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Mitigating Cross Contamination in Four Retail Foodservice Sectors

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ABSTRACT

The purposes of this study were to identify food-handling practices that contribute to cross contamination and to assess whether intervention strategies mitigated the occurrence of these practices. A convenience sample of sixteen retail foodservice operations from four sectors of industry participated in the 3-year project. Data were collected during two visits in year one and a third visit in year three, following a 1-year intervention period. Observational data were collected using three structured forms: a food flow form; a food practices assessment form; and a validated handwashing observation form. Temperatures of cold deli meat were tracked with a data logger. Intervention activities focused on mitigation strategies and included formal training as well as provision of tools and supplies. The food flow step with the highest number of cross-contamination opportunities was preparing/thawing, followed by lack of standard operating procedures for cleaning and sanitizing. Food safety practice scores improved between groups pre- and post-interventions. Data showed reduction in times hands should have been washed, and some improvements in handwashing frequency and procedures. Mild temperature abuse of cold meats was noted both pre- and post-interventions. Findings indicate that intervention efforts were partially effective, but further investigation of effective delivery of food safety messages and assessments of the workplace food safety culture is needed.

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INTRODUCTION

Recent estimates show that 31 major pathogens caused 9.4 million episodes of foodborne illness each year *(17)*, and over half of the reported foodborne illnesses originated in retail foodservice establishments *(5)*. The Food and Drug Administration (FDA) *(25, 26)* evaluated risk factors for foodborne illness through observations in hospitals, nursing homes, elementary schools, fast food and full service restaurants, and retail foodservices (delis, meat and poultry, seafood, and produce) in 1998 and 2003 and identified three categories of risk factors for which there was a high rate of noncompliance: improper holding/time and temperature; poor personal hygiene; and contaminated equipment/prevention of contamination. Bean, Goulding, Griffin, and Ivey *(3)* studied CDC reports of foodborne outbreaks for the period 1988–1992 and found improper holding temperatures of foods and poor personal hygiene of food workers reported in 59% and 36% of outbreaks, respectively. The *Report of the FDA Retail Food Program Database of Foodborne Illness Risk Factors (25)* identified cold holding of potentially hazardous foods and ready-to-eat foods as one of four practices and behaviors for which the out-of-compliance rate exceeded 40%.

Proper handwashing was the practice with the highest out-of-compliance rate for all facility types in both FDA studies *(25, 26)*, ranging from a 34% noncompliance rate for hospitals to 73% for full-service restaurants. Higher com-

pliance was noted in noncommercial institutional settings than in commercial operations. This finding was consistent with a recent observational study of handwashing practices in four sectors of the foodservice industry *(23)*. LeBaron et al. *(12)* reported that hands may be the most important means by which enteric viruses are transmitted; thus, frequent and proper handwashing is critical. Hand contact with ready-to-eat foods represents a potentially important mechanism by which pathogens may enter the food supply *(9)*.

Both FDA studies also noted a 40% or higher noncompliance rate for cleaning and sanitizing practices, which can lead to contamination of foods. Proper cleaning and sanitizing of equipment was observed only in elementary schools, with 33% to 70% of all other types of foodservices being noncompliant. Cross contamination through poor employee practices often is cited as a reason for a foodborne illness. Guzewich and Ross *(9)* cautioned that pathogens may come in contact with ready-to-eat foods through cross contamination via food handlers, contaminated surfaces, other foods, or hands contaminated with organisms from a person's intestinal tract. Food can become contaminated at many points from origin to service, and the contamination can be inadvertent or it can be an intentional effort to sabotage the food supply.

Cleaning cloths and food contact surfaces also have been noted as contributing factors *(4, 18)*. Cross contamination of bacterial and viral pathogens in home and retail foodservice establishments has been reported as a major contributor to foodborne illness *(4, 6, 9)*. Chen, Jackson, Chea, and Schaffner *(6)* investigated bacterial transfer rates between hands and common surfaces involved in food preparation in the kitchen, including chicken to hand, cutting board to lettuce, hand to lettuce, and pre-washed hand to post-washed hand. Transfer rates among hands, foods, and kitchen surfaces were highly variable, ranging from .0005% to 100%.

Because the USDA estimates that approximately half of every food dollar is spent on food prepared away from home, it is imperative that those working in retail foodservices be provided with the knowledge and attitudes to practice safe food handling *(24)*. Because proper food-handling practices may not be learned in the home, as evidenced by research noting high contamination in home kitchens *(6)*, it is critical that retail foodservice employees receive training in correct procedures. Unfortunately, training is often not conducted because of lack of time and money. Further, it is well known that high turnover exists within the foodservice industry; thus, managers often lack sufficient expertise to provide effective training, although all editions of Food Code since 1993 (one of which is used by all states in the United States as the regulatory basis for inspections of licensed foodservice establishments) have required that the person in charge demonstrate knowledge about safe food handling principles.

