Junehee Kwon,* Kevin R. Roberts, Kevin Sauer, Kerri B. Cole and Carol W. Shanklin

The Center of Excellence for Food Safety Research in Child Nutrition Programs, Dept. of Hospitality Management and Dietetics, Kansas State University, 104 Justin Hall, Manhattan, KS 66506, USA

PEER-REVIEWED ARTICLE

Food Safety Risks in Restaurants and School Foodservice Establishments: Health Inspection Reports

ABSTRACT

Each day, schools provide meals to over 31 million children, while restaurants serve 198 million customers. These operations are responsible for most foodborne illness outbreaks, and health inspection reports may reveal food safety challenges. To identify food safety risks and address behavior changes in restaurants and school foodservice, health inspection reports for 2,511 schools and 2,624 restaurants in Oklahoma, Pennsylvania, and Rhode Island were reviewed and compared. Violations were coded into 30 categories and grouped as critical and/or behavioral violations. Total, critical, and behavioral violations were calculated for both restaurants and schools and compared by use of *t*-tests. Odds ratios evaluated the likelihood that a specific violation type would occur. Behavioral and critical violations were more frequent in restaurants than in schools ($P < 0.001$). Odds ratios revealed that restaurants were 3.6 times more likely than schools to be cited for behavioral violations and 3.0 times more likely to be cited for critical violations. Restaurants had more behavioral violations in most categories, whereas violations for schools tended to involve equipment and facility maintenance. Our data revealed that food safety challenges differed between schools and restaurants. Results provide guidance for behavior changes and necessary facility maintenance at these operations.

INTRODUCTION

Although the status of food safety in the United States (U.S.) has improved, the Centers for Disease Control and Prevention (CDC) estimated that 19,531 foodborne infections, 4,563 hospitalizations, and 68 deaths were caused in 2012 by 10 pathogens commonly transmitted through food *(3)*. In 2008, 1,034 foodborne illness outbreaks occurred, resulting in 23,152 illnesses, 1,276 hospitalizations, and 22 deaths in the U.S. *(2)*. Of those, 868 outbreaks were attributable to single foodservice settings, with restaurants

*Author for correspondance: Phone: +1 785.532.5369; Fax: +1 785.532.5522; Email: jkwon@ksu.edu

and deli operations responsible for most (n = 452, 52.1%), affecting 4,767 people *(2)*. Ensuring food safety remains a challenge for the industry, because more than 980,000 restaurants and 13 million employees serve 190 million meals or snacks daily *(17)*.

Lynch et al. *(16)* identified commercial restaurants (n = 3,334, 50.2%), private residences(n = 1,297, 19.5%), and school foodservice operations (n = 285, 4.3%) as the top three sources of foodborne illness outbreaks. In view of the fact that more than 31 million students eat daily in one of 100,000 school cafeterias *(23)*, foodborne illness outbreaks that originate in school foodservice operations are remarkably uncommon. Possible reasons for the relatively low number of foodborne illness outbreaks associated with schools include specific food safety regulations and mandates. For example, school foodservice operations must establish food safety programs based on Hazard Analysis Critical Control Point (HACCP) principles and be inspected at least twice per year to evaluate food safety *(5)*. Additional regulations may have also reduced the number of potential foodborne illness outbreaks, despite the massive number of meals served daily in schools. However, the average number of foodborne illness cases per outbreak from 2002 to 2011 was higher for outbreaks associated with schools (mean = 48.1) than with restaurants or delis (mean = 14.1) (http://www.cdc.gov/foodborneoutbreaks/Default.aspx).

Maintaining the safety of food is challenging, given the many opportunities for contamination throughout food production and distribution. More precisely, most foodborne illnesses in the U.S. have been linked to poor food-handling behaviors *(16)*. Identifying which behaviors specifically contribute to foodborne illness outbreaks may be an important part of food safety training. Certainly, direct or video-recorded observations can reveal behavioral variations and effectiveness of training programs *(4, 6, 19)*. However, methodologies can be limited with regard to the number of facilities and participants that can be observed, specifically because of time and personnel constraints.

