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6200 Aurora Ave., Suite 200W, Des Moines, IA 50322-2864

Food Safety Training and Foodservice Employees' Knowledge and Behavior

KEVIN R. ROBERTS,[1]* BETSY B. BARRETT,[1] AMBER D. HOWELLS,[1] CAROL W. SHANKLIN,[1] VALERIE K. PILLING[2] and LAURA A. BRANNON[2]

[1]Kansas State University, 104 Justin Hall, Manhattan, KS 66506, USA; [2]Kansas State University, 492 Bluemont Hall, Manhattan, KS 66506, USA

SUMMARY

Statistics show that 59% of foodborne illnesses are traced to restaurant operations. Food safety training has been identified as a way to assure public health, yet evidence supporting the effectiveness of training has been inconclusive. A systematic random sample of 31 restaurants in three midwestern states was selected to assess the effect of training on food safety knowledge and behavior. A total of 402 employees (242 pre-training and 160 post-training) participated in this study. Pre- and post-training assessments were conducted on knowledge and behavior related to three key food safety practices: cross contamination, poor personal hygiene, and time/temperature abuse. Overall knowledge ($P \leq .05$) and compliance with standards of behavior ($P \leq .001$) improved significantly between pre- and post-training. When each practice was examined independently, only handwashing knowledge ($P \leq .001$) and behavior ($P \leq .001$) significantly improved. Results indicated that training can improve knowledge and behaviors, but knowledge alone does not always improve behaviors.

INTRODUCTION

The United States has one of the safest food supplies in the world. However, food safety has again come to the forefront in the past year with outbreaks of *Escherichia coli* O157:H7, including two associated with lettuce consumed at Mexican restaurants in the midwestern and northeastern United States *(5)*. This attention has caused many consumers to doubt the safety of food served in restaurants and other institutions *(2, 14)*.

Foodborne illness prevention is a significant concern and a public health priority in the United States. Yet, foodborne illnesses remain prevalent, and in spite of the positive strides made in commercial eating establishments, a significant proportion of foodborne illness cases are traced back to restaurants *(9, 10, 22)*. In 2005, 59% of foodborne illness outbreaks reported to FoodNet were associated with restaurants *(4)*.

The top five risk factors of foodborne outbreaks in foodservice operations include improper holding temperatures, inadequate cooking, contaminated equipment, purchase and receipt of food from unsafe sources, and poor personal hygiene. These are all directly related to food handler error and can be prevented if food handlers follow proper food safety practices *(12, 13, 15)*.

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*Author for correspondence: 785.532.2399; Fax: 785.532.5522
E-mail: roberts@humec.ksu.edu

In 1998, the Food and Drug Administration (FDA) *(12)* conducted a study to ascertain the rate at which food handlers were in-compliance with standards established in the Food Code (*11)*. The FDA (*12)* found that only 60% and 74% of quick-service and full-service restaurants, respectively, were in compliance with identified standards *(12)*. Compliance rates in the restaurant industry were lower than those in hospitals (80%), nursing homes (82%), and elementary schools (80%). The lowest compliance rates in restaurants were related to cross contamination (70%), improper holding/time-temperatures (67%), and poor personal hygiene (55%), all of which have been identified as the most frequently implicated factors in foodborne illness outbreaks *(3, 7, 20)*. A follow-up study by the FDA *(13)* found that scores across the six risk factors had improved only 1.4% in full-service restaurants and had not changed in quick-service restaurants.

Researchers have reported that food safety training is effective in increasing sanitation inspection scores *(8, 17)*, the microbiological quality of food *(6)*, and self-reported changes in food safety practices *(19)*. However, research has found that foodservice managers and employees receiving training on proper food handling practices and obtaining adequate food safety knowledge does not always translate into improved behaviors (e.g., *16, 18, 23*).

Wright and Feun *(23)* evaluated the effect of foodservice manager certification on inspection scores. They found no significant improvements in knowledge scores between pre- and post-tests, whether the post-tests were administered immediately following the program or six months later. Mathias et al. *(18)* compared the inspection violations for foodservice establishments with varying numbers of food handlers who were educated in food safety or not. Results indicated that the number of food handlers trained in food safety had no significant effect on food safety inspection violations.