While some research concludes that training does result in increased knowledge *(13, 16)* and more positive attitudes about safe food handling *(11, 28)*, changes in actual employee practices may not occur *(20, 22)*. Yet, other research has found that training managers and employees will improve employees' compliance with safe food handling practices *(7, 16, 29)*. Emerging research highlights the important role of the manager and supervisor in ensuring that food safety standards are practiced. Arendt and Sneed *(2)* proposed a model describing the role of the manager/supervisor in impacting the workplace culture and employee practices. This model has been refined to include employee motivations to practice safe food behaviors *(1)*.

The purposes of this study were to identify food handling practices that contribute to cross contamination and to assess whether intervention strategies mitigated the occurrence of these practices.

MATERIALS AND METHODS

Sample

Sixteen retail foodservice operations in one Midwestern state were recruited to participate in a 3-year study to investigate the impact of employee training on mitigation of cross contamination. The convenience sample consisted of four operations in each of four sectors of the foodservice industry: assisted living, child care, restaurants, and schools. One additional operation was selected from each sector to serve as a control. A total of 234 employees worked either part-time or full-time at the 16 operations; 44 were employed in the assisted living facilities, 15 in the four childcare operations, 110 in the four restaurants and 65 in the schools. The number of employees ranged from 3 at a childcare center to 63 at one restaurant. In the operations with fewer employees, the post-intervention observations typically were of the same staff. However, because of schedules and turnover, this was not always the case. No monetary incentives were given; however, the manager in each operation was mailed a written report of the observations and training, and food safety education materials were provided. A press release also was provided to use in communications with stakeholders to show the organization's commitment to food safety.

Data collection

Data collection instruments and protocol were reviewed and approved by the Institutional Review Board for Iowa State University prior to the start of the study. Data were collected during site visits to each establishment by two members of the research team. Each site visit occurred for a three-hour period during meal preparation and service times. Two visits were made in year one and the third visit in year three, following a 1-year period of interventions that included on-site, face-to-face training along with on-site training supplies and materials. In addition, site visits to observe handwashing behaviors were made in years one and three of the study.

Observational data were collected to determine the potential for cross contamination. Three instruments were used: a Food Flow Form to examine practices at each step in the flow of food; a Food Practices Assessment Form to determine compliance with the FDA's 2005 Food Code *(27)* best practices; and a Handwashing Observation Form to determine handwashing frequency and techniques. In addition, temperatures of a cold meat were tracked with a data logger (GL 100, Cooper Instrument Co., Middlefield, CT) from storage through service.

The Food Flow Form was developed to determine food handling practices that could result in cross contamination at each step in the flow of food: purchasing, receiving, storing, thawing/preparing, cooking, holding, transporting, serving, cooling, and reheating. An open-ended form was used during the first site visit; observers noted the foods handled and identified specific practices at each step that could contribute to cross contamination. For example, during the preparation

phase, it was noted that fresh produce items such as onions were not washed prior to chopping for use in a cold salad. This form was modified after the first site visits, listing the observed practices and yes/no responses to quantify future observations. Thus, in the second site visit, observers noted with a yes/no whether fresh produce was washed prior to use. Findings were used to identify important messages for employee training. Inclusion of the potential of contamination from unwashed produce was a topic that was included.

The Food Practices Assessment Form, used in previous studies *(8, 10, 19, 21)* and updated to reflect the FDA 2005 Food Code *(27)*, was used to determine compliance with best practices in food safety. Observers followed an established protocol for decision making, and the protocol was pilot tested prior to data collection to determine inter-rater reliability *(15)*. For each of the 78 practices on the form, "yes" was noted if the practice was present or observed being done properly for a majority of the observation time. The majority of the time was defined as "over half the occasions the action was observed conducted by all applicable employees on site during the visit." For example, one practice observed was "end point cooking temperatures are taken with a calibrated thermometer." If temperatures were checked for two of the three hot food items, this practice was considered as properly completed. A "no," "not observed," or "not applicable" response was used if the practice was not being followed or observed at the time of the visit. Once the Food Practices Assessment Form was completed, a Food Safety Practices Score (FSPS) was determined by dividing the number of "yes" responses by the total number of "yes" and "no" responses and then multiplying by 100. Items that were not observed (for example, cooling rates) or not applicable (e.g., manual ware washing) were not included in the FSPS calculation. Comparisons of FSPS between pre- and post-intervention for all participating foodservices were conducted using ANOVA.

