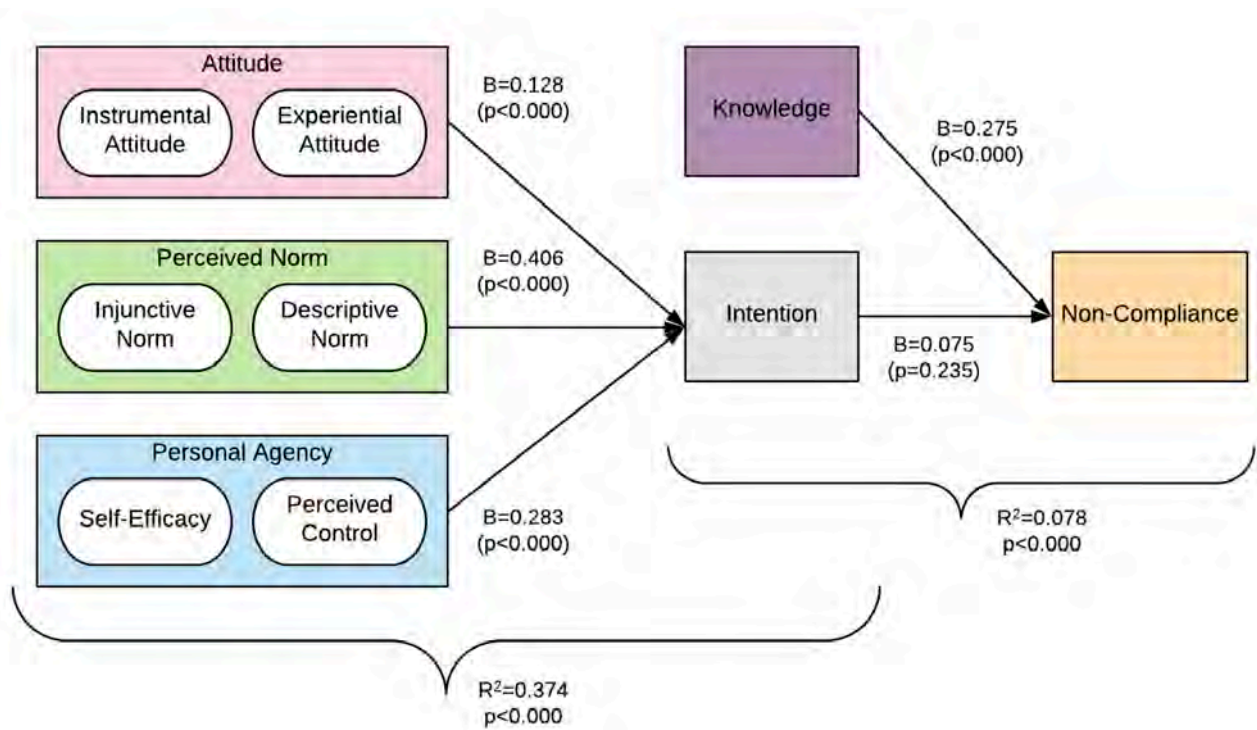


Figure 5. Regression of the integrated behavior model with pretest results. Attitude, perceived norms, personal agency, intentions, and knowledge were measured via employee surveys. Compliance was measured for each site via supervisor audits.