An alternative method for assessing large-scale food safety risk is the comprehensive audit of health inspection data. The Food Code *(24)* specifies that each foodservice facility must be inspected once a year, unless more frequent inspections are required because of food safety risks. Many local and/or state health departments disclose inspection results online to consumers and restaurateurs. Researchers have suggested that consumers may want access to health inspection information before dining at a particular establishment *(25)* and will change their behaviors based on that information *(9)*.

The amount of inspection information available to the public varies. Some jurisdictions include very specific Food Code violations, while others post letter grades or total inspection scores only. Those reporting specific violations have been used by previous researchers to identify the association between inspection scores and foodborne illness outbreaks *(10, 18)*. More recently, researchers have used inspection reports to identify food safety training needs for restaurants *(12, 13, 20)* and for health inspectors *(15)*. Inspection scores did not, however, predict foodborne illness outbreaks *(18)*, despite previous findings to the contrary *(10)*. Moreover, researchers have found significant food safety violations in restaurants with no reported critical violations or repeated critical violations *(26)*.

Even with such inconsistent results of previous studies, researchers have agreed that reviewing inspection reports can identify which behaviors require additional training *(18)*. One of the main limitations of using inspection reports is incompatibility between reports gathered in different states or counties.

The main challenge of observational studies, that only a relatively small number of facilities can be included, means that a review of health inspection reports can allow researchers to include many more facilities than would be feasible through direct observations. Thus, findings may serve to reveal food safety risks in a large number of foodservice operations. Therefore, the purpose of this research was to use health inspection reports in Oklahoma, Pennsylvania, and Rhode Island to identify food safety risks and focus on behavior changes in restaurant and school foodservice operations. Specifically, the objectives of this research were to (a) identify food safety risks related to employee behaviors, which would reveal the need for employee behavior changes, and (b) compare restaurant and school health inspection data and the risks exposed in that data.

MATERIALS AND METHODS

This research used data available to the public and did not involve human subjects. Therefore, approval from the institutional review board was not necessary.

Sample

Researchers for the Center of Excellence for Food Safety Research in Child Nutrition Programs gathered health inspection reports for all schools participating in the National School Lunch Program in three randomly selected states: Oklahoma, Pennsylvania, and Rhode Island. Schools included 1,227 in Oklahoma, 1,011 in Pennsylvania, and 273 in Rhode Island, for a total of 2,511 schools.

To establish comparable sample sizes for health inspection data of restaurants, a similar number of restaurants were randomly selected from each state: 1,231 from Oklahoma, 1,024 from Pennsylvania, and 369 from Rhode Island. In total, 2,624 restaurants were included in the sample, representing 7% of restaurants in Oklahoma, 3% in Pennsylvania, and 4% in Rhode Island. The number of restaurants from each state was divided by the number of school inspections available for each of the three states to establish the interval for sample selection. Once this number was determined, every 15th (Oklahoma), 31st

(Pennsylvania), or 24th (Rhode Island) restaurant from the list, arranged by county name, was selected to be included in the sample. Only restaurants and delis not associated with a gas station, grocery store, or caterer were included in the sample.

Some states reported violation summaries, while others included detailed health inspection reports. The most recent routine inspection report from each establishment was selected for analysis. Dates of inspections ranged from June 2009 to February 2012.

Data collection and consolidation

State health inspection forms included different violations (i.e., Oklahoma notes 51 different violations, Pennsylvania 208, and Rhode Island 54), with inconsistent wording. The original wording was maintained for categorizing and further analyses of the data. Before combining the Food Code violations into predetermined categories, each violation was recorded, based on each state's inspection form. The Microsoft Access database with a separate file for each state.

Food Code violations were evaluated and assigned to predetermined violation categories (i.e., behavioral versus non-behavioral, critical versus non-critical). Oklahoma and Rhode Island inspection reports included instances in which the descriptions implied both behavioral and non-behavioral violations. For example, one violation related to handwashing stated, "Handwash facilities adequate/Accessible with soap and towels." Even though employees have no control over adequate/inadequate handwashing facilities (non-behavioral), employees can ensure that soap and paper towels are properly stocked (behavioral). Another example, related to sinks' stated, "Proper number of sinks: mop sinks, dishwashing sinks, food preparation sinks, used for intended purposes." An establishment may be cited for this code, based on inadequate facilities (non-behavioral) or improper use of sinks (behavioral). Because these cases cannot be verified as behavioral or non-behavioral violations, they were categorized as both. Therefore, the sum of behavioral and non-behavioral code violations slightly exceeds the total inspection items for both Oklahoma and Rhode Island.