Pre- and post-intervention observations (years 1 and 3 of the study) of handwashing were conducted using the validated Handwashing Observation Form *(14, 23)*. Observations were made during the three primary functions of food production, service, and cleaning. Trained observers made detailed notations of selected employees prior to and after the intervention period (five three-hour observations at each site pre-intervention of five employees for a total of 80 employees over 240 hours; three hours of observation at each site post-intervention of 54 employees). Observations of when hands should have been washed, when hands were washed, and techniques for how hands were washed were based on recommendations in the 2005 Food Code.

Food product temperatures were tracked and recorded to determine whether conditions were favorable for bacterial growth. Sanitized data loggers (GL 100, Cooper Instrument Co., Middlefield, CT) were used. At the beginning of each site visit, a sanitized data logger was inserted into a package or container of ready-to-eat cold meat and was kept with the meat as sandwiches were made and to the time of service. The data logger was programmed to check temperatures every 10 minutes initially; however, after the first site visits data were recorded every minute to capture a more detailed picture of temperature changes during production, holding and service periods in each type of retail foodservice operation. Sandwiches were clearly labeled "do not eat" and were removed before a customer could get the product. Data logger information was downloaded and imported into an Excel spreadsheet for analysis.

Interventions

Interventions focused on showing ways to minimize cross contamination, when and how to wash hands, and proper use and changing of gloves. Interventions included installing soap dispensers with an audible beep at 20 seconds at the primary hand sink to encourage proper length of each handwashing occasion, posting a 1-year calendar at a central location with a different monthly message related to cross contamination, and conducting formal training on cross contamination. Glow-in-the-dark lotion and UV lights were used as one activity and were left at each site for future use in training. Educational materials were provided throughout the intervention period, such as newsletters and "yuck" photos that showed microbial growth resulting from contaminated surfaces. Modifiable Standard Operating Procedures, developed for each sector of retail foodservices that encompassed the food flow, personal health and hygiene, and cleaning and sanitizing were sent to each participating operation. In addition, each manager received a brochure entitled "Guide to Food Safety Practices"; a Food Defense checklist; Handwashing Lesson Plans and laminated posters for in-service trainings; and summary reports with assessments of strengths and areas for improvement based on observations from the site visits. Although a member of the research team made periodic announced visits to each location to check installed equipment, the study did not collect day-to-day data.

RESULTS AND DISCUSSION

Potential cross contamination practices in the food flow

A summary of practices that could contribute to cross contamination observed at each step in the flow of food before and after intervention efforts is presented in Table 1. In these 16 operations, the step with the highest number of cross contamination opportunities was preparing/thawing. The second area of most concern was related to implementation of standard operating procedures, particularly with practices of not sanitizing work surfaces, failing to wash hands between handling dirty and clean dishes, and failure to check concentrations of sanitizer solutions. Written standard operating procedures are a fundamental component of a food safety plan; guidelines can serve as a training tool and a resource for employees. Without the use of consistent directions for employees, they may not understand what is intended to be communicated because of differences in verbal and non-verbal methods. Intervention efforts included reference to an electronic data base of modifiable standard operating procedures for the specific sector of foodservice (available at www.iowahaccp.iastate.edu). Yet the provided standard operating procedures were not observed to have been incorporated into the organizational system during the year 3 visit. A hard copy of the standard operating procedures was sent during intervention.

Food safety practice scores (FSPS)

A summary of mean food safety practice scores (FSPS) from each sector of retail foodservices in the study for visits one and three are shown in Table 2.

TABLE 1. Observed pre- and post-intervention practices that could contribute to cross contamination in four types of retail foodservice operations: assisted living (N = 4), childcare (N = 4), restaurants (N = 4), and schools (N = 4)

