PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 40, No. 3, p. 154–163

2900 100th Street, Suite 309, Des Moines, IA 50322-3855

Soojin Lee* and Pei Liu

*Hospitality Management, University of Missouri-Columbia, Columbia, MO 65201, USA

Food Safety in School Foodservice Operations: A Review of Health Inspections in the State of Missouri

ABSTRACT

Foodborne illness is a growing health concern, endangering many people in the state of Missouri, U.S. This study focused on assessing the frequencies of the most common food violations in schools, using a review of health inspection data. The present study analyzed publicly available health inspection reports from a total in 509 schools in 28 counties in Missouri. Among the various types of health inspections, the routine inspection was the one most frequently conducted at schools. The top three critical violations found at schools were food temperature control for potentially hazardous foods, improper equipment usage, and misuse of poisonous and toxic materials. For non-critical violations, the top three violations were related to improper equipment usage, physical facilities, and equipment for holding food at a given temperature. The results showed that more non-critical violations than critical violations occurred at schools. One-way ANOVA revealed significant differences, particularly in non-critical violations, among the thirteen different types of schools. The study indicates that school foodservice management needs to improve food safety practices by focusing on preventive training, ServSafe certification, and personally conducted inspections. Hence, this study provides practical recommendations and identifies areas that should be improved, which could result in preventing foodborne outbreaks and reducing the number of food code violations detected during health inspections.

INTRODUCTION

In the United States, restaurants are regularly inspected by the health department of each state or county *(23)*. Approximately 48 million people become sick or hospitalized because of foodborne pathogens each year *(5)*, and this figure is predicted to continue into the 2020s *(20)*. The number of foodborne outbreaks started to increase rapidly in 2009 and reached its peak in 2016 *(5, 6)*. For these reasons, it is crucial that health inspections be conducted to reduce the numbers of sicknesses and deaths caused by foodborne disease outbreaks.

*Author for correspondence: Phone: +1 213.393.3484; Email: slff5@mail.missouri.edu

Foodborne illness, which occurs after consumption of contaminated foods or beverages *(5)*, is also referred to as "food poisoning" *(5)*. Numerous contaminants can cause such outbreaks; a growing number of them are caused by bacteria, viruses, and parasites *(29)*. *Salmonella* is identified as one of the most frequently implicated pathogens *(5)*. Common foodborne illness symptoms are vomiting, diarrhea, fever, respiratory failure, nausea, and abdominal pain *(29)*. Each year during the early 2010s, an estimated 1 in 6 Americans reported having had a foodborne illness; 128,000 people were hospitalized, and approximately 3,000 died as a result of consuming contaminated foods each year *(4)*. Obviously, contaminated food can result in substantial numbers of illnesses, hospitalizations, and deaths *(4, 5)*.

During the 1990s, foodborne illness outbreaks occurred in numerous schools in the U.S., affecting approximately 16,000 students, with around 300 cases reported *(7)*. A study by Dewey-Mattia *(9)* states that 69 foodborne outbreaks and 2,164 illnesses were reported between 2009 and 2015. At schools, the average number of illnesses per outbreak was 31 cases. With regard to these findings, schools are required to constantly comply with food safety policies and regulations to minimize the risk of foodborne illness. Since students consume the majority of the meals served at schools and are particularly vulnerable *(9, 11, 22)*, and because schools serve more meals than restaurants do, it is crucial that schools implement food safety policies that ensure students' well-being *(20, 26)*.

Restaurant inspection results are an important aspect of evaluating the risk of foodborne outbreaks *(12, 25)*. Many people use publicly available restaurant inspection results to help them decide where to dine, as health inspections can ensure the adequacy of food hygiene and food safety practices at restaurants *(2, 32)*. Moreover, as Seiver and Hatfield *(23)* pointed out, health inspection plays a key role in increasing awareness on the part of restauranteurs to comply with regulations. According to the CDC *(7)*, a total of 139 and 147 foodborne illnesses occurred at schools in the State of Missouri in 2016 and 2017, respectively. School foodservice operations in Missouri receive at least one health inspection annually *(7)*. Kwon et al. *(14)* stated that a higher frequency of inspection indicates a lack of food safety practices, as an increased number of inspections is due to complaints and the need for follow-up visits.

