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## Do Certified Food Manager Knowledge Gaps Predict Critical Violations and Inspection Scores Identified during Local Health Department Restaurant Inspections?

### ABSTRACT

**T**he majority of foodborne disease outbreaks in the United States originate in restaurants. Local health departments regularly inspect restaurants, but food safety knowledge is not routinely examined.

This study determined the relationship between food safety knowledge among suburban Chicago certified food managers and restaurant inspection scores. A cross-sectional survey of 729 food handlers, including 254 certified food managers, was conducted at 211 suburban Chicago restaurants from June 2009 through February 2010. A 50-question survey was administered in either English or Spanish. Inspection results from the routine inspection just prior to the knowledge survey were obtained from participating restaurants. The overall mean food safety knowledge score was only 79% for certified food managers. The mean restaurant inspection score was 90.6 out of 100 points. Two critical violations, related to maintaining proper temperature of food and cross-contamination, were identified in nearly 30% of the inspections. Although the correlation between overall certified food manager

knowledge score and restaurant inspection score was not significant, associations between knowledge scores and specific critical violations related to hand hygiene were identified. With the exception of hand hygiene, however, restaurant inspection reports did not generally correlate well with certified food manager knowledge.

### INTRODUCTION

**T**he majority of foodborne disease outbreaks in the United States originate in restaurants (26). Of the 868 foodborne disease outbreaks reported in 2008, approximately 52% were associated with restaurants or delicatessens (5). U.S. Food and Drug Administration (FDA) guidelines state that “a principal goal to be achieved by a food establishment inspection is to prevent foodborne disease.” Ensuring food safety at local eating establishments is an important feature of state and local health department efforts to protect public health (10).

Often, restaurant inspection programs involve a numeric scoring system in which a point value is assigned to each food safety violation, depending on its severity. The Illinois Department of Public Health restaurant inspection scoring

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method is patterned after the FDA model. A perfect score is 100 points. Each of the 45 violations is categorized as either critical or non-critical and has a corresponding value that is deducted from the 100 point score (12). Depending upon the specific jurisdiction within Illinois, a restaurant can fail an inspection by scoring below 70%, having repeated food temperature control or hand washing violations, or having other serious critical violations that could lead to foodborne illness (including lack of a certified food manager on site or pest problems) (16). Local jurisdictions throughout the U.S. have also adopted similar restaurant inspection models. Although restaurant inspections are performed regularly, their effectiveness in preventing foodborne disease remains inconclusive. Some studies have found an association between lower overall inspection scores and foodborne disease outbreaks (3, 13), while others have not (7, 14, 23). Buchholz and colleagues, for example, reported that lower inspection scores and the presence of any food safety violation were significantly associated with the occurrence of an investigated foodborne illness incident in Los Angeles County (3). However, no such associations were observed in studies performed in Florida, Tennessee, or Alabama and Mississippi (7, 14, 23). Similarly, few data exist regarding the appropriate restaurant inspection frequency needed to prevent foodborne illness outbreaks (2, 19, 21, 28). Recently, however, Zablotsky Kufel et al. reported that counties in Maryland with high inspection rates also had lower rates of foodborne illness and concluded that strong local food protection programs appear to protect the food chain better than those with fewer resources dedicated to food safety (28).

Although routine inspections do determine compliance with the local food code rules/regulations at the time of the inspection, they traditionally do not involve standardized food safety knowledge assessment. To reduce the risk of food poisoning, restaurant food handlers need accurate knowledge of food safety principles as a starting point if the outcome is to be optimal food safety behavior. In Illinois, it is particularly important for certified food managers to have sufficient food safety knowledge, as they are ultimately responsible for disseminating this information to other employees. According to the FDA, the most common food handler behaviors contributing to foodborne outbreaks are poor hand hygiene, improper temperatures for cooking and holding food, and cross contamination (10). In 2008, Newbold et al. determined that there was no association between food safety compliance and increased inspection frequency alone, but rather that inspections should serve as a method to protect the public by educating food handlers (21). Similarly, Cates and colleagues reported that the presence of a certified food manager during an inspection appears to be protective against most critical food safety violations (4). Few published studies have assessed restaurant food handler knowledge in general and none have examined the

specific relationship between food safety knowledge and restaurant inspection scores (1, 8, 9, 15, 18, 20, 22).