Food Flow		Yes[a]		No[b]		N/A[c]	
Step	Practices Observed	Pre	Post	Pre	Post	Pre	Post
Receiving	Delivery person placed products in walk-ins, refrigerators, etc.	4	4	9	12	3	
Storing	Storage areas accessible to non-foodservice employees	5	6	11	10		
	Food stored on floor	2	7	14	9		
	Food stored in area where it could be contaminated (broken ceiling tiles over, etc.)	2	1	14	15		
	Raw and prepared food stored in same refrigerated unit	1	3	15	13		
	Food items stacked	1	5	15	11		
	Food stored without adequate covering/wrapping	1	2	15	14		
	Raw products placed on shelves over prepared or ready-to-eat products	0	1	16	15		
Preparing/ Thawing	Packaging placed on countertops (tomato boxes, etc.)	12	6	4	10		
	Refrigerator or freezer handles touched without washing hands afterwards	12	7	4	9		
	Multiple items prepared on same cutting board without sanitizing between	9	3	7	13		
	Hands not washed before donning gloves	8	5	8	11		
	Same gloves used for multiple tasks	7	9	9	7		
	Sanitizing of food contact surface not done	6	3	10	13		
	Handwashing not done	5	1	11	15		
	Fruits and vegetables not washed in preparation	5	4	11	12		
	Sink used for other purposes used for washing fruits and vegetables that would not be cooked	5	3	11	13		
	Handwashing not done properly	3	8	13	8		
	Slicer used for multiple products without sanitizing between	3	2	13	14		
	Towels (not single use) used for drying surfaces	2	0	14	16		
	Cans not washed off before opening	2	2	14	14		
	Towels used for wiping multiple surfaces	1	3	15	13		
	Items placed in refrigerator after preparation without adequate coverings	1	1	15	15		
	Eating at work station	1	0	15	16		
	Utensils not sanitized between uses	1	2	15	14		
Cooking	Food contact surfaces not sanitized	3	2	8	14	5	
	Food thermometer not sanitized between use with different foods	1	1	10	15	5	
	Gloves not changed as needed	1	2	10	14	5	

TABLE 1. Observed pre- and post-intervention practices that could contribute to cross contamination in four types of retail foodservice operations: assisted living (N = 4), childcare (N = 4), restaurants (N = 4), and schools (N = 4) *(continued)*

Food Flow Step	Practices Observed	Yes[a] Pre	Yes[a] Post	No[b] Pre	No[b] Post	N/A[c] Pre	N/A[c] Post
Holding	Food stored uncovered	3	1	13	15		
Transporting	Appropriate containers (that can be sanitized) used for transporting food	1	5	10	10	5	1
	Food transported uncovered	0	1	12	15	4	
Serving	Self-service done by customers	7	7	9	9		
	Sanitizing of work surfaces for preparation at service not done	7	3	9	13		
	Inadequate handwashing by employees	5	5	11	11		
	Food product boxes or wrappings on food contact surface	5	1	11	15		
	Ready-to-eat foods served with ungloved hands	4	3	12	13		
	Gloves not changed when needed	4	6	12	10		
	Tables not sanitized	1	0	15	16		
	Ice or food not covered	2	4	14	12		
	Ice scoop handle in ice	0	2	16	14		
Cooling	Cooling items placed in refrigerator uncovered	3	0	13	16		
SOPs	Sanitizing of work surfaces not done	8	3	8	13		
	Handwashing between handling dirty and clean dishes not done	8	8	8	8		
	Sanitizing solution concentration not checked	7	13	9	3		
	Hot water temperature not checked	5	8	11	8		
	Facility not clean so dust and other particles could contaminate food	5	1	11	15		
	Sanitizing buckets not changed frequently	4	0	12	16		
	Sanitizing solutions at too low a concentration	3	1	13	15		
	Hot water sanitizers not hot enough	2	0	14	16		
	Sanitizing solutions at too high a concentration	2	2	14	14		
	Corrective actions were not taken when sanitizing solution concentration incorrect	2	0	14	16		
	Corrective actions were not taken when temperature too low for sanitizing	1	0	15	16		

[a]Number of times the practice was present or observed being done properly

[b]Number of times the practice was not followed

[c]Number of times the practice was not applicable at the time of observation

TABLE 2. Food safety practice scores for four types of retail foodservice operations: assisted living (N = 4), childcare (N = 4), restaurants (N = 4) and schools (N = 4)

	Mean Pretest Scores	Mean Posttest Scores
Schools	84.1 ± 1.8	90.0 ± 4.9*
Assisted Living	76.8 ± 14.0	82.5 ± 10.7*
Child Care	68.0 ± 11.4	72.2 ± 9.9*
Restaurants	63.7 ± 5.7	70.7 ± 7.7*

*Significant differences between pre-test and post-test scores ($P \leq 0.001$)

FSPS improved for all four groups. When ANOVA comparisons were made, differences between pre- and post-test scores were found for all types of retail foodservice operations. At pre-intervention, schools had higher scores (84.1) than child care (68.0) and restaurants (63.7). At the end of the project, schools again had the highest FSPS (90.0) and were higher than the lowest FSPS observed in restaurant settings (70.7). These findings suggest that, to some extent, intervention efforts of printed materials, training guidance, and summary report were successful in improving safe food handling behaviors. However, a limitation is that several employees who were observed changed over the course of the study as the result of line level staff turnover. In addition, one operation in each of the four categories experienced a change in management during the 3-year study, a 25% rate (n = 4). Further observations and analysis are needed to determine the extent to which management change affects organizational practices. These findings suggest that the role of management influences the practice of safe food handling by employees and adds to the growing body of literature about the importance of organizational culture and management in ensuring food safety practices *(1, 2)*.

