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Restaurant Manager and Worker Food Safety Certification and Knowledge

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Abstract

Over half of foodborne illness outbreaks occur in restaurants. To combat these outbreaks, many public health agencies require food safety certification for restaurant managers, and sometimes workers. Certification entails passing a food safety knowledge examination, which is typically preceded by food safety training. Current certification efforts are based on the assumption that certification leads to greater food safety knowledge. The Centers for Disease Control and Prevention conducted this study to examine the relationship between food safety knowledge and certification. We also examined the relationships between food safety knowledge and restaurant, manager, and worker characteristics. We interviewed managers ($N = 387$) and workers ($N = 365$) about their characteristics and assessed their food safety knowledge. Analyses showed that certified managers and workers had greater food safety knowledge than noncertified managers and workers. Additionally, managers and workers whose primary language was English had greater food safety knowledge than those whose primary language was not English. Other factors associated with greater food safety knowledge included working in a chain restaurant, working in a larger restaurant, having more experience, and having more duties. These findings indicate that certification improves food safety knowledge, and that complex relationships exist among restaurant, manager, and worker characteristics and food safety knowledge.

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Introduction

Two-thirds of foodborne illness outbreaks in the United States are associated with restaurants or delis (Gould *et al*., 2013). To combat restaurant-related outbreaks, many public health agencies require food safety certification for restaurant kitchen managers. Food safety certification requires managers to pass a food safety knowledge examination. This examination is typically preceded by food safety training or education. Current certification efforts are based on the assumption that certification leads to greater food safety knowledge, and managers knowledgeable in food safety will operate safer restaurants. In some cases, public health agencies also require food safety certification for restaurant food workers under a similar assumption that certified food workers will have greater food safety knowledge and, thus, handle food more safely.

A few studies have examined the relationship between food safety certification and food safety knowledge. For example, Manes *et al*. (2013) found that certified managers had higher food safety knowledge scores than noncertified managers. However, this study was conducted only in suburban Chicago restaurants. Other existing studies conducted on this topic also have been local (Lynch *et al*., 2003; DeBess *et al*., 2009).

In 2012, the Centers for Disease Control and Prevention's (CDC) Environmental Health Specialists Network (EHS-Net) conducted a study to examine the relationship between restaurant manager and worker food safety certification and food safety knowledge. EHS-Net collected data in six sites; the sites were diverse demographically and provided good geographical coverage of the United States. Food safety knowledge likely is determined by factors (e.g., socio-demographic characteristics) other than certification. Thus, we took a comprehensive approach to this study and examined the relationship between food safety knowledge and certification, and several other factors (i.e., restaurant, manager, and worker characteristics).

Materials and Methods

EHS-Net, a collaborative program of CDC, the Food and Drug Administration, the U.S. Department of Agriculture, and state and local health departments focused on investigating the environmental causes of foodborne illness, conducted this study. When this study was conducted, six state and local health departments were funded by CDC to participate in EHS-Net. These state and local health departments, or EHS-Net sites, were located in California, Minnesota, New York State, New York City, Rhode Island, and Tennessee. California, Minnesota, New York City, and Rhode Island required kitchen manager certification at the time of the study.

Sample

Our sample was composed of restaurants randomly selected from the restaurant populations in selected jurisdictions in the six EHS-Net sites. In each site, data were collected in approximately 65 restaurants. Restaurants were defined as establishments that prepare and serve food to customers, excluding institutions (e.g., hospitals), food carts, mobile food units, temporary food stands, supermarkets, restaurants in supermarkets, and caterers. Due to limited resources, only restaurants with managers who spoke English well enough to be interviewed in English were included in the study. Data collectors (EHS-Net site personnel) determined English proficiency during their recruiting calls- if the data collector could not conduct a conversation in English with a manager, the restaurant was excluded from the sample.

Data collection

Data collectors telephoned restaurants in each EHS-Net site to request study participation and arrange for face-to-face interviews with a kitchen manager (i.e., a manager with authority over the kitchen) and a food worker (i.e., a worker who primarily prepares or cooks food) in the restaurant. Data collectors interviewed managers about the following:

- The restaurant's characteristics (e.g., ownership)
- Their characteristics (e.g., age)
- Their certification and training (e.g., whether they had ever received food safety training; whether they had ever been certified; and if so, whether the certification was from one of three accredited organizations [i.e., approved by the American National Standards Institute]; whether their certification was current [i.e., not expired]; whether they had received food safety training immediately before their certification).