Critical versus non-critical violations were determined on the basis of each state's inspection reports, because violations were not consistently reported from state to state. If the state's inspection report indicated certain violations as critical, we classified them as critical even though the other two states may not consider them critical.

After each code violation was classified into one of 30 violation categories and as behavioral/non-behavioral, and critical/non-critical, the data from all schools and restaurants were recoded, using the following Microsoft Excel equation:

$$N_{cat\#,\,beh} = N_{code1} \times Beh_{(0\text{ or }1)} + N_{code2} \times Beh_{(0\text{ or }1)} + N_{code3} \times Beh_{(0\text{ or }1)} + \ldots$$

where $N_{cat\#,\,beh}$ is the number of behavioral code violations in category #; $N_{code\#}$ is the number of code violations within the category #; and $Beh_{(0\text{ or }1)}$ is the behavioral violation factor when 0 is assigned for non-behavioral and 1 for behavioral code violations. A similar equation was used to calculate total critical violations:

$$N_{cat\#,\,Crit} = N_{code1} \times Crit_{(0\text{ or }1)} + N_{code2} \times Crit_{(0\text{ or }1)} + N_{code3} \times Crit_{(0\text{ or }1)} + \ldots$$

where $N_{cat\#,\,Crit}$ is the number of critical code violations in category # and $Crit_{(0\text{ or }1)}$ is the critical violation factor when 0 is assigned for non-critical 1 for critical code violations. The number of behavioral, non-behavioral, critical, and non-critical violations in each food code violation category for each establishment was calculated using Microsoft Excel formulas.

After each state's data were recoded into consistent categories and the numbers of behavioral, non-behavioral, critical, and non-critical violations were calculated, the data from all three states were compiled into one Microsoft Excel file, which was then converted to an SPSS format for further analysis. The final dataset included both restaurant and school inspection reports, with the number of behavioral and non-behavioral violations identified within each food code violation category. Data analysis was performed with 2,624 restaurant inspection reports and 2,511 school inspection reports.

Data analyses

SPSS for Windows (version 19.0, 2011) was used for data analysis. Descriptive statistics, with frequencies, means, and standard deviations were calculated to summarize the data. Cross-tabulation with chi-square analysis was conducted to compare the distribution of the data between restaurants and schools. Differences in the numbers of code violations between restaurants and schools were compared by use of independent sample *t*-tests for each category within the behavioral and non-behavioral violation classifications. Finally, the likelihood of behavioral, non-behavioral, critical, and non-critical violations in restaurants compared with schools was calculated by use of odds ratios. Before odds ratio analysis, data were recoded as1 if there were any violations within each classification and as 0 if there were no violations. Statistical significance was determined at $P < 0.01$.

RESULTS AND DISCUSSION

Overall, restaurants had more total violations (4.75 ± 4.51) than schools (1.99 ± 1.98) ($P < 0.001$). In fact, schools had fewer violations in every category (behavioral, non-behavioral, critical, and non-critical) than restaurants, albeit the most highly significant difference (*t* value) was observed for behavioral violations *(Table 1)*.

In general, the number of food code violations in this study revealed that food safety risks were fewer and might be less severe for school foodservice establishments than for commercial restaurants, possibly because food preparation in school foodservice is less complex, with fewer items prepared than in restaurants. Many school foodservice operations use a large amount of pre-prepared food products to help contain operational costs *(1)*, which also reduces personnel requirements. These factors may lessen the number of violations in schools.