Handwashing behaviors

Table 3 shows the total number of times hands should have been, and were washed, and the compliance with the 2005 Food Code recommendations for all observations by each of the four studied sectors of retail foodservice. See *Journal of Food Protection* for details of pre-intervention findings *(23)*. Post-intervention data show that, overall, there was a reduction in number of times hands should have been washed, which suggests that employees and management were organizing tasks more efficiently, thus minimizing the need for handwashing. In the pre-intervention observations, hands should have been washed 3,414 times during 240 hours of observation of 80 employees (14.2 times per employee hour) while in the post observations, hands should have been washed 608 times (during 48 hours of observations of 54 employees), or 12.7 times per employee hour, which was a decline in required handwashing occasions. Thus, the observational findings suggest that intervention efforts to reorganize work assignments or sequence were successful. Handwashing frequency does present continued challenges, as pre-observation found that hands were only washed about 16% of the time they should have been (556 of the 3,414 observed occasions), while post-intervention observations showed that hands were washed 172 of the 608 times they should have been, or 29% of the time. The post-intervention observations also suggest improvements in handwashing procedures. Of the 556 times that hands were observed being washed during the pre-intervention observations, they were done so correctly (in compliance with Food Code recommendations of a 20 second process including use of soap, lathering for at least 10 seconds, rinsing, drying with disposable towel or dryer, and avoidance of touching faucet handles with clean hands) 30% of the time (165 correct handwashings of the 556 occurrences). Post-intervention observations indicated that hands were washed 172 times, with 75 of the times in compliance with Food Code (44%), which was an improvement in the handwashing process. Findings were most notable in the restaurant sector; in pre-intervention observations, hands were not washed in compliance with Food Code recommendations at all, while in post-intervention, proper procedures were observed in 6 of 30 occasions (20%). Observations of occasions when hands should have been washed but were not remained consistent across all sectors: when changing tasks, before donning gloves, and after touching clothing, such as aprons.

Table 4 shows handwashing benchmarks proposed for each sector of retail foodservice studied after the first set of observations, and the benchmarks identified after the last period, post-intervention. Benchmarks indicate the number of times an employee should wash hands each hour, based on the 2005 Food Code recommendations *(27)*. Few changes were noted as a result of the interventions for child care and schools, yet there was a dramatic decrease in post-intervention benchmarks for restaurants, with a drop from 27 to 16 times per hour that each employee should wash hands. An increase was seen in benchmarks for assisted living facilities, from 7 times per hour per employee to 11. Turnover of staff, enhanced supervisory expertise, increased attention to handwashing practices, and/or improved strategies of work sequencing may explain both improvements and negative changes between pre-and post-intervention efforts. Table 5 summarizes interventions used.

Food holding temperatures

A summary of temperature data for each foodservice sector during the

TABLE 3. Observed handwashing frequency and compliance with 2005 Food Code recommendations during production, service, and cleaning in assisted living centers (AL), childcare centers (CC), restaurants (R), and schools (S) post intervention efforts