The manager also completed a self-administered, 10-item, paper-and-pencil, multiple-choice food safety knowledge assessment (Fig. 1).

When possible, the data collectors also interviewed a worker. To increase participation and cooperation, data collectors asked managers to choose the worker to be interviewed. The interview asked the chosen worker about the following items:

- Their characteristics (e.g., age)
- Their certification and training (e.g., whether they had received food safety training, had ever been certified, and if so, whether the certification was from one of three accredited organizations).

The interview also contained an 8-item food safety knowledge assessment (Fig. 2). We used an interview assessment, rather than a self-administered assessment, because of concerns about worker reading comprehension. To better accommodate the interview format, we asked fewer questions than we asked the managers, and phrased the questions in a Yes/No format, rather than in a multiple choice format. All data collection instruments were in English.

The food safety knowledge assessments were developed by EHS-Net staff, and were based on existing certification examinations. The assessments included the topics of hand hygiene, cooking and hot and cold holding temperatures, and cross-contamination; the manager assessment also included the topic of foodborne illness. Observational data on food preparation practices were also collected during the visit but are not presented here.

The study protocol was cleared by the CDC Institutional Review Board (IRB) and the appropriate IRBs in the EHS-Net sites. Data collectors participated in training designed to increase data-collection consistency. No data were collected that could identify individual restaurants, managers, or workers.

Data analysis

Managers who answered 8 of 10 assessment questions correctly (score $\geq$80%) were scored as passing the assessment. Workers who answered 6 of 8 assessment questions correctly (score $\geq$75%) were scored as passing the assessment. We also calculated mean percent-correct scores (percent of questions answered correctly, averaged across respondents) for the total assessment and for subparts of the assessment.

We constructed two sets of bivariate and multivariable logistic regression models—one each for managers and workers—to examine associations between potential explanatory variables and the outcome variable of passing the assessment. Potential explanatory variables included restaurant and manager characteristics for the manager analyses, and restaurant, manager, and worker characteristics for the worker analyses. We considered variables significant at $p < 0.30$ in bivariate analysis as potential predictors in the multivariable logistic regression modeling. As in previous work (Carpenter *et al*., 2013), we chose $p < 0.30$ to allow for more inclusiveness, given the relative exploratory nature of these analyses. We used a stepwise selection method for variable selection and determination-of-model fit. We included variables significant at $p < 0.05$ in the final multivariable models. We tested two-way interaction terms among the significant predictors in the models. We found no significant interaction terms; therefore, we removed them from the final models. We used SAS version 9.3 (SAS Institute Inc., Cary, NC, USA), to analyze the data.

Results

Restaurant, manager, and worker characteristics

Forty-four percent ($N = 399$) of managers of eligible restaurants agreed to participate in the study. A manager was interviewed in 100% of those restaurants; a worker was interviewed in 94% of those restaurants ($N = 377$). Twelve restaurants were excluded because they did not meet our restaurant definition. Thus, data are reported on 387 restaurants and managers and 365 workers.

Table 1 contains descriptive data on restaurant, manager, and worker characteristics. According to managers, 59% of restaurants were independently owned, 66% served an American (non-ethnic) menu, 81% cooked raw animal products, and 71% required kitchen manager certification. Additionally, 38% of restaurants could seat $\geq$ 100 customers and 39% served $\geq$ 400 meals on their busiest day of the week. Manager interview data also indicated that 68% of managers were male, 29% were aged 41–50 years, 38% had acquired some community college education or a degree, 73% spoke English as their primary language, and 64% had > 2 years of manager experience. According to workers, 60% were male, 47% were < 31 years of age, 54% had acquired some high school education or a diploma, 66% spoke English as their primary language, 88% had > 2 years of food service experience, and 52% had 4–5 primary job duties (e.g., cooking, cleaning).

Manager and worker training, certification, and knowledge assessment scores

According to managers, almost 95% had received food safety training, almost 80% had been food safety certified, and 71% held a current food safety certificate (Table 2). Of the managers who said they had been certified, 78% said they had been certified by an accredited organization, and 98% said they had received food safety training along with their certification. The most frequent type of training reported was classroom training (90%).