TABLE 1. Mean number of behavioral, non-behavioral, critical, and non-critical violations in restaurants and schools

	Restaurants (n = 2,624)	Schools (n = 2,511)		
	Mean ± SD		t	P[a]
Behavioral Violations	2.94 ± 3.23	0.94 ± 1.21	29.17	<0.001
Non-behavioral Violations	1.68 ± 1.89	0.90 ± 1.24	17.56	<0.001
Critical Violations	1.68 ± 1.89	0.90 ± 1.24	17.56	<0.001
Non-critical Violations	1.68 ± 1.89	0.90 ± 1.24	17.56	<0.001
Total Violations	4.75 ± 4.51	1.99 ± 1.98	28.61	<0.001

[a]Based on independent *t*-tests between school inspections and restaurant inspections

Behavioral violations

Of 30 violation categories, behavioral food code violations were present in 26 categories. Schools had fewer behavioral citations than restaurants in 20 violation categories *(Table 2)*. Results for the following four categories did not differ between restaurants and school foodservice operations: *Approved Food Sources, Cooling, Use of Thermometers and Test Kits, and Display of Valid Permit and Consumer Advisories.* Schools had more behavioral violations than restaurants in two categories: *Ware Washing and Garbage and Recycling Facilities Outside.*

Restaurants were more challenged than school foodservice operations ($P < 0.001$) with regard to *Use of Single-use Gloves and Utensils/Bare Hand Contact* (0.38 ± 0.86 vs. 0.04 ± 0.22), *Non-food Contact Surface Maintenance* (0.27 ± 0.53 vs. 0.09 ± 0.29), and *Protecting Food from Contamination* (0.29 ± 0.58 vs. 0.10 ± 0.32), all of which are related to cross-contamination and other food contamination. Other challenging areas for restaurants were *Maintenance of Utensils and Linens* (0.24 ± 0.56 vs. 0.07 ± 0.27) and *Time and Temperature Control* (0.18 ± 0.49 vs. 0.08 ± 0.29). Although previous research has indicated higher relative risks *(14)*, violations related to adequate cooking were rare in both restaurants and schools (0.05 ± 0.26 vs. 0.01 ± 0.11).

Restaurants and schools did not differ in the number of violations for *Approved Sources of Food.* School foodservice operations have strict regulations related to food sources and vendor selection. A more detailed investigation of the school foodservice inspection data showed that of the 133 violations in this category, 93 were due to use of unpasteurized eggs in Rhode Island. The Rhode Island food codes, consistent with the federal food codes, state that using unpasteurized eggs is prohibited when further cooking of the eggs is not required *(22)*. The types of food affected by this prohibition include: "[s]alad dressings, sauce such as hollandaise or Béarnaise, mayonnaise, meringue, ice cream, or raw egg containing beverages" *(24)*. We could not identify the food products using unpasteurized eggs because this was a retrospective study.

School foodservice and restaurant operations did not differ significantly in violations related to cooling practices. Cooling practices are often implicated in foodborne illness outbreaks in foodservice establishments *(7)*, but improper cooling practices continue to be a particular concern in school foodservice operations *(11)*. School foodservice directors identified several challenges to proper cooling: cooling not being completed before the workday ends, lack of equipment, and inadequate refrigerator and freezer space *(11)*. Our results are consistent with this finding. School foodservice and restaurant operations did not differ significantly in behavioral violations related to *Use of Thermometer and Test Kits*; the numbers were low, indicating that this issue was not a common problem (0.01 ± 0.10 for restaurants vs. 0.00 ± 0.07 for school foodservice operations).

Food code violations in the *Ware Washing* category, one of two categories in which restaurants performed better than schools, included "equipment and utensils scraped and soaked," "wash rinse water clean," "proper temperature (for ware washing)," and "sanitization frequency and methods." These violations are related to employee behavior, as are the following in *Garbage and Recycling Facilities Outside*:

TABLE 2. Mean number of behavioral violations within each category in schools and restaurants