According to the Missouri Department of Health and Senior Services *(18)*, all health inspections, including inspections of schools in the State of Missouri, should use the principles of Hazard Analysis Critical Control Points (HACCP) as a basis for food safety practice. Local health departments in Missouri routinely inspect all foodservice facilities for risks to public health. One of the food code categories, called "compliance and enforcement," explains that foodservice establishments should maintain and demonstrate their HACCP plans accordingly. According to the food code for food establishments in the State of Missouri; *(19)*, management and personnel; food; equipment, utensils, and linens; water and plumbing; physical facilities; poisonous or toxic materials; and compliance and enforcement are the seven major categories in the Missouri state inspection food code. Foodservice establishments with poor inspection results are at an increased risk of being the source of foodborne outbreaks *(12)*.

In Missouri, two different types of food violations can be detected during the health inspection: critical and non-critical violations *(18)*. Foodservice operation violations are classified as either critical or non-critical, depending on the condition of the facility during the inspection. According to Ambrose *(1)*, critical violations pose unacceptable health risks that can lead to foodborne illness, while non-critical violations do not. Common critical violations can include failure to maintain proper food temperature, food storage, employee hand washing, labeling, pest control, and poisonous material use *(1, 27, 28)*. A study by Philips, Elledge, Basara, Lynch, and Boatright *(21)* revealed that unacceptable food-holding temperatures and employee hygiene practices were the two most frequently cited critical violations during the health inspections. Because critical violations have a direct impact on the safety of diners, immediate actions are required to adjust the problem *(1)*. Restaurants repeatedly given reports of critical violations are subject to being suspended for at least a day. Although non-critical violations are not required to be adjusted immediately, they may possibly lead to critical violations in the future *(3)*. When routine inspections are conducted at schools, the schools are required to be prepared for immediate adjustments if critical violations occur *(15, 24)*. If the violations are non-critical, follow-up inspections must be performed within a short period of time to verify that corrective actions have been taken *(24)*.

This study examined the relationship between the number of critical and non-critical violations recorded and food safety issues in a sample of schools in Missouri, to predict which aspects of health inspections are most lacking in schools in Missouri. Although previous studies have investigated restaurant inspection results in other states in the U.S., none has explored school foodservice inspection results specifically in the state of Missouri. Thus, the main objective of this research study is to access the current food safety practices at school foodservice operations in Missouri by reviewing health inspection reports. Specifically, this study will use secondary data to review the past six years of health inspection results at school foodservice operations, to assess which categories of violations are most frequently seen, and to provide recommendations on improving food safety practices, with the ultimate goal of preventing foodborne disease outbreaks at schools.

TABLE 1. Number of health inspections conducted by types (*N* = 3,174)

Type of inspection	*N*	%
Routine	2,984	94.0
Follow-up	177	5.6
Pre-opening	11	0.3
Complaint	2	0.1
Total	**3,174**	**100**

TABLE 2. Number of food violations during school health inspections (*N* = 3,180)

Type of violations	*N*[a]	Mean ± SD
Critical Violation	1,108	1.53 ± 0.88
Non-critical Violation	2,072	1.90 ± 1.40
Total	**3,180**[b]	

[a]Number of violations found at school foodservice operations from January 2013 through December 2018
[b]0 number of violations excluded from the total

METHODS

The study analyzed data on a total of 509 schools from 28 counties in the state of Missouri, using health inspection results that were available to the public on each county's website. From the list of all foodservice operations with inspection results from each county, only schools were used as the sample of this study. Accordingly, there was no need to obtain approval from the Institutional Review Board, because the data collected were available to all on the website. All violations from school foodservice operations in Missouri were coded and then cross-checked by two research assistants. Health inspection data on Missouri School foodservice operations from January 2013 through December 2018 were collected and analyzed for the study. Routine inspections, follow-ups, complaints, and pre-opening permits at school foodservice operations were included. Health inspections had been performed by personnel in each county health department in accordance with Missouri state laws and regulations. Inspection results with scale grading, letter grades and similar results that did not include critical or non-critical violation codes were removed from the analysis. Although Missouri has 114 counties *(31)*, the study utilized school health inspection results from only 28 counties, as data from these were available to the public. The data included information such as the name of the school, type of inspection, county, location, phone number, date of inspection, and type of foodservice provided. The collected data were analyzed by use of the IBM SPSS 25.0 statistical package.