Little research has been conducted exploring actual behavior of foodservice employees before and after food safety training. The purpose of this study was to determine if food safety knowledge and behaviors among employees improved as a result of taking a four-hour food safety training class based on ServSafe®.

METHODOLOGY

The population for this study was food handlers in commercial independent and chain restaurants licensed to sell food in Kansas, Missouri, and Iowa. Because of budgetary limitations, to qualify for the sample, operations had to be located within 300 miles of the research university. Kansas and Iowa restaurants were chosen from a state agency listing of licensed operations. For Missouri, the telephone directory was used to obtain the names of operations, because the state has no licensing system. Using a systematic random sample, 1,298 restaurant managers were called to request that they participate in the study. In return for their participation, managers were offered free food safety training for their production employees.

Prior to training, employees were asked to complete a 54-item knowledge assessment targeting the three main behaviors that contribute to foodborne illness. The assessment included three questions for each of the three behaviors: cross contamination (properly handling food and work surfaces), time and temperature abuse (use of thermometers), and personal hygiene (handwashing). Each of the nine multiple choice questions had six response options. Respondents were asked to circle all answers within each question they believed to be correct. If an employee circled a response that was correct, that item was coded with a 1. If the response circled was incorrect, the item was coded as a 0. Thus, the mean of each of the 54 individual knowledge items could range from 0 to 1, with an overall composite score of 54 possible. All of the questions within each behavioral category were then combined for possible composite scores of 18. For example, if a respondent answered 13 handwashing questions correctly, his or her composite handwashing score would be 13.

After the knowledge assessment was completed, trained researchers observed each employee in a three-hour period during a lunch or dinner work shift, using a validated restaurant food safety observation form *(21)*. This form included nine behaviors for properly handling food and work surfaces, six for thermometer use, and 16 for handwashing (10 for when to wash hands and six for how to wash hands). During observations, researchers recorded whether these behaviors were performed correctly or incorrectly. For each of the 31 specific behaviors, the number of occasions that behavior was performed correctly was divided by the total number of observations of that behavior to obtain a percentage of behaviors performed correctly. As an example, if researchers observed an employee washing his or her hands prior to using gloves on two occasions and observed the employee not doing so on three other occasions, the total number of observations would be five, making the percentage of behaviors performed correctly 40%. Composite percentages also were calculated for each of the three broad behaviors (handwashing, handling of food/cleaning and sanitizing, and thermometer use) to represent the extent to which the three behaviors were performed properly.

Following the initial knowledge assessment and observations, employees attended a four-hour ServSafe® class in which the ServSafe® Employee Guide and supporting materials were used. Following the training, employees completed the same knowledge assessment they had completed prior to training and then were observed in the restaurant operation while using the same research procedures.

Through use of SPSS for Windows 11.5, descriptive statistics (frequencies, means, and standard deviations) and independent samples t-tests were used to analyze the data. Reliability analysis was conducted for both the pre-training and post-training knowledge assessment questions, yielding an alpha coefficient of .70 and .75, respectively. Simple linear regression was used to analyze relationships among variables. The type I error rate for all comparisons was set at .05.

RESULTS

Response rate

Of the 1,298 restaurant managers contacted, 31 restaurant managers agreed to participate and completed this phase of the project, yielding 242 employees who completed the pre-training assessment. Due to employee turnover and dropouts, 160 employees were trained and completed the post-training knowledge assessment and observation period.