The objective of this study was to determine the association of food safety knowledge of food handlers and certified food managers to restaurant inspection score. We hypothesized that restaurant certified food manager knowledge would be positively correlated with either overall restaurant inspection scores, prevention of specific critical violations, or both.

## MATERIALS AND METHODS

### Sample and participants

A list of 2,087 food establishments in three Illinois counties was obtained from the business credibility provider Dun and Bradstreet [www.dnb.com]. Restaurants in Kane, Lake, and Suburban Cook counties were eligible for inclusion. Managers from a random sample of 668 restaurants (32%) were then asked to participate in this study. Seven hundred twenty-nine food handlers were interviewed at 211 (32%) restaurants from June 2009 through February 2010 (18). Among these, 254 were certified food managers. The reasons for restaurant nonparticipation included refusal (156; 23%), restaurant was "not available" (63; 9%), closure or vacancy (58; 9%), no English- or Spanish-speaking food handlers (89; 13%), not meeting the inclusion criteria (41, 6%), and having changed names or moved locations (50, 8%). Eligible participants were defined as restaurant employees who prepare food to be consumed by the patrons. Those who did not speak either English or Spanish or were younger than 18 years of age were considered ineligible for participation. Food handlers provided informed consent, and the names of participating food handlers and restaurants were kept confidential. A \$15.00 compensation was offered to each participating food handler. Food handler demographic information and restaurant characteristics were obtained, including primary language, race/ethnicity, history of food safety training and certification, years of food handling experience, and frequency of specific food handling tasks (including handling and cooking raw meat/poultry, seafood, eggs and vegetables/fruits) and restaurant service style, size, food type and average entrée price. Administration of questionnaires in English or Spanish was performed by the University of Illinois Survey Research Laboratory staff and trained students from the University of Illinois at Chicago School of Public Health. Approval from the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects was received prior to survey initiation.

### Data collection

A food safety survey consisting of 40 multiple-choice, true-false, and fill-in-the-blank knowledge questions was developed as previously reported (18). The primary

**TABLE 1. Frequencies and proportion of all possible violations at restaurants in Kane, Lake, and Suburban Cook Counties, 2010 (N = 211)**

Violation Category	Requirement not met	Point Deduction	N (%) N = 211 restaurants
Floors, Walls, and Ceilings	Floors; constructed, drained, clean, good repair, covering installation, dustless cleaning methods	1	70 (33.2)
Food Equipment and Utensils	Non-food contact surfaces of equipment and utensils clean	1	65 (30.8)
Food Protection <sup>a</sup>	Potentially hazardous food meets temperature requirements during storage, preparation, display, service, and transportation	5	61 (28.9)
Food Protection <sup>a</sup>	Food protection during storage, preparation, display, service and transportation	2	59 (28.0)
Food Equipment and Utensils	Food-contact surfaces of equipment and utensils clean, free of abrasives and detergents	2	54 (25.6)
Food Equipment and Utensils	Non-food contact surfaces designed, constructed, maintained, installed and located	1	53 (25.1)
Toilet and Hand-washing Facilities	Toilet rooms enclosed, self-closing doors, fixtures, good repair, clean; hand cleanser, sanitary towels/hand drying devices provided, proper waste receptacles, tissue	2	53 (25.1)
Floors, Walls, and Ceilings	Walls, ceiling, attached equipment; constructed good repair, clean surfaces, dustless cleaning methods	1	45 (21.3)
Food	Original container, properly labeled	1	39 (18.5)
Food Equipment and Utensils	Wiping cloths; clean, use restricted	1	37 (17.5)
Plumbing	Installed, maintained	1	37 (17.5)
Other Operations	Toxic items properly stored, labeled, and used	5	35 (16.6)
Food Equipment and Utensils	Food (ice) dispensing utensils properly stored	2	27 (12.8)
Food Protection <sup>a</sup>	Unwrapped and potentially hazardous food not re-served	4	26 (12.3)
Food Equipment and Utensils	Sanitation rinse; clean, temperature, concentration	4	26 (12.3)
Lighting	Lighting provided as required – Fixtures shielded	1	25 (11.9)
Other Operations	Management personnel certified	n/a	25 (11.9)
Food Protection <sup>a</sup>	Thermometer provided and conspicuous	1	22 (10.4)
Insect, Rodent, Animal Control	Presence of insects/rodents, outer openings protected, no birds, turtles, other animals	4	22 (10.4)
Food Protection	Handling of food minimized, methods	2	20 (9.5)
Other	Premises maintained free of litter, unnecessary articles, cleaning/maintenance equipment properly stored, authorized personnel	1	20 (9.5)
Food Equipment and Utensils	Storage, handling of clean equipment and utensils	1	9 (9.0)