Violation Categories	Restaurants (n = 2,624)	Schools (n = 2,511)	t	P[a]
	Mean ± SD			
Use of Single-use Gloves & Utensils/ Bare Hand Contact	0.38 ± 0.86	0.04 ± 0.22	19.28	< 0.001
Pest & Animal Controls	0.23 ± 0.68	0.00 ± 0.04	17.43	< 0.001
Protecting Food from Contamination	0.29 ± 0.58	0.10 ± 0.32	14.47	< 0.001
Use of Utensils & Linens	0.24 ± 0.56	0.07 ± 0.27	14.37	< 0.001
Non-food Contact Surface Maintenance	0.27 ± 0.53	0.09 ± 0.29	14.96	< 0.001
Time & Temperature Control	0.18 ± 0.49	0.08 ± 0.29	9.60	< 0.001
Date-marking & Labeling	0.17 ± 0.43	0.03 ± 0.19	14.89	< 0.001
Personal Cleanliness & Grooming	0.14 ± 0.39	0.03 ± 0.19	12.44	< 0.001
Storage of Toxic Items & Personal Items	0.13 ± 0.38	0.05 ± 0.23	8.73	< 0.001
Food contact Surface Maintenance	0.13 ± 0.34	0.06 ± 0.23	8.49	< 0.001
Handwashing & Handwash Sinks	0.09 ± 0.31	0.03 ± 0.18	7.86	< 0.001
Person in Change	0.09 ± 0.30	0.02 ± 0.16	9.49	< 0.001
Wiping Clothes	0.08 ± 0.27	0.03 ± 0.16	8.32	< 0.001
Approved Food Sources[b]	0.07 ± 0.27	0.05 ± 0.23	1.79	0.074
Premises & Equipment Maintenance	0.07 ± 0.26	0.04 ± 0.22	3.34	0.001
Cooking	0.05 ± 0.26	0.01 ± 0.11	7.73	< 0.001
Display of Valid Permit and Consumer Advisories[c]	0.05 ± 0.24	0.04 ± 0.21	1.76	0.079
Ware Washing[d]	0.04 ± 0.21	0.07 ± 0.27	-4.60	< 0.001
Thawing	0.04 ± 0.19	0.02 ± 0.16	3.32	0.001
Employee Health	0.02 ± 0.17	0.00 ± 0.05	5.30	< 0.001
Cooling[e]	0.02 ± 0.15	0.02 ± 0.14	1.36	0.174

Table 2 Continued on next page

TABLE 2. Mean number of behavioral violations within each category in schools and restaurants

Violation Categories	Restaurants (n = 2,624)	Schools (n = 2,511)	t	P[a]
	Mean ± SD			
Water & Ice Supply	0.02 ± 0.15	0.00 ± 0.03	6.79	< 0.001
Garbage & Recycling Facilities Outside[f]	0.02 ± 0.14	0.03 ± 0.19	-2.96	0.003
Reheating	0.02 ± 0.13	0.01 ± 0.07	3.67	< 0.001
Use of Thermometers & Test Kits[g]	0.01 ± 0.10	0.00 ± 0.07	1.23	0.220

[a]Based on independent *t*-tests between school inspections and restaurant inspections

[b]Examples of Approved Food Sources: Food shall be safe, unadulterated and honestly presented; Discarding or reconditioning unsafe, adulterated or contaminated food; Food obtained from approved source; Food in good condition, safe, and unadulterated; Proper disposition of returned, previously served, reconditioned, and unsafe food; Pasteurized egg used when needed

[c]Examples of Display of Valid Permit and Consumer Advisories: Consumer advisory required with respect to animal-derived foods that are raw, undercooked, or not otherwise processed to eliminate pathogens; Valid license to operate, non-renewal of license, license not transferable

[d]Examples of Ware Washing: Equipment and utensils scraped and soaked, wash rinse water clean, proper temperature; sanitization frequency and methods

[e]Examples of Cooling: Proper cooling time and temperature

[f]Examples of Garbage and Recycling Facilities Outside: Operating and maintenance of storage areas; redeeming machines, receptacles and waste handling units

[g]Examples of Use of Thermometers and Test Kits: Thermometer repair and calibration

"operating and maintenance of storage areas" and "redeeming machines, receptacles and waste handling units." Although school foodservice establishments had more violations in these categories, the effects of these violations on food safety are not as serious as the effects of other behavioral violations *(14)*. Food safety experts have rated avoiding cross-contamination as the most important factor in food safety, followed by personal hygiene, keeping food at safe temperatures, and adequate cooking, all of which can be addressed in training *(14)*.