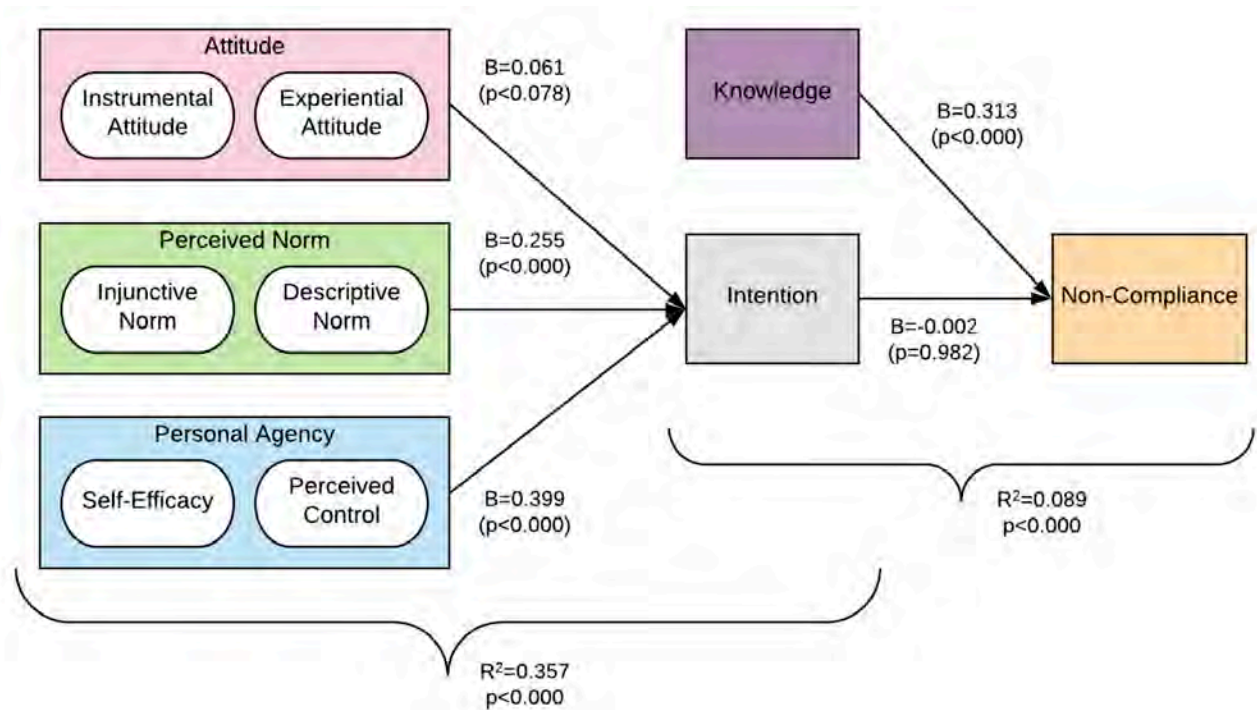


Figure 6. Regression of the integrated behavior model with post-training results. Attitude, perceived norms, personal agency, intentions, and knowledge were measured via employee surveys. Compliance was measured for each site via supervisor audits.

8.9% of the variance in posttest compliance ($R^2 = 0.089$, $P < 0.000$). Posttest knowledge was a significant predictor of compliance ($B = 0.313$; $P < 0.000$), but intention was not.

DISCUSSION

Effect of food safety trainings on compliance

In this case study, training resulted in apparent increases in compliance (i.e., decreases in noncompliance) for criteria associated with the training topics altogether and specifically for the lessons on GMPs 1 and food defense. (Fig. 1). However, with a one-tailed comparison P -value of 0.08 and sample size of eleven processing plants, the significance of this result was marginal, and more audit samples would be needed to provide more confidence in this interpretation of the data. This uncertain relationship between training and compliance has been reported by other researchers. A gap between training and behavior has been reported (1, 3). However, Nieto-Montenegro et al. (11) reported a reduction in rates of noncompliance for several food safety practices in their food safety training assessment study. The results from the present study could be influenced by the lower response rate (responding plants might have lower pretest noncompliance than nonresponding plants), respondent bias (reporting less noncompliance than actually present), or high starting levels of compliance. Each plant that completed supervisor audits did not administer the same type of training to all employees, so comparisons could not be made for the effect of each training on measured compliance within those individual facilities.

Effect of food safety trainings on knowledge

There was a significant increase in knowledge indicated by the aggregate data. This association between a training intervention and an increase in knowledge is consistent with findings from other training assessment studies, although those researchers did not reference learning theories in their work (9, 11, 13). In the comparison between pre- and posttest training knowledge scores, group training was generally more effective for generating knowledge gains. The two group training options (direct instruction and social and situated learning) resulted in significant increases in knowledge as indicated by the aggregate data, but the programmed instruction did not. Because both of the interventions that had significant effects were performed in group settings rather than an individual setting, group training appeared to be more effective than individual training. However, because the experimental design did not directly allow for this comparison, definitive claims comparing group and individual training could not be made. Increased presence of management during training may help convey food safety values of management and the importance of training and allow for discussion between employees and management that could resolve any questions or confusion. Occupational safety leadership had a direct positive effect on safety performance and

indicates that the relationship is mediated by occupational safety culture (16). Another explanation for the knowledge score differences across training delivery methods could be that the knowledge increase scores were biased by the pretest knowledge scores, whereas the posttest knowledge scores were very similar for all training delivery methods (83.33 to 85.00) compared with the pretest knowledge scores (75.00 to 80.00).