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**TABLE 1. Frequencies and proportion of all possible violations at restaurants in Kane, Lake, and Suburban Cook Counties, 2010 (N = 211) (continued)**

Food Equipment and Utensils	Food dispensing utensils properly stored	1	17 (8.1)
Garbage and Refuse Disposal	Containers or receptacles covered, adequate number, insect/rodent proof, frequency, clean	2	16 (7.6)
Food Equipment and Utensils	Dishwashing facilities; designed, constructed, maintained, installed, located, separated	2	15 (7.1)
Personnel <sup>a</sup>	Hands washed and clean, good hygienic practices	5	12 (5.7)
Toilets and Handwashing Facilities	Number, convenient, accessible, designed, installed	4	12 (5.7)
Food Equipment and Utensils	Accurate thermometers, chemical test kits, and gauges provided	1	11 (5.2)
Food Protection <sup>a</sup>	Facilities to maintain product temperature	4	9 (4.3)
Food Protection <sup>a</sup>	Potentially hazardous food properly thawed	2	7 (3.3)
Food	Source, wholesome, no spoilage	5	6 (2.8)
Food Equipment and Utensils	Single-service articles, storage, dispensing	1	5 (2.4)
Garbage and Refuse Disposal	Outside storage areas and enclosures; properly constructed, clean, controlled incineration	1	5 (2.4)
Dressing Rooms	Rooms clean, lockers provided and clean	1	5 (2.4)
Personnel	Clean clothes, hair restraints	1	4 (1.9)
Food Equipment and Utensils	No reuse of single-service articles	2	3 (1.4)
Plumbing	Cross-connection, back siphonage, back flow	5	3 (1.4)
Food Equipment and Utensils	Wash, rinse water; clean, proper temperature	2	2 (1.0)
Water	Water source; safe, hot and cold under pressure	5	2 (1.0)
Ventilation	Rooms and equipment; vented as required	1	2 (1.0)
Other	Clean, soiled linen properly stored	1	2 (1.0)
Personnel <sup>a</sup>	Personnel with infections restricted	5	1 (0.5)
Sewage	Sewage and waste water disposal	4	1 (0.5)
Food Equipment and Utensils	Pre-flushed, scraped, soaked	1	0
Other	Complete separation from living/sleeping quarters, laundry	1	0
<sup>a</sup> High Risk Violation			

outcome, food safety knowledge score, was determined by the proportion of correctly answered knowledge questions. Knowledge tested included the optimal temperatures for bacterial growth, appropriate temperatures for heating and cooling foods, cross-contamination, hand hygiene, and when to discard food. For example, cross-contamination questions addressed proper separation and storage of potentially contaminated and ready to eat foods, and hand hygiene questions addressed the proper washing and drying of hands. Information on demographic variables and self-reported food safety behaviors was also collected.

The most recent report of a routine restaurant inspection within approximately 12 months prior to survey initiation was acquired for each of the 211 restaurants in the study. An inspection dataset was created that included all violations and the corresponding overall score (1-100 points) for each participating restaurant. Overall inspection score was calculated by the local health department by deducting points for each violation from 100 possible points. Per their routine protocol, four points were deducted for critical violations concerning temperature control facilities, cross-contamination, sanitization, sewage disposal, hand washing facilities, and pest control (defined in [Table 1](#)). Five points were deducted for the most critical violations regarding approved sources for food, food temperatures, employee health, personal hygiene, approved water supply, backflow prevention, and chemical use and storage. One, two, or zero points were deducted for non-critical violations. Eight of the 45 possible violations were selected as addressing food handler behaviors that could create a critical risk for the transmission of foodborne disease (high risk violations). A risk category of 1 (highest risk), 2, or 3 was assigned to each restaurant by local health departments, depending on the type and complexity of food preparation. Restaurants of higher risk categories had been inspected more frequently as per health department protocol (three times per year for risk category 1 restaurants, two times per year for risk category 2 restaurants, and once per year for risk category 3 restaurants).