TABLE 1. Characteristics of employees

Characteristic	n (%[a]) Total (n=402)	Pre-Training (n=242)	Post-Training (n=160)	Characteristic	n (%[a]) Total (n=402)	Pre-Training (n=242)	Post-Training (n=160)
Age				**Education**			
25 years or younger	175 (43.5)	95 (39.3)	80 (50.0)	Less than High School	68 (17.0)	39 (16.1)	29 (18.1)
26 – 35 years	79 (19.7)	43 (17.8)	36 (14.9)	High School Graduate	119 (29.6)	65 (26.9)	54 (33.8)
36 – 45 years	42 (10.5)	27 (11.2)	15 (9.4)	Some College	79 (19.7)	45 (18.6)	34 (21.2)
45 years or older	24 (6.0)	15 (6.2)	9 (5.6)	Associate's Degree	28 (7.0)	17 (7.0)	11 (6.9)
				Bachelor's Degree	24 (6.0)	13 (5.4)	11 (6.9)
Gender							
Male	225 (56.0)	128 (52.9)	97 (60.6)	**Hours Worked/Week**			
Female	109 (27.1)	59 (24.4)	50 (31.3)	Less than 20	36 (9.0)	19 (7.8)	17 (10.6)
				20 – 39	159 (39.6)	93 (38.4)	66 (41.3)
Years of Experience in the Foodservice Industry				40 - 59	95 (23.6)	51 (21.1)	44 (27.5)
				60 – 79	24 (6.0)	13 (5.4)	11 (6.9)
Less than 1 year	37 (9.2)	20 (8.2)	17 (10.6)	80 or more	1 (0.3)	0 (0)	1 (0.6)
1 – 5 years	123 (30.6)	73 (30.1)	50 (31.3)				
6 – 10 years	80 (19.9)	43 (17.8)	37 (23.1)	**Food Safety Certified**			
11 – 15 years	26 (6.5)	13 (5.3)	13 (8.1)	Yes	110 (27.4)	63 (26.0)	47 (29.4)
16 – 20 years	19 (4.7)	12 (4.9)	7 (4.4)	ServSafe®	84 (20.9)	45 (18.6)	39 (24.4)
21 years or longer	19 (4.7)	10 (4.1)	9 (5.6)	Serving-it-Safe	12 (3.0)	6 (2.5)	6 (3.8)
				Other	11 (2.7)	9 (3.7)	2 (1.2)
Years in Current Position				No	206 (51.2)	113 (46.7)	93 (58.1)
Less than 1 year	163 (40.6)	95 (39.3)	68 (42.5)				
1 – 5 years	117 (29.1)	61 (25.2)	56 (35.0)				
6 – 10 years	16 (4.0)	7 (2.9)	9 (5.6)				
11 – 15 years	4 (1.0)	2 (0.8)	2 (1.2)				
16 – 20 years	1 (0.3)	1 (0.4)	0 (0)				
21 years or longer	6 (1.5)	4 (1.7)	2 (1.3)				

[a] Percentages may not total 100% due to non-responses

TABLE 2. Comparison of pre- and post-training knowledge composite scores

Category	Mean Correct ± SD[a] Pre-Training[b] (n = 177)	Post-Training[b] (n = 146)
Cross contamination	14.0 ± 2.05	14.0 ± 2.60
Handwashing	15.2 ± 2.14	16.3 ± 1.86**
When to wash hands	5.4 ± .79	5.5 ± .80
How to wash hands	9.8 ± 1.74	10.7 ± 1.30*
Use of thermometers	13.6 ± 2.55	13.9 ± 2.47
Overall knowledge	42.8 ± 5.1	44.1 ± 5.3*

[a] Mean Number of Items Correct ± Standard Deviation

[b] Responses were coded on a two point scale with 0 for incorrect responses; and 1 for correct responses; a perfect score would be 54, or for each practice (cross contamination, handwashing, or use of thermometers) 18. For when to wash hands, a perfect score was 6, for how to wash hands 12.

*$P \leq .05$

**$P \leq .001$

Employee characteristics

Characteristics of employees who participated in the project are presented in Table 1. The majority of employees were male (56.0%). The age of employees ranged from 15 to 79, with a mean of 28 years. Employees had worked an average of 7.6 years in the foodservice industry and an average 2.3 years in their current position. The majority of employees (69.4%) worked more than 20 hours per week.