Non-behavioral Violations

The mean scores of non-behavioral violations in most categories were higher for restaurants than for schools *(Table 3)*. Most non-behavioral violations were non-critical and related to facility maintenance and conditions over which foodservice employees have little control; however, such violations cause low health inspection scores and negative publicity. Because the general public may not understand that different types of violations affect food safety risks differently, foodservice managers in both restaurants and schools must resolve these issues quickly.

Overall, restaurants had significantly more non-behavioral violations, although restaurants and school foodservice establishments did not differ significantly in the number of violations in two categories: *Premises and Equipment Conditions and Waste Water and Sewage*. Examples of these violations are "floors, walls, ceilings in good repair, clean, constructed properly," "dressing rooms and lockers adequate, clean," and "equipment in good repair and properly adjusted." This finding indicates that both school foodservice establishments and restaurants need to maintain their facilities better. Even though the mean scores were low, schools also have slightly more violations related to having appropriate equipment for holding hot and cold food *(Adequate Equipment for Cold/Hot Holding; $t = -4.14, P < 0.001$)*.

TABLE 3. Mean number of selected non-behavior-related violations within each category in schools and restaurants

Violation Categories	Restaurants (n = 2,624)	Schools (n = 2,511)	t	P[a]
	Mean ± SD			
Premises & Equipment Maintenance[b]	0.33 ± 0.56	0.30 ± 0.62	1.85	0.064
Plumbing & Adequate Toilet Facilities	0.26 ± 0.64	0.11 ± 0.36	10.62	< 0.001
Food Contact Surface Maintenance	0.15 ± 0.41	0.05 ± 0.23	11.52	< 0.001
Ware Washing	0.15 ± 0.42	0.03 ± 0.19	12.78	< 0.001
Non-food Contact Surface Maintenance	0.14 ± 0.37	0.09 ± 0.29	4.96	< 0.001
Water & Ice Supply	0.14 ± 0.43	0.02 ± 0.16	12.73	< 0.001
Lighting & Ventilation	0.14 ± 0.45	0.08 ± 0.36	5.47	< 0.001
Use of Thermometers & Test Kits	0.11 ± 0.34	0.07 ± 0.27	5.21	< 0.001
Pest & Animal Controls	0.05 ± 0.21	0.03 ± 0.18	2.58	0.010
Waste Water & Sewage[c]	0.02 ± 0.13	0.03 ± 0.17	-1.87	0.062
Adequate Equipment for Cold/ Hot Holding [d]	0.00 ± 0.00	0.01 ± 0.09	-4.14	< 0.001

[a]Based on independent *t*-tests between school inspections and restaurant inspections

[b]Examples of Premises and Equipment Maintenance: Floors, walls, ceilings in good repair, clean, constructed properly; dressing rooms and lockers adequate, clean; equipment good repair and proper adjustments

[c]Examples of Waste Water and Sewage: Capacity and drainage of sewage holding tank; disposal of sewage and non-sewage; proper disposal of waste water

[d]Examples of Adequate Equipment for Cold/Hot Holding: Cooling, heating, and holding capacities

According to the 2009 Food Code *(24)*, time, as the method of control (§3-501.19), is appropriate if food is < 41ºF or >135ºF when it is placed in holding equipment and if it is consumed within four hours. Many schools prepare food close to the serving time, so hot holding equipment may not be needed. The authors, cannot determine, however, if cited institutions fit into this category. Both school foodservice professionals and restaurant owners may need to evaluate their operations and provide appropriate holding equipment to make sure food temperature remains at safe levels.

Critical and Non-critical Violations

On average, critical violations in most categories were more frequent in restaurants than in school foodservice operations *(Table 4)*. Most critical violations in restaurants were related to *Protecting Food from Contamination, Time and Temperature Control, Handwashing and Handwash Sinks, Storage of Toxic Items and Personal Items, Food Contact Surface Maintenance, Person in Charge, and Use of Single-use Gloves and Utensils/Bare Hand Contact.* The only two critical violations for which mean scores did not differ significantly between restaurants and schools

TABLE 4. Mean number of critical violations within each category in schools and restaurants