RESULTS

Descriptive statistics

This study examined the relationship between the results of Missouri school service operations health inspections and food safety violations. The results, a total of 3,176 inspection results from 509 school foodservice operations, indicated the types of inspection conducted: routine, follow-up, pre-opening, and complaint *(Table 1)*. Of all inspections, routine inspection (n = 2984, 94.0%) was the most frequently conducted, followed by follow-up (n = 177, 5.6%), pre-opening (n = 11, 0.3%), and complaint (n = 2, 0.1%). *Table 2* shows the total number of critical and non-critical violations recorded during these health inspections. A total of 1,108 critical violations (M = 1.53, SD ± 0.88) and 2,072 (M = 1.90, SD ± 1.40) non-critical violations were found. The number of both critical and non-critical violations were rank-ordered by county, as shown in *Table 3 and 4*. The number of food codes for each one of the critical violations was computed. Of the 28 counties, the top four with the most critical food code violations were identified. As shown in *Table 3*, Clay County (n = 295, 26.6%) was the county having the most critical violations, followed by Cape Girardeau (n

TABLE 3. Number of critical violations by county in rank order (*N* = 1,108)

County[a]	Rank order	*N*	%[b]
Clay	1	295	26.6
Cape Girardeau	2	137	12.4
Saint Francois	3	135	12.2
Boone	4	96	8.7
Ste. Genevieve	5	86	7.8
Adair	6	75	6.8
Johnson	7	63	5.7
Newton	8	55	5.0
Andrew	9	41	3.7
Saint Francois	10	34	3.1
Harrison	11	20	1.8
Randolph	12	18	1.6
Shannon	13	10	0.9
Taney	14	9	0.8
Jackson	15	7	0.6
Perry	16	7	0.6
Daviess	17	4	0.4
Ripley	18	4	0.4
Butler	19	3	0.3
Christian	20	3	0.3
Mercer	21	3	0.3
Mississippi	22	2	0.0
Warren	23	1	0.0
Benton	24	0	0
Laclede	25	0	0
Howell	26	0	0
Stone	27	0	0
Dallas	28	0	0
Total		**1,108**	**100**

[a]For some counties, inspection results were not publicly available

[b]Percentage is rounded to the nearest tenth

= 137, 12.4%), Saint Francois (*n* = 135, 12.2%) and Boone County (*n* = 96, 8.7%). Additionally, the number of non-critical violations by county was computed, and is shown in *Table 4*. Cape Girardeau (*n* = 365, 17.6%) was the county with the most non-critical violations, followed by Johnson (*n* = 244, 11.8%) and Adair (*n* = 209, 10.1%). As shown by the number of critical violations displayed in *Table 5*, food violations associated with temperature (*n* = 537, 48.5%) were the violations reported most frequently at school foodservice operations. Equipment usage, storing and cleaning of utensils, and linens (*n* = 317, 28.6%) followed in the rank order. Of the non-critical violations *(Table 6)*, equipment usage, storing and cleaning of utensils, and linens (*n* = 917, 44.3%) appeared to be the most frequently violated food codes from schools in Missouri, followed by physical facilities (*n* = 612, 29.5%), foods/temperatures (*n* = 279, 13.4%), and

TABLE 4. Number of non-critical violations by county in rank order (*N* = 2,072)

County[a]	Rank order	*N*	%[b]
Cape Girardeau	1	365	17.6
Johnson	2	244	11.8
Adair	3	209	10.1
Greene	4	202	9.8
Butler	5	195	9.4
Clay	6	157	7.6
Saint Francois	7	141	6.8
Boone	8	119	5.7
Randolph	9	106	5.1
Andrew	10	101	4.9
Newton	11	51	2.5
Shannon	12	42	2.0
Ripley	13	30	1.5
Harrison	14	27	1.3
Jackson	15	19	0.9
Taney	16	13	0.6
Christian	17	8	0.4
Mercer	18	8	0.4
Ste. Genevieve	19	8	0.4
Howell	20	7	0.3
Perry	21	7	0.3
Daviess	22	6	0.3
Warren	23	3	0.2
Benton	24	2	0.1
Dallas	25	1	0
Stone	26	1	0
Laclede	27	0	0
Mississippi	28	0	0
Total		**2,072**	**100**

[a]For some counties, inspection results were not publicly available
[b]Percentage is rounded to the nearest tenth

water, plumbing, and waste (n = 216, 10.4%). These top four violation categories accounted for more than 90 percent of the total violations.