Knowledge

Independent samples t-tests were conducted to assess the effect of food safety training on knowledge. Overall, knowledge scores increased significantly between the pre- (M = 42.8, SD = 5.1) and post-training (M = 44.1, SD = 5.3) assessments ($P \leq .05$). When the mean composite scores for the separate categories were compared between pre-and post-training, knowledge increased significantly only for the handwashing composite score ($P \leq .001$) (Table 2). Within the handwashing assessment questions, the composite score for questions just related to how to wash hands improved significantly ($P \leq .001$). However, questions related to when to wash hands did not improve significantly.

The number of correct responses for several individual questions within each behavioral category increased significantly between pre- and post-training assessments (Table 3). Despite having attended the food safety training class that included discussion of correct food safety practices about food handling and cleaning and sanitizing work surfaces, employees' scores decreased for individual knowledge questions related to ensuring sanitation of work cutting surfaces ($P \leq .05$) and washing hands when working in food production ($P \leq .001$). However, significant improvement was found in knowledge scores for cleaning and sanitizing surfaces between each food preparation task ($P \leq .05$). Additionally, after training, more employees correctly answered the questions related to cleaning work surfaces every two hours when performing the same food preparation task ($P \leq .05$) and minimizing raw food contact with bare hands when food will be cooked ($P \leq .05$).

For knowledge questions related to thermometer use, scores improved in knowing that cold food is to be held at 41°F or lower ($P \leq .05$), that hot food is to be held above 135°F ($P \leq .001$), and that a thermometer should be used to check the temperature of foods when it is reheated ($P \leq .05$). More employees also correctly responded that baked goods need not be held above 70°F ($P \leq .05$) to ensure food safety. Significant decreases were found for questions related to improper thermometer usage, including the question on tasting as an acceptable way to assure the food is done ($P \leq .001$) and the question on whether one would need to measure the temperature of food prior to cooking ($P \leq .001$). These findings may be a concern to trainers, given that employees were taught that tasting is not an acceptable method for ensuring that food is cooked.

For handwashing questions, employees' knowledge had improved after training for understanding that shaking hands vigorously is not a proper drying method ($P < .05$). Scores showed that respondents had learned that 20 seconds ($P \leq .05$) rather than 15 seconds ($P \leq .001$) is necessary for proper handwashing, and that warm water should not be used to wash hands ($P \leq .001$) (hands should be washed with hot water). Also, scores showed that trainees understood that using a hand sanitizer ($P \leq .05$) is not necessary for proper handwashing. As for when to wash hands, the one factor for which the score did improve significantly was ensuring that hands are washed before glove usage ($P \leq .001$).

Simple linear regression was used to examine the relationship between the post-training total knowledge score (dependent variable) and the employees' characteristics – gender, age, education, certification, years of experience, and hours worked per week – as the independent variables. The stepwise regression model showed that the overall model was significant ($F = 14.798$, $P \leq .001$). The significant independent variable in the model was the employees' educational level (ß = .334, $P \leq .001$); as an employee's educational level increased, so did his or her food safety knowledge.

Behaviors

Independent samples t-tests were conducted to assess the effect of food safety training on behavioral compliance. The overall percentage of behaviors performed correctly across the three behavioral categories increased significantly between pre-training and post-training ($P \leq .001$). When the composite mean percentages of each behavioral category were examined independently, only the behavioral composite related to handwashing increased significantly ($P \leq .001$) (Table 4). Specific behaviors for which a significant improvement was observed included washing hands at designated times to reduce cross contamination ($P \leq .001$) and using the correct handwashing procedure ($P \leq .05$).

Several individual behaviors observed showed significant improvement between pre- and post-training observations (Table 5). For properly handling food and work surfaces, significant improvements were made in assuring that food contact surfaces were clean ($P \leq .05$) and storing sanitizing cloths in a sanitizing solution ($P \leq .05$). No significant improvements on individual items for thermometer use were found, as thermometers were often not available for employees to use, which is a concern because such unavailability is a health code violation. However, for handwashing, all employees in the post-training observations washed their hands at the beginning of the shift ($P \leq .001$), compared to the initial observations in which only 62.5% of employees did so. Significant improvements also were noted in washing hands before putting on gloves ($P \leq .001$), after handling raw food ($P \leq .05$) or chemicals ($P \leq .001$), and when food preparation tasks were interrupted or changed ($P \leq .05$). Within handwashing procedures, employees improved on washing hands for 20 seconds ($P \leq .05$), washing their arms above their wrists ($P \leq .001$), cleaning between fingers ($P \leq .001$), and drying their hands with a single-use paper towel or warm-air hand dryer ($P \leq .05$).