The computer-based training events performed in a group setting utilizing direct instruction was more effective than the group discussion-based virtual tour utilizing social and situated learning training in terms of increasing knowledge and intentions. This difference could be due to the fact that the virtual tour training is a new technology that plant operators were unfamiliar with and so might not have been utilized to its fullest potential. Future experiments should compare trainings that are designed on the same platform with different learning theories to determine whether differences in effectiveness are due to the technological platform or the learning theory. The differences also could be due to the fact that the direct instruction module was very structured, whereas deviation and variation was possible in the social and situated learning module. The direct instruction training option was the most effective in terms of knowledge transfer. However, this training option was not designed for this study specifically, and the plant employees administering the training decided to take what was given to them and deliver the training themselves. Thus, these results should be interpreted cautiously. One outside factor that might have affected the performance of the social and situated learning training option is the familiarity of the trainers and employees with the training medium. Virtual reality is still a novel concept, so trainers may not have been comfortable leading the training, despite having received instructions via a webinar.

Effect of food safety trainings on intentions

For the aggregate data, there was a significant increase in food safety intentions after training, but when comparing the three training deliveries, there was only a significant increase for the direct instruction training. Training that incorporates the direct instruction learning theory may have a stronger impact on increasing employee intentions than do the other two learning theories. However, because the distributions for the pre- and posttest intentions were so negatively skewed, we question whether our survey questions led to social positive desirability bias. Thus, it was unclear how accurate these comparisons were.

Mediators of intentions and compliance

There was an overall significant predictive effect of pre- and posttest employee attitudes, perceived norms, and personal agency on employee food safety pre- and posttest intentions for the aggregate data, which was expected based on the

IBM model (1). There was also a significant positive effect of pretest intention and knowledge on pretest compliance for the aggregate data, but this effect was not consistent with the data for any of the individual training topics. Pretest intention and knowledge were significant predictors of pretest compliance ($P < 0.05$), but this regression explained only 7.8% of the variance in the data, suggesting the existence of other external factors affecting employee behaviors. This result contradicts that reported by Ajzen et al (1), who found that knowledge was not a predictor of behavior, and by Mullan et al. (10) and Nummer et al. (13), who commented on the gap between food safety knowledge and behaviors. This contradiction could be due to the fact that those authors observed behavior, whereas observed compliance was recorded in the present study, which is an indirect measure of behavior and could lead to differences in results.

Unlike pretest knowledge and intention, the changes in knowledge and intention were not predictors of changes in compliance. Thus, merely increasing an employee's food safety knowledge during a training intervention may not necessarily lead to an improvement in compliance; instead, the overall knowledge level is related to compliance. This conclusion is supported by the finding of no significant change in compliance after the food safety training. The regression of change in knowledge and intention for predicting change in compliance was also not significant nor were the aggregate data or any of the individual training topics. Observed noncompliance is an indirect measure of behavior and thus does not necessarily fit into the model because the IBM is used to predict behavior (1). A more accurate measurement would have been direct behavioral observations, which were outside the scope and capability of this project.

Because of the limitations of this study, direct behavioral observations could not be made, which affected the accuracy of the compliance data. Although the supervisor audit forms were used to measure compliance to certain standards, observations in the form of video surveillance would have been a more accurate measure. Another limitation of this study was that each manufacturing plant performed training in different ways. Measuring the effect of training on compliance was difficult because data were not received from all employees at each location, and the type of training the majority of employees received in each plant was not known. Future research should consider performing more controlled experiments to specifically measure the effect of various types of training on employee behaviors by administering only one type of training to the employees of a manufacturing location and collecting compliance data over a longer period of time.

CONCLUSION

Significant changes in compliance were not found before and after training, but increases in knowledge were found for the aggregate data and group trainings. Group trainings that incorporated supervisor involvement and implemented the direct instruction and social and situated learning models were consistently the most effective in terms of knowledge gains. Group interaction may make training more engaging and/or more easily customizable by the supervisor to meet the needs of their employees. This finding supports the argument against individual distant-based training, which by design can be less engaging and customizable. These data also indicate that depending on the objective of the training program (e.g., increasing food safety knowledge and/or changing intentions) one training design may be better than others.

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