One-way ANOVA and critical/non-critical violations

The most critical violations were related to management and personnel $F(9, 37) = 0.457$, $P > 0.05$; temperatures $F(11, 378) = 0.634$, $P > 0.05$; equipment, utensils, and linens $F(10, 256) = 0.461$, $P > 0.05$; water, plumbing, and waste $F(5, 41) = 0.736$, $P > 0.05$; physical facilities $F(8, 58) = 0.297$, $P > 0.05$; poisonous or toxic materials $F(6, 61) = 0.896$, $P > 0.05$; and compliance and enforcement $F(3, 6)$ = n/a, $P > 0.05$. The thirteen different types of schools were similar with regard to all reported critical violations. As described in *Table 7*, the most frequently seen non-critical violations were those related to food temperatures. Special needs'

TABLE 5. Number of critical violations reported in rank order (*N* = 1,108)

Food Code Description[a]	Rank order	*N*	%
*Temperatures	1	537	48.5
*Equipment, utensils, and linens	2	317	28.6
*Poisonous and toxic materials	3	73	6.6
*Physical facilities	4	72	6.5
*Management and personnel	5	50	4.5
*Water, plumbing, and waste	6	49	4.4
*Compliance and enforcement	7	10	0.9
Total		**1,108**	**100**

[a]Description of violations provided by Missouri Food Code for food establishments in the state of Missouri

TABLE 6. Number of non-critical violations reported in rank order (*N* = 2,072)

Food Code Description[a]	Rank order	*N*	%
*Equipment, utensils, and linens	1	917	44.3
*Physical facilities	2	612	29.5
*Temperatures	3	279	13.4
*Water, plumbing, and waste	4	216	10.4
*Management and Personnel	5	33	1.6
*Poisonous and toxic materials	6	8	0.4
*Compliance and enforcement	7	7	0.4
Total		**2,072**	**100**

[a]Description of violations provided by Missouri Food Code for food establishments in the state of Missouri

schools ($M = 0.24$, $SD = \pm 0.54$) reported significantly more non-critical violations related to keeping foods at proper temperatures $F\,(3, 54) = 3.492$, $P < 0.001$, storing equipment and utensils $F\,(12, 1) = 8.458$, $P < 0.001$, management and personnel $F\,(12,1) = 3.781$, $P < 0.001$, water, plumbing, and waste $F\,(12, 3\,) = 2.621$, $P < 0.05$, and compliance and enforcement $F\,(12, 4) = 17.442$, $P < 0.001$ than did juvenile schools. For food code categories that specifically include management controls, special needs' schools ($M = 0.10$, $SD = \pm 0.30$) also reported significantly elevated numbers of violations. Thus, one-way ANOVA tests uncovered possible differences in non-critical violations among thirteen different types of schools; K–12, childcare, juvenile, preschool, elementary, high school, middle school, after school, campus dining, culinary, Christian, Catholic, and special needs' schools. The descriptions of critical and non-critical violations are presented in *Table 8*.

DISCUSSION

The present study reports key findings about the past six years' health inspection results at school foodservice operations in Missouri. Results show that a relatively large number of routine inspections as opposed to follow-up inspections, were conducted at school foodservice operations. Among different types of inspections, more than 1,100 critical and 2,000 non-critical violations were observed. Foodservices that serve high-risk populations should select credible vendors for foods and supplies and create preventive programs, including employee training programs *(30)*. As indicated by Bishop *(3)*, schools should