Simple linear regression was used to examine the relationship between the employees' post-training behavior composite score (dependent variable) and total knowledge score (independent variable). The regression model showed that there was a significant ($F = 4.266$, $P \leq .05$) positive relationship between the two. Further analysis determined that none of the post-training knowledge scores influenced their corresponding post-training behaviors in any of the three behavioral categories. In other words, general knowledge is related

TABLE 3. Comparison of pre- and post-training knowledge scores

Questions[a] – Food Handling, Cleaning and Sanitizing Work Surfaces	Mean % Correct ± SD Pre-Training (n=177)	Mean % Correct ± SD Post-Training (n=146)	% Change in Mean
1. Which of these things should be cleaned and sanitized when working in the food preparation area?			
A. Cutting surfaces*	99.4 ± 7.6	94.9 ± 22.0	-4.5
B. Hands*	99.4 ± 7.7	92.0 ± 27.1	-7.4**
C. Utensils*	97.1 ± 16.9	94.9 ± 22.0	-2.2
D. Countertops*	93.5 ± 24.6	92.0 ± 27.2	-1.5
E. Floors*	61.8 ± 48.7	55.0 ± 49.9	-6.8
F. Stovetops*	76.5 ± 42.5	73.1 ± 44.5	-3.4
2. Food surfaces should be cleaned and sanitized at which of the following times?			
A. Before preparing foods*	91.8 ± 27.6	87.0 ± 33.8	-4.8
B. When switching from one food preparation task to another*	84.7 ± 36.1	95.6 ± 20.5	10.9**
C. Between each food preparation task*	80.6 ± 39.6	89.1 ± 31.2	8.5*
D. When they become contaminated*	77.7 ± 41.8	79.7 ± 40.4	2
E. When only working with ready-to-eat foods	78.2 ± 41.4	77.6 ± 41.9	-0.6
F. Every 2 hours when performing the same food preparation task	45.3 ± 49.9	56.5 ± 49.7	11.2*
3. Raw foods that will be cooked before serving should not come into contact with which of the following?			
A. Ready-to-eat foods*	94.7 ± 22.5	94.2 ± 23.4	-0.5
B. Floor*	87.7 ± 33.0	81.8 ± 38.7	-5.9
C. Utensils	66.5 ± 47.3	71.7 ± 45.1	5.2
D. Other raw foods*	67.0 ± 47.1	64.5 ± 48.0	-2.5
E. Countertops	53.5 ± 50.0	52.9 ± 50.1	-0.6
F. Bare hand	36.4 ± 48.2	54.4 ± 50.0	18**
Questions[a] – Use of Thermometers			
4. Which of the following temperatures are correct for food preparation?			
A. Cold food is held below 41°F*	89.4 ± 30.9	95.7 ± 20.5	6.3*
B. Food is reheated to 165°F*	81.2 ± 39.2	84.8 ± 36.1	3.6
C. Baked goods are held above 70°F	72.4 ± 44.9	81.9 ± 38.6	9.5*
D. Beverages are held below 50°F	68.8 ± 46.5	76.1 ± 42.8	7.3
E. Hot food is held above 135°F*	65.3 ± 47.7	86.2 ± 34.6	20.9**
F. Ice must be below 0°F	65.9 ± 47.6	64.5 ± 48.0	-1.4
5. To properly check the temperature of food, which of the following should be done?			
A. Taste it to see if it tastes right	97.1 ± 16.9	86.2 ± 34.6	-10.9**
B. Use a calibrated, sanitized thermometer*	95.8 ± 19.9	96.4 ± 18.8	0.6
C. Touch it to see that it is hot enough	95.3 ± 21.2	94.2 ± 23.5	-1.1
D. Look at it to make sure it is the right color	79.4 ± 40.5	70.3 ± 45.9	-9.1
E. Check the center of the food rather than the surface*	66.5 ± 47.3	71.0 ± 45.5	4.5
F. Make sure it has been cooking for the correct amount of time	55.3 ± 49.9	50.0 ± 50.2	-5.3
6. When should a thermometer be used to check the temperature of food? (Circle all that apply.)			
A. At the completion of cooking*	88.2 ± 32.3	89.8 ± 30.3	1.6
B. Prior to cooking	81.2 ± 39.2	63.0 ± 48.5	-18.2**
C. After reheating*	71.2 ± 45.4	85.5 ± 35.3	14.3*
D. On the hotline*	66.5 ± 47.3	68.8 ± 46.5	2.3
E. On the coldline*	65.8 ± 47.5	66.7 ± 47.3	0.9
F. At the midpoint in cooking	56.5 ± 49.7	55.0 ± 49.9	-1.5