### Statistical analysis

Bivariate analyses were performed to identify food handler and restaurant variables associated with restaurant inspection score and specific high-risk violations. To determine factors associated with inspection score, overall scores, numbers of overall violations, and numbers of high-risk violations by restaurant were compared using ANOVA models, and Tukey's test and an item-wise analysis was conducted using chi-square testing and Fisher's exact test. To determine if overall inspection score was correlated with certified food manager knowledge score, we conducted a subset analysis containing only certified food managers in order to avoid weighting the data by the number of food handlers per restaurant. Within this subset, we conducted a linear regression of overall inspection score to mean certified

food manager score per restaurant. The primary dependent variable of interest was the mean inspection score per restaurant, and the primary independent variable was mean certified food manager knowledge score per restaurant. We determined whether specific food safety citations were correlated with any certified food manager missing any one of the knowledge questions in the same category, using chi-square testing and Fisher's exact test. Statistical analysis was performed using SAS 9.2 for Windows (SAS, Cary, NC).

## RESULTS

### Sample characteristics

Among the 211 participating restaurants, 33% (70) were small (< 10 tables or < 40 seats), 42% (89) were medium-sized (10 – 30 tables or 40 – 120 seats), and 25% (52) were large (> 30 tables or > 120 seats). Average restaurant entrée price was \$10 or less for 64% (135), between \$10 and \$20 for 33%, and \$20 or more for 3% of restaurants (7). Thirty-five percent (254) of the 729 food handlers interviewed were certified food managers. Two or more certified food managers were surveyed in 25% of restaurants. The overall mean knowledge score was 72% (29/40) for the 729 food handlers interviewed and 79% (32/40) for the 254 certified food managers interviewed. Other restaurant characteristics and the results of the knowledge survey have been previously reported (18). Food handler knowledge gaps included the following categories: optimal temperatures for cooking, holding and refrigeration, cross-contamination, and hygiene. Ninety-six percent (700) of the 729 food handlers could not correctly identify the proper minimum internal temperature to which to cook chicken or ground beef. The median number of hand-washing questions missed was one out of eight possible (13%). Among the hand hygiene questions, 26% of food handlers said that it was true that, "At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands." The results were similar regardless of whether or not the food handler was a certified food manager (26% versus 28%, respectively). Nearly 29% of food handlers did not accurately identify the correct way to turn off the water after washing their hands (for example, by using a paper towel and not bare hands).

### Inspection score

Overall, the mean number of violations was 4.6 out of the possible 45 (Standard deviation: 3.4 violations; range 0 [n = 21 restaurants] to 19 [n = 1 restaurant]). The mean inspection score was 90.6 (median 92.0, standard deviation 7.3). Two of the 10 most commonly reported violations met our definition of high risk. One high-risk violation was the failure to maintain temperature requirements of potentially hazardous food (29%); the other was inadequate food protection from potential cross-contamination during storage, preparation, display, service, and transportation



(28%) (Table 1). A critical violation regarding hand hygiene was found in nearly 6% of restaurants. Other commonly reported violations were in the categories of ‘Food Equipment and Utensils’ (70%), ‘Floors, Walls, and Ceilings’ (39%), and ‘Toilet and Hand-washing Facilities’ (29%). The median time between inspection and interviews was 2.5 months, with 40 restaurants (19%) inspected less than one month and one restaurant (0.5%) inspected approximately one year prior to their interviews.