TABLE 7. One-way ANOVA of non-critical violations results

	Types of violation						
Type of school	Temperature	Equipment	Management	Physical facilities	Water, plumbing, waste	Poisonous & toxic	Compliance & enforcement
K–12[a]	0.10 ± 0.35	0.30[eik] ± 0.64	0.01[m] ± 0.12	0.21 ± 0.56	0.05[f] ± 0.23	0.00 ± 0.00	0.00[m] ± 0.00
Childcare[b]	0.06 ± 0.24	0.53[eh] ± 0.78	0.05[eg] ± 0.22	0.16 ± 0.40	0.02 ± 0.16	0.00 ± 0.00	0.01[m] ± 0.11
Juvenile[c]	0.00 ± 0.00	0.38 ± 0.52	0.00[i] ± 0.00	0.25 ± 0.46	0.00 ± 0.00	0.00 ± 0.00	0.00[m] ± 0.00
Preschool[d]	0.08 ± 0.28	0.22 ± 0.42	0.01[m] ± 0.00	0.17 ± 0.38	0.05 ± 0.23	0.00 ± 0.00	0.00[m] ± 0.00
Elementary[e]	0.05[fi] ± 0.27	0.18[abfgikm] ± 0.46	0.00[bim] ± 0.07	0.16 ± 0.54	0.06[f] ± 0.24	0.00 ± 0.00	0.00[m] ± 0.03
High school[f]	0.11[e] ± 0.37	0.35[ei] ± 0.78	0.01[m] ± 0.12	0.24 ± 0.67	0.11[ae] ± 0.37	0.00 ± 0.00	0.00[m] ± 0.00
Middle school[g]	0.10 ± 0.35	0.30[eik] ± 0.70	0.00[bim] ± 0.06	0.18 ± 0.53	0.09 ± 0.29	0.01 ± 0.09	0.00[m] ± 0.00
After school[h]	0.03[i] ± 0.18	0.16[bikm] ± 0.44	0.00[m] ± 0.00	0.16 ± 0.72	0.00 ± 0.00	0.00 ± 0.00	0.00[m] ± 0.00
Campus dining[i]	0.22[e] ± 0.45	0.62[ae] ± 0.90	0.05[e] ± 0.22	0.36[j] ± 0.61	0.09 ± 0.33	0.00 ± 0.00	0.00 ± 0.00
Culinary[j]	0.15 ± 0.37	0.30 ± 0.47	0.00 ± 0.00	0.00[i] ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Christian[k]	0.12 ± 0.36	0.57 ± 0.97	0.01 ± 0.11	0.27 ± 0.67	0.08 ± 0.31	0.00 ± 0.00	0.00 ± 0.00
Catholic[l]	0.08 ± 0.32	0.30 ± 0.63	0.00 ± 0.00	0.16 ± 0.46	0.06 ± 0.25	0.00 ± 0.00	0.00 ± 0.00
Special needs[m]	0.24 ± 0.54	0.76 ± 0.94	0.10 ± 0.30	0.05 ± 0.22	0.19 ± 0.51	0.00 ± 0.00	0.14 ± 0.48
F	3.492	8.458	3.781	1.865	2.621	0.794	17.442
Sig	**0.000****	**0.000****	**0.000****	**0.034***	**0.002***	0.657	**0.000****

pay close attention to non-critical violations, since these can become critical violations that affect many students if they are neglected. Additionally, in line with prior research emphasizing the need to conduct health inspections repeatedly *(33)*, managers at school foodservice operations should maintain proper food safety practices equal to those of other foodservice establishments with no critical violations. In discussing the number of critical and non-critical violations by county, in rank order, we found differences in the number of violations seen in schools in different counties.

Food temperature, food storage, and labeling appear to be the most frequently violated food safety practices at schools in Missouri. These observations of critical violations are consistent with results in the literature *(1, 24)*. According to Thomas et al. *(24)*, keeping foods at appropriate temperatures can significantly reduce the number of foodborne illnesses. Another study *(16)* also reported that food temperature should be accurately measured with a thermometer. In terms of food temperature control, our results indicate that more critical than non-critical violations were observed at school foodservice operations. Since failure to hold foods at proper temperatures can likely contribute to foodborne outbreaks, there is an obvious need for schools in Missouri to train foodservice employees properly on controlling food temperatures. The food code categories of equipment usage and storing and cleaning of utensils were also frequently violated in childcare, campus dining, and special needs' schools. Because a significant number of foodborne illnesses are caused by failure to prevent cross-contamination, foodborne illnesses can be prevented by properly storing utensils and linens *(24)*.

Hence, it is essential that schools pay more attention to keeping all utensils and equipment clean. In addition, the current study shows that equipment usage and storing of utensils were most often associated with non-critical violations, followed by maintenance of physical facilities, management of food temperatures, and prevention of food waste. The results call attention to the need for all equipment at foodservice operations to be kept clean and free of chips, cracks, inclusions, and imperfections. Receptacles should be cleaned in a way that does not contaminate food or equipment. Exterior surfaces of food establishment buildings, such as outdoor walking areas, driving areas and storage areas, should be protected from contamination, and food waste should be kept outside the foodservice operation in containers with tight-fitting lids.

The current study examined the differences between types of school and food violations within the seven food code

TABLE 8. Description of critical and non-critical violations

General category	Critical violations	Non-critical violations
1. Management and personnel	1. Eating, drinking, or using tobacco 2. Absence of food protection manager certification	1. Food employees shall wear hair restraints 2. Employees must wash hands between working with raw food and ready-to-eat food
2. Food/temperature	1. Potentially hazardous food, hot and cold holding 2. Packaged and unpackaged food separation	1. Food should be stored 6" above the floor 2. Food contact with equipment and utensils
3. Equipment, utensils, and linens	1. Equipment food-contact surfaces and utensils 2. Hot water and chemical, equipment surfaces, and utensils shall be sanitized	1. Nonfood-contact surfaces 2. Fixed equipment, spacing or sealing
4. Water, plumbing, and waste	1. Providing an air gap for backflow prevention 2. Prohibiting a cross connection	1. Handwashing sink shall be maintained at all times 2. Receptacles and waste handling units kept covered
5. Physical facilities	1. Hand drying provision 2. Presence of insects, rodents, and other pests	1. Walls and ceilings should be protected from dust and debris 2. Ventilation systems malfunctioning
6. Poisonous and toxic materials	1. Containers of poisonous or toxic material items shall have a legible manufacturer's label 2. Pesticides or toxic materials cannot contaminate food, equipment, utensils, and linens	1. Chemical sanitizers and other chemical antimicrobials applied to food-contact surfaces shall meet requirements 2. Poisonous or toxic material should be stored separately
7. Compliance and enforcement	1. Failure to obtain approval to open 2. Conformance with the HACCP plans	1. Food establishments shall develop written standard procedures 2. Forms must be submitted to the regulatory authority