TABLE 3. *(Continued)* Comparison of pre- and post-training knowledge scores

Questions[a] – Handwashing	Mean % Correct ± SD Pre-Training (n=177)	Mean % Correct ± SD Post-Training (n=146)	% Change in Mean
7. After handwashing, hands should be dried:			
A. With a single use paper towel*	98.8 ± 10.8	98.5 ± 11.9	-0.3
B. On pants	98.2 ± 13.2	100.0 ± 0.00	1.8
C. With an apron	95.8 ± 19.9	99.3 ± 8.5	3.5
D. With a common towel	90.6 ± 29.3	93.5 ± 24.8	2.9
E. By shaking vigorously	90.6 ± 29.3	95.7 ± 20.5	5.1
F. With an air dryer*	67.7 ± 46.9	55.8 ± 49.8	-11.9*
8. Which of the following are necessary for proper handwashing?			
A. Soap*	99.4 ± 81.0	94.9 ± 22.0	-4.5
B. 20 seconds*	87.7 ± 33.0	96.4 ± 18.8	8.7*
C. 15 seconds	87.0 ± 33.7	96.4 ± 18.8	9.4*
D. Hot water*	72.4 ± 44.8	86.2 ± 34.6	13.8*
E. Warm water	57.7 ± 49.6	81.9 ± 38.7	24.2**
F. Hand sanitizer	40.0 ± 49.1	73.9 ± 44.1	33.9**
9. Hands should be washed for food safety purposes in which of the following circumstances?			
A. After going to the restroom*	98.2 ± 13.2	96.4 ± 18.8	-1.8
B. Before work*	97.1 ± 16.9	96.4 ± 18.8	-0.7
C. After touching body parts*	95.8 ± 21.9	96.4 ± 18.8	0.6
D. When switching food preparation tasks*	90.0 ± 30.1	94.9 ± 22.0	4.9
E. Before putting on gloves*	82.9 ± 37.7	94.2 ± 23.5	11.3*
F. Before going to the bathroom	70.6 ± 45.7	73.2 ± 44.5	2.6

[a]Respondents were asked to circle all responses that were correct for each question.

*$P \leq .05$

**$P \leq .001$

*Denotes that the item was correct if circled.

TABLE 4. Comparison of pre- and post-training behavior composite scores

Category	N Pre-Training	N Post-Training	Mean % Correct ± SD[a] Pre-Training[b]	Mean % Correct ± SD[a] Post-Training[b]
Cross contamination	186	91	60.4 ± 33.5	65.8 ± 32.8
Handwashing	208	98	31.2 ± 24.5	45.5 ± 25.0**
When to wash hands	212	98	24.5 ± 25.7	35.2 ± 28.8**
How to wash hands	174	94	53.0 ± 27.5	62.3 ± 23.7*
Use of thermometers	70	35	19.8 ± 35.9	24.5 ± 38.1
Overall food safety compliance[c]	208	98	36.8 ± 22.8	47.2 ± 23.8**