#### Factors associated with inspection score

Highest risk restaurants (risk category 1, those that had the most food handler contact with hazardous food) were generally more costly than restaurants in risk categories 2 or 3. The greatest number of high risk violations occurred within the risk category 1 restaurants (Table 2). However, neither the overall inspection scores nor the total number of violations

differed among the restaurants by risk category (Table 3). Restaurants with average entrée price greater than \$20 had significantly lower overall inspection scores (82.4 points, range 63–100,  $P = 0.0008$ ) and twice as many violations compared with less costly restaurants ( $P = 0.004$ ) (Table 3). However, only 7 restaurants were in this most expensive category. An association between higher-priced menu items and high-risk violations was marginally significant. National or regional chain restaurants had slightly fewer high-risk violations compared with non-chain restaurants (0.09 mean high-risk violations and 0.13 mean high-risk violations, respectively,  $P = 0.0536$ ).

#### Correlation of overall inspection score with certified food manager knowledge score

In the subset analysis of only certified food managers, a non-significant correlation was identified between better

**TABLE 2. Frequencies and proportions of eight possible high-risk violations in restaurants overall and by risk category in Kane, Lake, and Suburban Cook Counties, 2010 (N = 211)<sup>a</sup>**

Requirement Not Met	Overall (N = 211 restaurants) N (%)	Risk Category 1 (N = 138 restaurants) N (%)	Risk Category 2 (N = 62 restaurants) N (%)	Risk Category 3 (N = 11 restaurants) N (%)	P-value
Potentially hazardous food meets temperature requirements during storage, preparation, display, service, and transportation <sup>b</sup>	61 (29)	45 (33)	14 (23)	2 (18)	0.281
Food protection during storage, preparation, display, service and transportation <sup>b</sup>	59 (28)	35 (25)	18 (29)	6 (54)	0.121
Unwrapped and potentially hazardous food not re-served. Cross-contamination.	26 (12)	20 (14)	4 (6)	2 (18)	0.173
Thermometer provided and conspicuous	22 (10)	12 (9)	7 (11)	3 (27)	0.122
Hands washed and clean, good hygienic practices	12 (6)	9 (7)	3 (5)	0	n/a
Facilities to maintain product temperature	9 (5)	6 (4)	3 (5)	0	n/a
Potentially hazardous food properly thawed	7 (3)	5 (4)	0	2 (18)	n/a
Personnel with infections restricted	1 (0.5)	1 (0.7)	0	0	n/a

<sup>a</sup>Analysis completed using Fisher’s exact test

<sup>b</sup>One of the top ten most commonly cited violations among all 45 violations possible

**TABLE 3. Mean overall inspection score, overall violations, and high risk violations for restaurants in Kane, Lake, and Suburban Cook Counties by risk category and average cost of entrée, 2010 (N = 211)**

	N (%)	Overall inspection score <sup>a</sup> Mean (SD)	P-value	Overall violations <sup>b</sup> Mean (SD)	P-value	High risk violations <sup>c</sup> Mean (SD)	P-value
<b>Restaurant Risk</b>							
<b>Category</b>							
1	138 (66)	90.2 (7.5)	0.501	4.6 (3.4)	0.968	1.0 (1.1)	0.459
2	62 (29)	91.4 (7.0)		4.5 (3.7)		0.8 (0.9)	
3	11 (5)	91.6 (5.5)		4.4 (2.6)		1.0 (1.1)	
<b>Average Price of Entrée</b>							
< \$10	135 (64)	91.0 (6.2)	0.008	4.3 (3.0)	0.004	0.8 (0.9)	0.057
\$10–\$20	69 (33)	90.6 (8.0)		4.4 (3.7)		1.0 (1.1)	
> \$20	7 (3)	82.4 (12.7)		8.7 (6.2)		1.7 (1.4)	
<sup>a</sup> Score out of 100 points possible <sup>b</sup> Violations out of 45 violations possible <sup>c</sup> High risk violations out of 8 possible							