	Number of times hands should have been washed				Number of times hands were washed				%Compliance Food Code frequency				Number of times hands were washed in compliance with Food Code procedure*				%Compliance with Food Code procedure*			
Task	**AL**	**CC**	**R**	**S**	**AL**	**CC**	**R**	**S**	**AL**	**CC**	**R**	**S**	**AL**	**CC**	**R**	**S**	**AL**	**CC**	**R**	**S**
Personal Hygiene																				
After touching bare skin	10	5	8	5	1	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
After touching clothing	5	1	20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After coughing/sneezing	0	3	3	0	0	0	1	0	0	0	33	0	0	0	0	0	0	0	0	0
After using handkerchief	0	0	1	0	0	0	1	0	0	0	100	0	0	0	1	0	0	0	100	0
After eating/drinking	4	1	8	1	2	0	0	1	50	0	0	100	1	0	0	1	50	0	0	100
Food Preparation																				
Before engaging in food preparation	5	6	5	3	4	4	3	3	80	67	60	100	3	3	1	1	75	75	33	33
When entering food preparation area	11	23	5	2	5	11	2	2	45	48	40	100	2	7	0	1	40	64	0	50
Before handling different types of food products	1	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
When switching between raw food and RTE	0	0	2	0	0	0	2	0	0	0	100	0	0	0	1	0	0	0	50	0
Before donning gloves	16	20	8	44	3	5	5	15	19	25	62	34	2	4	0	3	67	80	0	20
After handling PHF	4	0	5	2	0	0	3	1	0	0	60	50	0	0	1	0	0	0	33	0
Cleaning																				
After cleaning equipment /utensils	8	6	9	8	3	2	4	3	38	33	44	38	0	1	1	2	0	50	25	67
After handling soiled equipment/utensils/ dishwashing	29	30	31	20	25	15	3	12	86	50	10	48	9	11	0	7	36	73	0	58
After cleaning	3	2	0	0	2	1	0	0	67	50	0	0	1	1	0	0	50	100	0	0
Other																				
When changing tasks	47	36	70	54	8	11	4	3	17	30	6	6	3	6	0	1	38	54	0	33
After handling money	0	0	10	0	0	0	2	0	0	0	20	0	0	0	1	0	0	0	50	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**143**	**133**	**187**	**145**	**53**	**49**	**30**	**40**					**21**	**33**	**6**	**15**				

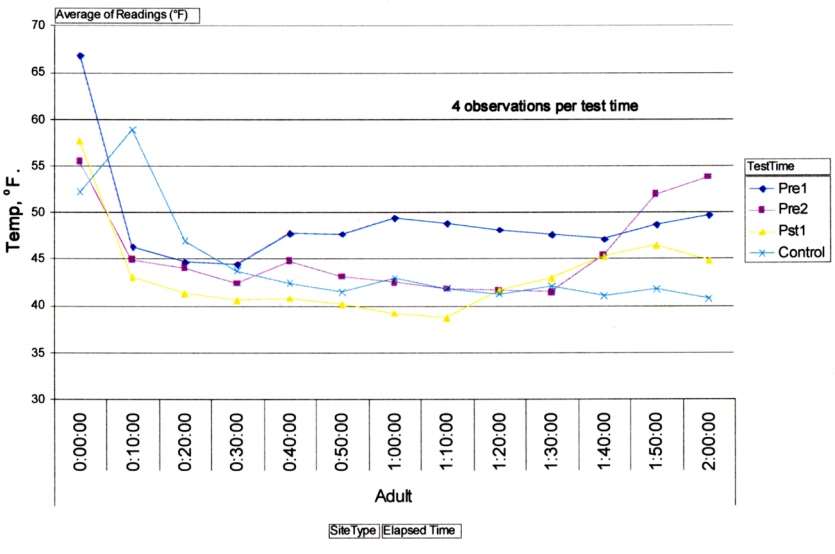
*Determined to be in compliance with Food Code if the following actions were observed: soap was used, lathering occurred for at least 10 seconds, hands were dried with disposable towel or heated air, and faucet handles were not touched with hands after washing.

two pre-intervention and one post-intervention site visits are shown by sector of foodservice in Figures 1, 2, 3, and 4. While one or two facilities within a sector could confound averages, the data do suggest that improvements could be made in temperature controls for the assisted living and child care sectors. Mild abuse was noted during the first pre-intervention site visit for all four facilities in the assisted living sector for the two-hour period of tracking, and for most of the child care operations during the second hour of tracking during the second pre-intervention visit, with temperatures hovering around 45°F for the first hour of the second pre-intervention visit. Mild abuse was also seen post intervention, yet there was reduced exposure to the temperature danger zone. A spike in temperature of the cold meat sandwich was noted after one hour and twenty minutes had elapsed, with temperature of product recorded at 50°F during the post-intervention site visit at child care operations. Based on summary data in school foodservices, there was mild temperature abuse (with temperature at approximately 47°F) between the 40 minutes and one hour and 20 minutes recordings. This may be due to the fact that schools work with large quantities of product in one assembly stage. Restaurant operations appeared to most consistently maintain recommended cold food temperatures of below 41°F, not surprising given that no transporting was involved and restaurants' employees typically prepare sandwiches to order. However, post-intervention findings showed that the temperatures were generally higher than those recorded during the first two visits, suggesting that the information about temperature controls presented during training was not applied. Prolonged temperature abuse of a potentially hazardous food such as deli meat is a potential cause of foodborne illness, especially for at-risk populations who eat the majority of their meals in assisted living, child care, or school settings, or