[a]Mean Percentage of Behaviors Performed Correctly ± Standard Deviation.
[b]Behaviors were coded as done either correctly or incorrectly. The number of behaviors performed correctly was divided by total number of behaviors observed to calculate the percent of behaviors performed correctly.
[c]Overall food safety compliance is a composite of the three behavioral categories.
*$P \leq .05$
**$P \leq .001$

TABLE 5. Pre- and post-training comparison of behavioral compliance percentages

Observed Activity	N		Mean % Correct ± SD[a]	
	Pre-Training	Post-Training	Pre-Training[b]	Post-Training[b]
Food Handling, Cleaning and Sanitizing				
Leftovers labeled & dated (check anything over 7 days old)	3	0	100.0 ± 00.0	--
Separate raw products from cooked and ready-to-eat products	24	5	83.3 ± 38.1	80.0 ± 44.7
Food contact surfaces are free of dust, dirt, and food particles	143	67	79.1 ± 34.1	88.9 ± 24.2*
Food is covered and labeled properly before holding or storing	76	42	78.6 ± 36.9	87.2 ± 31.5
Food is covered when transported	84	32	68.9 ± 42.6	54.7 ± 46.4
Wiping cloths are stored in a sanitizing solution	72	25	69.4 ± 44.8	88.0 ± 33.2*
Separate wiping cloths are used for food and nonfood surfaces	31	6	38.7 ± 49.5	66.7 ± 51.6
All food-contact surfaces must be washed, rinsed, and sanitized anytime the type of food or ingredients are switched	88	44	23.2 ± 38.6	28.5 ± 37.4
All food-contact surfaces must be washed, rinsed, and sanitized after touching anything that might contaminate the food contact surface	84	34	15.1 ± 33.9	27.3 ± 42.4
Thermometers				
Food stored on the hot line is at least 135°F	4	2	100.0 ± 0.0	100.0 ± 0.0
Food stored on the cold line is 41°F or less	3	4	66.7 ± 57.7	87.5 ± 25.0
Check internal temperature of food by inserting the thermometer stem or probe into the thickest part of the product	16	7	64.6 ± 47.9	71.4 ± 48.8
Wash, rinse, sanitize, and air-dry before and after use	12	10	33.3 ± 49.2	30.0 ± 48.3
Check temperature of food at the completion of cooking	60	29	14.7 ± 34.3	21.2 ± 41.0
Check temperature of food at the completion of reheating	15	5	13.3 ± 35.2	20.0 ± 44.7
Handwashing				
When shift begins	40	15	62.5 ± 49.0	100 ± 00**
Returning to the work area (after smoking, eating, chewing gum or tobacco, bussing dirty dishes, or using the restroom)	165	68	47.8 ± 40.4	50.2 ± 42.3
Before putting on clean gloves	148	78	41.5 ± 36.9	57.8 ± 35.0**
When food preparation tasks are interrupted or changed	162	65	37.4 ± 38.9	54.0 ± 385*
Handling chemicals that might contaminate food	50	21	18.8 ± 37.0	66.7 ± 42.8**
Handling raw food (before and after)	91	41	15.9 ± 31.0	34.7 ± 39.2*
Touching anything else that may contaminate hands, such as unsanitized equipment, work surfaces, cleaning cloths, and drinking straw	189	74	10.8 ± 22.7	17.1 ± 24.2
Sneezing, coughing, or using a handkerchief or tissue	18	4	11.1 ± 27.4	25.0 ± 50.0
Touching body parts (hair, face, or body)	106	31	4.8 ± 18.3	17.7 ± 36.7
Touching clothing or aprons	149	67	1.1 ± 5.6	2.5 ± 12.9
Hand Washing Procedure				
Dry hands and arms with a single-use paper towel or warm-air hand dryer	172	94	93.3 ± 21.2	98.9 ± 8.9*
Rinse thoroughly under running water	173	94	93.1 ± 24.2	95.3 ± 16.8
Clean between fingers	173	94	44.1 ± 44.5	65.1 ± 39.7**
Vigorously scrub hands for at least 20 seconds	173	94	35.6 ± 43.3	51.7 ± 41.1*
Vigorously scrub arms above wrists for at least 20 seconds	173	94	27.9 ± 40.1	45.6 ± 41.0**
Clean under fingernails	173	94	22.1 ± 40.2	17.3 ± 34.5

[a] Mean Percentage of Behaviors Performed Correctly ± Standard Deviation

[b] Behaviors were coded as either done correctly or incorrectly. The number of behaviors performed correctly was divided by total number of behaviors observed to calculate the percent of behaviors performed correctly.