performance during inspections and higher certified food manager knowledge score (Correlation Coefficient = 0.01,  $P = 0.147$ ). In general, hand hygiene knowledge gaps were correlated with hand hygiene violations. A violation related to hand hygiene was almost twice as likely to occur in restaurants where at least one certified food manager had missed at least one question related to hand hygiene (RR = 1.96, 95% CI 1.38–2.78,  $P = 0.047$ ). However, a violation related to inadequate hand-washing facilities was neither substantially nor statistically more likely to occur with these same criteria (RR = 1.09, 95% CI 0.71–1.68,  $P = 0.691$ ). Associations that were not statistically significant were also found in the categories of temperature regulation, thermometer use, sanitation, and cross-contamination. Certified food managers working at restaurants that had received a high risk violation for improper regulation of temperature were not significantly more likely to have knowledge gaps related to temperature requirements (RR = 1.01, 95% CI 0.78–1.32,  $P = 0.911$ ). Certified food managers working in restaurants at which a violation had been found concerning not having thermometers were minimally more likely to have missed questions related to thermometer use; however, this difference was not significant (RR = 1.20, 95% CI 0.59–2.43,  $P = 0.620$ ). Although the

relationship was not significant, restaurants that had at least one certified food manager who did not know the definition of sanitizing were more likely to be cited for a violation related to sanitation and cleaning (RR = 1.53, 95% CI 0.87–2.67,  $P = 0.146$ ). Similarly, restaurants employing at least one certified food manager who missed at least one question related to minimizing direct food contact were more likely to have committed a violation of this nature (RR = 1.55, 95% CI 0.75–3.25,  $P = 0.259$ ). A restaurant that had at least one certified food manager who missed at least one question regarding where to store meat in the refrigerator was not more likely to have committed a violation related to cross-contamination (RR = 0.70, 95% CI 0.36–1.37,  $P = 0.249$ ).

## DISCUSSION

Our study suggests that restaurant inspection reports generally do not correlate with certified food manager knowledge. Although the restaurants in this study had an overall mean inspection score of 90.6 points, there were some commonly cited violations that represent an increased risk for foodborne disease transmission. Among the most commonly cited high-risk violations, several may contribute to outbreaks including improper temperatures for cooking and holding food, evidence of cross-contamination, and inadequate hand hygiene (10).

In our study, the most commonly cited high-risk violation was for potentially hazardous food not meeting temperature requirements during storage, preparation, display, service, and transportation (28.9% of restaurants) (41°F or less for cold food, 135°F or above for hot food). Holding food at temperatures within this “danger zone” for bacterial growth may lead to the proliferation of pathogenic bacteria. In a Kansas study of 500 independent ethnic restaurants in 14 counties, Kwon et al. found that time and temperature control of potentially hazardous foods was the most frequently violated food code category (39% of restaurants) (15). These frequencies are higher than those reported by Menachemi and colleagues in a Jefferson County, Alabama study of critical food safety violations in 1,829 restaurants over a 3-year period in which this violation was reported for 14% of restaurants (20). Regardless of the variability of these numbers, failure to maintain temperature requirements is a major public health threat. For example, of the 608 U.S. foodborne outbreaks for which a contributing factor was reported between 2009 and 2010, proliferation and survival factors related to time and temperature control were cited in 33% and 17%, respectively (6). Similarly, in a 2003 World Health Organization (WHO) study of foodborne disease surveillance systems in 34 countries, between 12.4 and 53.8% of outbreaks were attributable to time and temperature abuse (24). Such violations can affect large numbers of people, as when a 2008 *Salmonella* outbreak caused more than 1,400 illnesses throughout the United States as a result of inadequate holding of tomato-based dishes containing Serrano peppers (17). The frequency of citation and substantial morbidity resulting from this violation suggest that ensuring that food handlers have adequate knowledge and utilize appropriate temperature control behaviors is important to preventing the transmission of foodborne disease in restaurants.

Adequate food protection is a critical aspect of food poisoning prevention. The WHO reports that inadequate protection has contributed to up to 27.9% of outbreaks (24). In this study, failing to employ adequate food protection during storage, preparation, display, service and transportation was the second most commonly cited violation. This violation is cited when food contamination may be due to environmental conditions such as failure to have a sneeze guard on a buffet, storage of uncovered foods stacked on top of one another, or inadequate dust protection mechanisms during transportation, storing or display. The frequency of this violation in our study is similar to that reported from Kansas (15), where “Food Protection from Contamination” was violated in 29% of restaurants, although it is much greater than the mean percentage (2% of restaurants) reported from Jefferson County, Alabama (20).