categories. No statistical differences were found among the thirteen types of schools and critical violations of the seven food code categories; this could possibly be explained by the relatively small number of critical violations. However, statistical differences in non-critical violations were seen. Special needs' schools had the highest mean scores for non-critical violations in all seven categories except for those related to physical facilities and poisons/toxins. Special needs' schools, which are segregated from regular schools, serve students with various types and severities of learning disabilities, such as autism, deafness, blindness, and other conditions that necessitate extra attention and understanding at school *(13)*. Although meals at all types of schools need to be safe, managers of special needs' schools must pay particular attention to food safety practices. A thorough program review of the foodservice department might be helpful in evaluating their current foodservice performance and developing training strategies accordingly.

Campus dining facilities, as well as special needs' schools, generally reported more non-critical violations than other schools. Specifically, college and university foodservice operations lacked adequate practices related to storing foods, managing food temperatures, and maintaining physical facilities. This area includes accurately labeling all foods, segregating raw foods of animal origin from ready-to-eat foods, controlling cooking temperatures, packaging foods, and preventing cross-contamination caused by incorrectly storing foods. They also need to draw more attention to use of equipment, such as cooking devices, prevention of chipping and malfunctioning of equipment, use of necessary detergents and sanitizers, and keeping all equipment, utensils and linens clean. The CDC *(4)* has emphasized that managers of campus dining services should analyze the reports of health inspection violations for which they have been cited, in order to create strategic ways of improving their current

food practices and policies. Campus dining managers could utilize the results of the present study to improve their employee food safety training programs or food safety manuals, focusing particularly on the areas that had the most non-critical violations. Campus dining employees should be regularly trained on the importance of labeling all foods being served, identifying and segregating foods, and keeping foods safe and unadulterated; they should be provided with manuals on how to clean facilities, as well as with enough handwashing supplies and facilities.

Because of the differences among types of schools, managers at school foodservice operations could use several different strategies to reduce the number of both critical and non-critical violations from the health inspections. Also, they could provide effective training materials to their employees; this would ultimately prevent foodborne illnesses in students, because food safety training can improve food handling practices *(8)*. Green and Selman *(10)* found that food safety programs need to address the full range of factors that impact food preparation behaviors, including control of food temperature, equipment usage, and employee hygiene practices. Other researchers have also indicated that trainings on food safety is needed to increase the motivation for food professionals to implement preventive measures *(34)*. Managers or supervisors at school foodservice operations can create training handbooks based on the results of this study. Restaurants at campus dining services need to work on reducing violations related to managing and controlling food temperatures, using temperature measuring devices, protecting foods from cross-contamination, maintaining air conditioning system vents, and keeping walls, ceilings, and light bulbs clean. Managers at foodservice operations should obtain ServSafe certifications in order to transfer food safety knowledge to their employees. Thus, managers could take a more active role in ensuring food safety by conducting a personal inspection to reinforce their current food safety practices *(34)*. A few other studies also have shown that food safety certification can improve restaurant inspection scores *(2, 8)*. Significantly, special needs' schools have an urgent need to train employees on hygiene practices. Employees should always wear hair restraints, wash their hands after each task, and eat, drink, and smoke tobacco only in designated areas. Also, foodservice operations at special needs' schools must focus on significantly reducing violations regarding compliance and enforcement. It is essential that they submit a HACCP plan as required by law *(17)*. The contents of HACCP include categorizations of the types of potentially hazardous foods, standard operating procedures, and designation of a person in charge. Moreover, it can be suggested that high schools and juvenile schools should focus on avoiding violations related to keeping walls and ceilings clean and durable, preventing muddy conditions, protecting the facility from dead or flying insects, and maintenance of outdoor areas.