Violation Categories	Restaurants (n = 2,624)	Schools (n = 2,511)	t	P[a]
	Mean ± SD			
Protecting Food from Contamination	0.20 ± 0.46	0.03 ± 0.18	17.41	< 0.001
Time & Temperature Control	0.16 ± 0.44	0.06 ± 0.27	9.42	< 0.001
Handwashing & Handwash Sinks	0.14 ± 0.40	0.06 ± 0.25	9.45	< 0.001
Storage of Toxic Items & Personal Items	0.13 ± 0.38	0.05 ± 0.23	8.73	< 0.001
Food Contact Surface Maintenance	0.12 ± 0.33	0.05 ± 0.22	9.47	< 0.001
Person in Change	0.09 ± 0.29	0.02 ± 0.16	9.49	< 0.001
Approved Food Sources	0.06 ± 0.24	0.02 ± 0.13	7.26	< 0.001
Pest & Animal Controls	0.05 ± 0.21	0.03 ± 0.18	2.58	0.010
Date-marking & Labeling	0.05 ± 0.22	0.01 ± 0.11	7.86	< 0.001
Display of Valid Permit and Consumer Advisories	0.05 ± 0.24	0.04 ± 0.21	2.09	0.037
Use of Single-use Gloves & Utensils/Bare Hand Contact	0.05 ± 0.28	0.00 ± 0.00	9.11	< 0.001
Personal Cleanliness & Grooming	0.03 ± 0.18	0.01 ± 0.08	5.90	< 0.001
Water & Ice Supply	0.03 ± 0.17	0.01 ± 0.10	4.15	< 0.001
Employee Health	0.02 ± 0.17	0.00 ± 0.05	5.30	< 0.001
Adequate Equipment for Cold/ Hot Holding	0.03 ± 0.16	0.01 ± 0.11	3.73	<0.001
Ware Washing	0.03 ± 0.16	0.04 ± 0.19	-2.01	0.45
Cooking	0.02 ± 0.15	0.00 ± 0.03	7.21	< 0.001
Reheating	0.02 ± 0.13	0.00 ± 0.07	3.68	< 0.001
Use of Utensils & Linens	0.01 ± 0.10	0.01 ± 0.08	1.28	0.202
Cooling	0.01 ± 0.09	0.00 ± 0.07	2.45	0.014

[a]Based on independent *t*-tests between school inspections and restaurant inspections

were related to: *Display of Valid Permit and Consumer Advisories and Ware Washing.* In both cases, *P* values were greater than 0.01.

Non-critical violations in most categories also occurred more often in restaurants than in school foodservice operations. The number and patterns of non-critical violations in different categories were similar to those of non-behavioral violations. Most non-critical violations were found in *Premises and Equipment Maintenance* for both restaurants (0.41 ± 0.65) and schools (0.34 ± 0.67), with $P < 0.001$. Other prevalent non-critical violation categories were *Non-food Contact Surface Maintenance, Plumbing and Adequate Toilet Facilities, Pest and Animal Controls, and Use of Utensils and Linens.* Schools had fewer citations than restaurants in all of these categories. Although the mean scores were low, restaurants had fewer violations ($P < 0.001$) than schools in two categories: *Approved Food Sources* (0.01 ± 0.11 versus 0.04 ± 0.20, $t = -6.05$) and *Adequate Equipment for Cold/Hot Holding* (0.00 ± 0.00 versus 0.0± 0.08, $t = -4.14$).

Two by two cross-tabulation tables were created and odds ratios of behavioral, non-behavioral, critical, and non-critical violations were calculated to evaluate the likelihood of restaurants receiving particular types of citations compared to schools. *Table 5* includes cross-tabulation tables and odds ratios.

Restaurants were 3.6 times more likely than schools to have behavioral violation citations and 3.0 times more likely than schools to have critical violation citations. Even though the facilities themselves were smaller, the odds of receiving non-behavioral and non-critical Food Code violation citations in restaurants were more than double those of schools.

Such clear differences in the odds of specific types of violations occurring were not unexpected. As explained earlier, restaurant and school operations differ in operating hours, types and number of food items prepared, and complexity of preparation. Therefore, restaurants may be more likely than schools to prepare or serve unsafe food. Previous research by the CDC showed that 10 times more foodborne illness outbreaks were associated with restaurants than schools *(16)*. Our findings based on health inspection reports are consistent with the frequency of foodborne illness outbreaks at these establishments.