Hand hygiene behavior is essential to prevent illness. Many foodborne illness outbreaks have reported problems with food handler hand hygiene (11, 25, 26, 27). Our study found

a significant association between having a food handler hand hygiene violation and at least one certified food manager missing at least one hand hygiene question on the knowledge survey. In Illinois, certified food managers are responsible for knowing and teaching their staff about food safety. If certified food managers lack knowledge about hand hygiene, then their staff may be less likely to know and/or carry out proper practices. These data speak to the issue of ensuring that managers are certified but also that they have strong knowledge in critical issues related to hand hygiene and prioritize such behavior in their restaurants. Food handler hygiene violations were documented in only 6% of our study restaurants, a value lower than that reported elsewhere. In contrast, 23% of Kansas restaurants (15) and 16% of Jefferson County, Alabama restaurants (20) were cited for a violation for employees failing to wash hands at appropriate times. Our lower prevalence may be due to a difference in study methods or perhaps to unmeasured inspection procedure variations.

Overall inspection scores and overall certified food manager knowledge were not correlated in our study. Although studies in Los Angeles County and Seattle-King County reported an association between lower overall inspection scores and foodborne disease outbreaks (3, 13), studies in Miami-Dade County (7), Alabama and Mississippi (23), and Tennessee (14) did not. The heterogeneity of these findings may be due to the extent that inspection forms emphasize physical aspects of restaurants relative to food handler characteristics and behaviors. These contradictory results also suggest that inspections alone may not be sufficient to either assess food handler knowledge or prevent the transmission of foodborne disease.

One of the limitations of our study was the inability to verify if the food handlers working at the time of the restaurant inspection were the same as those for whom knowledge was evaluated. However, to minimize this problem, we utilized only the data from the most recent inspection prior to the survey of knowledge. As a result, the mean time between inspection and knowledge assessment was only three months, reducing the probability that turnover had greatly affected the results of this study. Another potential limitation may be that some of the violations include environmental features that are not as obviously behavior-related. For example, one of the violations involved having a conspicuously placed thermometer. However, even violations such as this one may involve behavior of certified food handlers who may be responsible for ensuring compliance with local health department regulations. A potential strength of this study was the inclusion of a sub-analysis focusing only on high-risk violations that are often reported in foodborne outbreaks. Performing this subset analysis allowed for an examination of knowledge of certified food managers with only those violations that are likely to play a direct role in the transmission of foodborne disease.



The overall restaurant inspection score cannot be relied on as an overarching measure of food safety risk factors within a restaurant. Our finding that food handler knowledge was not associated with restaurant inspection scores supports this conclusion. With the exception of hand hygiene, there was no correlation between certified food manager knowledge and the restaurant inspections violations. Restaurant inspections are relatively infrequent and observe only a small number of relevant behaviors. Compliance with these critical prevention behaviors often derives from a sound knowledge of food safety principles, including the rationale for their prioritization and, in some restaurants, on protocols that limit opportunities for error. Future research should focus on enhancing restaurant manager knowledge and determining what factors may motivate restaurant managers to ensure compliance with food safety policies that inspections are intended to monitor.

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## ACKNOWLEDGMENTS

This study was supported by the National Institute of Food and Agriculture of the United States Department of Agriculture (Award Number 2008-35201-04479). The authors thank the Chicago Health Department, Cook County Health Department, Lake County Health Department, Kane County Health Department, DuPage County Health Department, and the Illinois Department of Public Health for advice related to survey development and project feedback. The authors also thank the University of Illinois Survey Research Laboratory for advice related to survey development and project feedback and substantial assistance with interviewing and data entry of the restaurant food handler surveys. The authors appreciate the thoughtful review of the manuscript by Jeff Eason, MPH-EH, REHS, MLT ASCP of the Utah Department of Health.

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# *In Memory*

## Orlowe M. Osten

*We extend our deepest sympathy to the family of Orlowe Osten who recently passed away. Mr. Osten was a member of the Association since 1957 and was President in 1972. IAFP will always have sincere gratitude for his contribution to the Association and the profession.*

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