TABLE 4. Handwashing benchmarks per employee hour in four sectors of the retail foodservice industry during operational phases of production, service and cleaning

Operation phases	AL		CC		R		S	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Production benchmark	7	13	9	11	28	16	11	18
No. of times hands should have been washed	186	50	199	43	582	65	300	70
Total observed hours	26	4	21	4	21	4	27	4
Service benchmark	7	12	9	11	33	20	12	13
No. of times hands should have been washed	149	46	197	44	930	100	250	51
Total observed hours	20	4	21	4	28	5	21	4
Cleaning benchmark	7	12	10	12	23	7	8	6
No. of times hands should have been washed	104	47	176	46	251	22	90	24
Total observed hours	14	4	18	4	11	3	12	4
Overall benchmark	7	12	9	11	29	16	11	12
No. of times hands should have been washed	439	143	572	133	1,763	187	640	145
Total observed hours	60	12	60	12	60	12	60	12

FIGURE 1. Temperature data for assisted living foodservice operations during the two pre-intervention and the one post-intervention site visits



for those dining in restaurants occasionally. Cross contamination of foods with high bacteria levels and food contact surfaces can result in an outbreak of a foodborne illness. Thus, prevention of time and temperature abuse of temperature controlled for safety foods, particularly ready-to-eat foods, must be part of an effective food safety plan.

CONCLUSIONS AND RECOMMENDATIONS

This study assessed the effectiveness of intervention efforts in mitigating cross contamination risks in four types of retail foodservice settings over a 3-year period. Commercial (restaurants) and noncommercial settings (assisted living, child care and schools) were used as data collection sites for this research, with all operations featuring cold luncheon meat and fresh produce menu items. Behaviors that contributed to cross contamination of these ready-to-eat items were observed by use of standardized data collection

TABLE 5. Summary of interventions

Interventions	Description
Tools	
Soap Dispensers	Audible beep emitted when soap was dispensed and again after 20 seconds, the prescribed handwashing period as per Food Code 2005.
Glow in Dark Lotion and UV Light	These tools were included in the formal presentation and then left for managers to use in follow-up in-services
Observation Reports	Prepared after site visits in year 1 and year 3; assessments of strengths and areas for improvement based on observations from the site visits.
Trainings	
Cross Out Cross Contamination	A 45-minute Power Point presentation with photos that illustrate cross contamination. Available at www.iowahaccp.iastate.edu.
Educational Materials	
Food Safety Calendar	Monthly calendar posted by the handwashing sink with a monthly message related to cross contamination. In November, the message is Vote for Soap. See www.iowahaccp.iastate.edu for downloadable version.
Newsletter	Monthly newsletters that included frequently asked questions. Available at www.iowahaccp.iastate.edu.
"Yuck" Photos	Laminated 8 x 11 posters that showed microbial growth resulting from cross contaminating surfaces. Available at www.iowafoodsafety.org.
Standard Operating Procedures	Modifiable SOP were developed for each sector of retail foodservices that encompassed the food flow, personal health and hygiene, and cleaning and sanitizing were sent to each participating operation. Available at www.iowahaccp.iastate.edu.
Guide to Food Safety Practices	Brochure developed in English and Spanish with target audiences for staff in childcare and school settings; assisted living facilities; and commercial restaurant operations. Available at www.iowahaccp.iastate.edu.
Food Defense Checklist	Checklist with inclusion of Best Practices for protection of food from intentional contamination. Available through Extension services.
Handwashing Lesson Plans	Guide for managers on how to conduct in-service trainings related to handwashing. Available at www.iowahaccp.iastate.edu.
Laminated Posters	Variety of posters with information about temperature controls and handwashing.

tools. Interventions provided to the sixteen foodservices included formal and informal methods. Changes in behaviors and practices in the retail foodservice settings between pre- and post-intervention observations over a three year period were minimal. Findings from this study suggest that training interventions (formal and informal) are only somewhat effective in improving practices that will reduce the risk of foodborne illness, such as handling practices at specific steps in the flow of food, general food safety procedures within the operation, handwashing behaviors, and temperature controls. Future research could investigate how to effectively communicate food safety messages in order to ensure that practices are consistent with requirements. Additional research could assess the impact of management and management retention on the culture of retail foodservice.