CONCLUSIONS/RECOMMENDATIONS

Our purpose was to identify target behaviors for food safety training, to indicate the need for necessary facility improvements, and to consider other non-behavioral risks. This study quantified the food safety risks using health inspection reports of restaurants and school foodservice operations, two of the most common foodservice environments responsible for foodborne illness outbreaks in the U.S. These data confirmed that school foodservice operations had significantly fewer health inspection citations than restaurants, which indicates lower food safety risks for school foodservice.

Food code violations for which numbers of citations were greater in restaurants were: *Use of Single-use Gloves and Utensils/Bare Hand Contact, Protecting Food from Contamination, Non-food Contact Surface Maintenance, Use of Utensils and Linens, Pest and Animal Controls, and Time and Temperature Control.* Other than *Non-food Contact Surface Maintenance* and *Use of Utensils and Linens,* all of these behavioral violations also are considered critical violations. School foodservice operations had fewer behavioral violations in all of these categories.

School foodservice operations had the greatest number of citations in *Premises and Equipment Maintenance,* followed by *Plumbing and Adequate Toilet Facilities.* Violations in these categories are often related to the age and poor maintenance of facilities and have little, direct impact on food safety risks. Furthermore, foodservice employees and managers have little influence over decisions to improve these facility problems. School foodservice personnel may need to bring the health inspection violations related to this category to the attention of school administrators to encourage needed improvements.

TABLE 5. Cross-tabulation and odds ratios of behavioral, non-behavioral, critical, and non-critical violations

	Restaurants (n = 2,624)	Schools (n = 2,511)	
	No. of Facilities with Violations (%)		Odds Ratio
Behavioral violations	2,123 (80.9%)	1,364 (54.3%)	3.6
Non-behavioral violations	1,793 (68.3%)	1,268 (50.5%)	2.1
Critical violations	806 (32.1%)	1,542 (58.8%)	3.0
Non-critical violations	2,194 (83.6%)	1,726 (68.7%)	2.3

School foodservice operations serve many children and garner frequent attention from the media *(8,21)*. However, our findings showed that in general, school foodservice operations incur far fewer violations than restaurants, especially high risk violations. School foodservice directors, managers, supervisors, and employees still must remain aware of their facilities, equipment, and overall food safety programs to minimize risks.

To our knowledge, this study was the first attempt to analyze health inspection reports over states. Because most state, county, or local health departments use different health inspection systems, a pre-determined coding system was created. Every food code item in the three states was used to determine appropriate categories and an alignment with behavioral or critical violations. This classification method allowed us to evaluate health inspection reports from three different states using consistent criteria. Food safety researchers who want to compare violations may benefit from using the categorization protocol developed for this research.

Our data are not free from limitations. The researchers selected a convenience sample of three states in the U.S., and our results may not be generalizable beyond these three states. Other states use different inspection systems, and violations identified in one state may not be always identifiable from other states' inspection reports.

While our data provide insight about general food safety challenges in restaurants and schools, many unanswered questions remain about health inspection data. One concern centers on the large number of citations for unpasteurized eggs in schools in one state. The Food Code *(24)* mandates the use of pasteurized eggs for only those food items that contains raw or undercooked eggs. To our knowledge, school foodservice operations do not typically serve raw or undercooked eggs or food items containing raw eggs. Under such conditions, use of unpasteurized eggs may not in itself pose a food safety threat. Further investigation may determine how purchasing fresh eggs violated the Food Code and/or how raw eggs are being used in schools. Based on such an investigation, we may be able to identify food safety risks associated with purchasing unpasteurized eggs, justifying the requirement that only pasteurized eggs be purchased.

The degree of severity of any violation may vary; our findings focus only on the frequency of citations. Because some Food Code violations may pose more food safety risk than others, our data may not adequately represent the severity of food safety risk in restaurants or school foodservice operations. Future research could quantify relative food safety risks for Food Code violations so that food safety training can be modified without the need to observe a large number of foodservice facilities. Future research could also evaluate food safety risks in other types of foodservice operations (e.g., long-term care facilities, hospitals, grocery stores, or lodging operations).

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