LIMITATIONS AND FUTURE STUDY

The current study has several limitations. First, it used health inspection results from schools only in the state of Missouri, so that the results not be generalized to all other types of foodservice operations and all other parts of the U.S. Second, the current study had difficulty accessing inspection reports from many counties because of incomplete information available to the public. Although some counties provide complete health inspection results for every foodservice facility, others do not reveal any information related to health inspections. Last, because not all counties included past health inspection results, the total number of critical and non-critical violations from some counties may not be available for all six years covered by this study. A few counties publicly released school health inspection reports for the entire six-year period. To avoid those limitations, the current study could be expanded by accessing inspection reports of other types of foodservice operations in Missouri and using a greater number of available inspection reports.

CONCLUSION

In the restaurant industry, inspections are important in ensuring the safety of patrons. In this study, the patrons are students, many of whom may be particularly vulnerable to foodborne illnesses. Thus, it is important that all safety regulations be complied with, to reduce the number of both critical and non-critical violations noted during the health inspections and improve the overall inspection score. The results of this study contain the most up-to-date inspection results for 28 counties in the state of Missouri and identify specific inspection criteria that were most and least frequently violated in school foodservice operations in Missouri. We gathered the available health inspection results from schools, coded critical and non-critical violations, and used statistical analyses to identify areas that need more attention from management. On the basis of the descriptive statistics and one-way ANOVA results, we can suggest improvements in specific areas of food safety practice, policy, and overall facility maintenance. The findings emphasize the need to increase food safety practices awareness among school foodservice managers or supervisors. However, many counties in Missouri do not make health inspection results public. Schools should not take advantage of this fact, but instead should strive to consistently provide foodservice in accordance with the Missouri food code *(19)*. The findings of the present study can be used to identify food safety training needs for school foodservice operations in Missouri.

ACKNOWLEDGMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Ambrose, E. E. 2016. How 'critical' are health code violations at restaurants? Available at: https://www.jconline.com/story/money/business/ 2016/08/05/how-critical-health-code-violations-restaurants/88182598/. Accessed 5 March 2019.
2. Binkley, M., D. Nelson, and B. Almanza. 2008. Impact of manager certification on food safety knowledge and restaurant health inspection scores in Tippecanoe County, Indiana. *J. Culinary Sci. & Tech.* 6:343–350.
3. Bishop, T. 27 September 2018. Fox 21 news right now. Restaurant report card: critical vs. non-critical violations. Available at: https://www.fox21news.com/news/local/restaurant-report-card-critical-vs-non-critical-violations/1480557249. Accessed 3 April 2019.
4. Centers for Disease Control and Prevention. 2011. School health guidelines to promote healthy eating and physical activity. Available at: https://www.cdc.gov/healthyschools/npao/pdf/mmwr-school-health-guidelines.pdf. Accessed 12 April 2019.
5. Centers for Disease Control and Prevention. 2017. Foodnet 2017 preliminary data. Available at: https://www.cdc.gov/foodnet/reports/prelim-data-intro-2017.html. Accessed 10 April 2019.
6. Centers for Disease Control and Prevention. 2018. Estimates of foodborne illness in the United States. Available at: https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html. Accessed 8 April 2019.
7. Centers for Disease Control and Prevention. 2018. National outbreak reporting system (NORS). Available at: https://wwwn.cdc.gov/norsdashboard/. Accessed 8 April 2019.
8. Cotterchio, M., J. Gunn, T. Coffill, P. Tormey, and A. Barry. 1998. Effect of a manager training program on sanitary conditions in restaurants. *Publ. Hlth. Rep.* 113:353–358.
9. Dewey-Mattia, D., K. Manikonda, A. J. Hall, M. E. Wise, and S. J. Crowe. 2018. Surveillance for foodborne disease outbreaks — United States 2009–2015. *Surveill. Summ.* 67:1–11.
10. Green, L. R., and C. Selman. 2005. Factors impacting food workers' and managers' safe food preparation practices: a qualitative study. *Food Prot. Trends* 25:981–990.
11. Holland, M. 2004. 'That food makes me SICK!' managing food allergies and intolerances in early childhood settings. *Young Child* 59:42.
12. Irwin, K., J. Ballard, J. Grendon, and J. Kobayashi. 1989. Results of routine restaurant inspections can predict outbreaks of foodborne illness: the Seattle-King County experience. *Am. J. Publ. Hlth.* 79:586–590.
13. Kennedy, R. 2019. Private school review. Special needs schools. Available at: https://www.privateschoolreview.com/blog/special-needs-schools. Accessed 10 March 2019.
14. Kwon, J., K. Roberts, C. W. Shanklin, P. Liu, and W. S. Yen. 2009. Food safety training need assessment for independent ethnic restaurants: review of health inspection data in Kansas. *Food Prot. Trends* 30:412–421.
15. Mathias, R. G., P. D. Riben, E. Campbell, M. Wiens, W. Cocksedge, A. Hazlewood, B. Kirschner, and J. Pelton. 1994. The evaluation of the effectiveness of routine restaurant inspections and education of food handlers: restaurant inspection survey. *Canadian J. Publ. Hlth.* 85:61–66.
16. Mazengia, E., Fisk, C., Liao, G., Huang, H., and J. Meschke. 2015. Direct observational study of the risk of cross-contamination during raw poultry handling: practices in private homes. *J. Food Prot.* 35:8–23.
17. Missouri Department of Health and Senior Services. 2014. Environmental health operational guidelines 2015-2018. Available at: https://health.mo.gov/atoz/ehog/pdf/ehogmanual.pdf. Accessed 12 April 2019.
18. Missouri Department of Health and Senior Services. 2017. Missouri health improvement plan 2013-2018. Available at: https://health.mo.gov/data/pdf/ mohealthimproveplan.pdf. Accessed 15 March 2019.
19. Missouri food code document. 2013. Missouri food code for the food establishments of the state of Missouri. Jefferson City, Missouri: Missouri Department of Health and Senior Services Bureau of Environmental Health Services. Available at: https://health.mo.gov/safety/foodsafety/pdf/missourifoodcode.pdf. Accessed 20 December 2018.
20. Murray, C. J., and A. D. Lopez. 2013. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Cambridge, MA: Harvard University Press.
21. Philips, M. L., B. L. Elledge, H. G. Basara, R. A. Lynch, and D.T. Boatright. 2006. Recurrent critical violations of the food code in retail food service establishments. *J. Environ. Hlth.* 68:24–30.
22. Scott, B., V. Curtis, and T. Rabie. 2003. Protecting children from diarrhea and acute respiratory infections: the role of handwashing promotion in water and sanitation programs. *WHO Reg. Hlth. Forum* 7:42–47.
23. Seiver, O. H., and T. H. Hatfield. 2000. Grading systems for retail food facilities: a risk-based analysis. *J. Environ. Hlth.* 63:22–27.
24. Thomas, E. M., B. Chapman, L. A. Jaykus, and T. Phister. 2014. Tracing temperature patterns of cut leafy greens during service in North Carolina school food service. *J. Food Prot.* 77:1495–1500.
25. United States Department of Agriculture. 2010. Final rule: school food safety inspections. Available at: https://www.fns.usda.gov/school-meals/fr-090209. Accessed 17 March 2019.
26. U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans. 2010. Available at: http://health.gov/ dietaryguidelines/dga2010/DietaryGuidelines2010.pdf. Accessed 18 March 2019.
27. U.S. Food and Drug Administration. 2001. Bacteriological Analytical Manual. Available at: http://www.fda.gov/Food/ScienceResearch/LaboratoryMethods/BacteriologicalAnalyticalManualBAM/ucm071429.html. Accessed 20 March 2019.
28. U.S. Food and Drug Administration. 2009. Food Code U.S. Public Health Service. Available at: https://wayback.archiveit.org/7993/20170406184540/https://www.fda.gov/downloads/Food/GuidanceRegulation/UCM189448.pdf. Accessed 20 March 2019.
29. U.S. Food and Drug Administration. 2018. Foodborne Illnesses: what you need to know. Available at: https://www.fdagov.proxy.mul.missouri.edu/ downloads/Food/FoodborneIllnessContaminants/UCM187482.pdf. Accessed 20 March 2019.
30. White, P. 2002. Food security. *School Foodserv. Nutr.* 56:42–46.
31. World Population Review. 2019. Missouri population 2019. Available at: http://worldpopulationreview.com/states/missouri-population/. Accessed 2 March 2019.
32. Worsfold, D., and P. M. Worsfold. 2007. How clean is that cafe? Online hygiene inspection reports for consumers. *J. Foodservice* 18:93–100.
33. Yeager, V. A., N. Menachemi, B. Braden, D. M. Taylor, B. Manzella, and C. Ouimet. 2013. Relationship between food safety and critical violations on restaurant inspections: an empirical investigation of bacterial pathogen content. *J. Environ. Hlth.* 75:68–73.
34. Yoon, E. Y., and C. W. Shanklin. 2007. Food security practice in Kansas schools and health care facilities. *J. Am. Diet. Assoc.* 107:325–329.