FIGURE 2. Temperature data for school foodservice operations during the two pre-intervention and the one post-intervention site visits

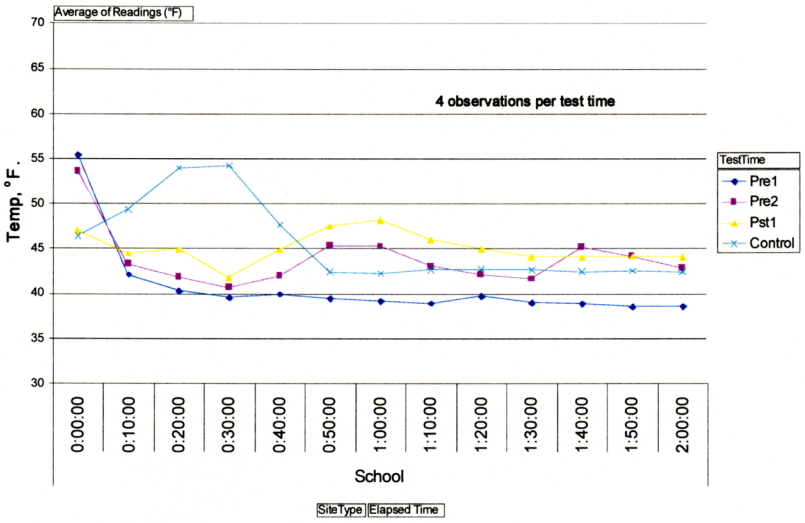


FIGURE 3. Temperature data for restaurants during the two pre-intervention and the one post-intervention site visits

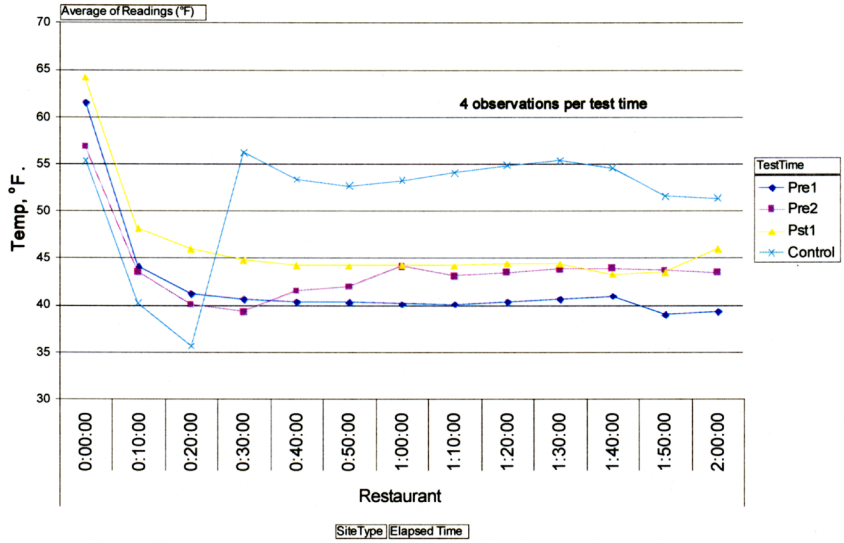
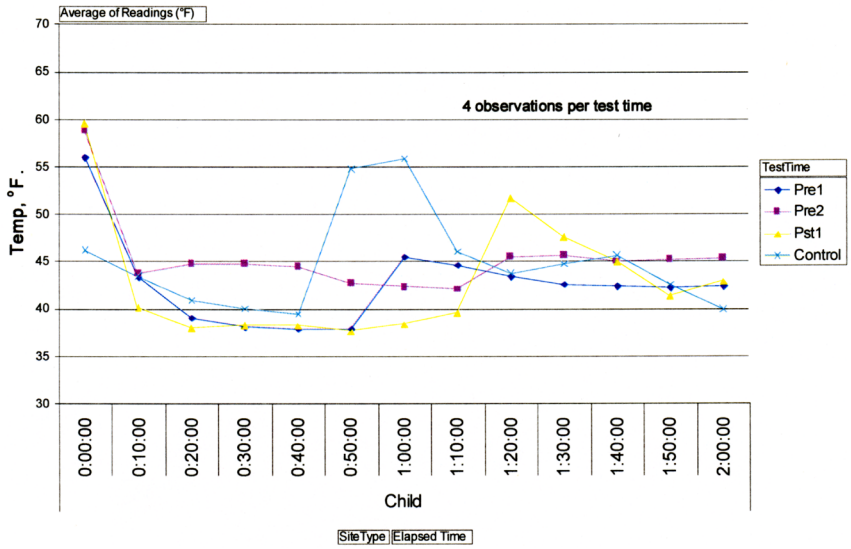


FIGURE 4. Temperature data for child care foodservice operations during the two pre-intervention and the one post-intervention site visits



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