* $P \leq .05$

** $P \leq .001$

to general behavior, but no individual behavior is driving the relationship more than others.

CONCLUSIONS AND APPLICATIONS

The results of this study found that overall behavioral compliance remained low even after food safety training. For several behaviors, the mean was fairly high in the pre-test (e.g., leftovers labeled and dated, food stored on the hot line is at least 135ºF) so there was not significant room for improvement. However, even those behaviors with low compliance scores during the pre-training observation (e.g., check internal temperature of food by inserting the thermometer stem or probe into the thickest part of the product), which could have improved substantially, did not. Results did indicate that food safety training had a significant influence on employees' overall handwashing knowledge and behaviors but had little impact on overall cross contamination and thermometer use. These results may be due to the training, which used a hands-on Glo Germ® demonstration to emphasize the importance of handwashing but which had no hands-on activities related to thermometer use and properly handling of food and work surfaces. Also, employees had greater prior knowledge of handwashing, and the training may have reinforced that preexisting knowledge. For thermometers, employees often did not have thermometers to use, which would inhibit their behaviors. It was interesting to note that even though employees' knowledge scores related to washing hands after they had become contaminated were very high in both pre- and post-training assessments, these high scores did not influence the behaviors of the employees.

For properly handling food and work surfaces, scores for only three of the 18 knowledge items and two of the nine behaviors increased significantly. The behavior in lowest compliance after training was the one related to the requirement that all food contact surfaces must be washed, rinsed, and sanitized; only 28% of employees correctly performed this task. This behavior item had high knowledge means. For use of thermometers, again, three knowledge items were significantly higher and two items significantly lower for post training. The behaviors observed out-of-compliance most often were checking food at the completion of cooking (21%) or reheating (20%). These behavior items had knowledge score means between .90 ± .30 and .86 ± .35, respectively.

This study illustrates that training can have a significant impact on improving knowledge and behaviors. Yet, increasing knowledge does not ensure that behaviors will change, as demonstrated by the high scores on knowledge and low percentages on corresponding behaviors. Therefore, knowledge alone is not sufficient to bring about changes in behavior. These results support the findings of Mathias et al. *(18)* and Wright and Feun *(23)*. Traditionally, food safety training has focused on increasing knowledge, but more emphasis should be placed on why the behavior should be changed. Clearly, trainers and training programs may be improved by targeting factors rather than just increasing knowledge to change behaviors. The current study indicates that an increase in knowledge does not necessarily mean that a change in behavior will take place.

Whether in a formal food safety class or while conducting inspections, it is imperative that sanitarians not only educate the managers and employees on proper techniques but also on why proper food safety practices must be followed. Key information about food-safety related outbreaks in the area and the consequences for the operation that caused the outbreak could be shared with the managers and employees in the form of newsletters and fliers. This may be more persuasive than what is currently given in formal training and might be enough to bring about a change in behavior.

A primary limitation of this research is the number of restaurants willing to participate in this study. Based on the number of calls (1,298) and the number of participating restaurants (31), the response rate was 2.4%. It was difficult to get restaurant managers to participate in a lengthy research process, even though free employee-paid food safety training was offered. For food safety to improve, restaurant managers must be willing to participate in studies of this type.

Future research should investigate why restaurant managers are unwilling to participate in this type of research and what are the barriers and/or motivators to increase the use of proper food safety practices within operations. According to the Theory of Planned Behavior *(1)*, such an increase could be attained by exploring ways to influence the attitudes, subjective norms, perceived behavioral controls, intentions and ultimately behavior of foodservice employees to create a long-term change in food safety practices.

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