According to workers, 90% had received food safety training. Only 29% of workers had been food safety certified. Of the workers who said they had been certified, 76% said they had been certified by an accredited organization, and 90% said food safety training had preceded their certification. The most frequent type of training reported was on-the-job training (94%).

Slightly more than half of both managers (55%) and workers (52%) passed the knowledge assessment (Table 3). The mean score was 75% for managers and 69% for workers. Mean scores varied across subparts of the assessment (managers: 15%-92%; workers: 17%-84%).

Bivariate analyses of characteristics associated with manager and worker knowledge assessment scores

Bivariate analyses identified 13 variables that were significantly associated (p <0.30) with a passing knowledge assessment score for managers (Table 4). Restaurant characteristics associated with higher odds of passing included: chain ownership, an American menu, required manager certification, raw animal product cooking, greater seating capacity, and more meals served on the restaurant's busiest day. Manager characteristics associated with higher odds of passing included: more education, English as a primary language, more management experience, food safety training, certification, current certification, and certification from an accredited organization.

Bivariate analyses identified 20 variables that were significantly associated (p <0.30) with a passing knowledge assessment score for workers (Table 5). Restaurant characteristics associated with higher odds of passing included chain ownership, raw animal product cooking, greater seating capacity, and more meals served on the restaurant's busiest day. Manager characteristics associated with higher odds of a passing worker score included English as a primary language, certification, current certification, certification from an accredited organization, and a passing assessment score. Worker characteristics associated with higher odds of passing included older age, more education, English as a primary language, more food service experience, having four to five job duties, certification, and certification from an accredited organization.

Multivariable analyses of characteristics associated with manager and worker knowledge assessment scores

Multivariable analyses identified 5 of the 13 potential explanatory variables (i.e., significant at the bivariate level) that were significantly associated (p <0.05) with a passing knowledge assessment score for managers (Table 6). Managers in chain restaurants had higher odds of passing the assessment than did managers in independent restaurants. Managers in restaurants that could seat ≥ 50 customers had higher odds of passing than did managers in restaurants that sat fewer customers. Managers whose primary language was English had higher odds of passing than did managers whose primary language was not English. Managers with > 2 years of experience had higher odds of passing than did managers with ≤ 2 years of experience. Managers who had been certified had higher odds of passing than did non-certified managers.

Multivariable analyses identified 4 of the 20 potential explanatory variables (i.e., significant at the bivariate level) that were significantly associated (p <0.05) with a passing knowledge assessment score for workers (Table 6). Workers whose managers passed the assessment had higher odds of passing the assessment than did workers whose managers had failed the assessment. Workers whose primary language was English had higher odds of passing than did workers whose primary language was not English. Workers with four to five job duties had higher odds of passing than did workers who had fewer job duties. Workers who had been certified had higher odds of passing than did non-certified workers.

Discussion

Our data indicated that most managers had been food safety certified. These results are not surprising; most of the jurisdictions in which we collected data required kitchen manager certification. Fewer workers had been certified; again, these data are not surprising, because few jurisdictions require worker certification.

Only about half of managers and workers passed the food safety knowledge assessment. These results suggest that despite the high levels of certification seen in this study, food safety knowledge is lacking. These data are concerning, particularly for managers. Managers are responsible for food safety in their restaurants; we would expect them to be more knowledgeable about food safety.

Characteristics associated with manager knowledge assessment scores

Multivariable model data indicate that certified managers were more likely to pass the assessment than were non-certified managers. These results support other researchers' findings, and clearly suggest that certification promotes food safety knowledge (Lynch *et al*., 2003; DeBess *et al*., 2009; Manes *et al*., 2013). This finding also suggests that certification leads to food safety knowledge retention. We did not ask when managers obtained their certification; however, we can assume that the length of time between when they were certified and when they took our assessment varied considerably, and that for some of these managers, it had been quite some time since they had been certified. Yet, we still see a relationship between certification and knowledge.

In bivariate analyses, managers' food safety training and food safety certification were both independently related to managers' food safety knowledge. However, when both variables were entered into the multivariable model together, training was no longer significantly related to knowledge, suggesting that training and certification are confounded. Training and certification are likely both important to food safety knowledge; however, the model including certification provides better goodness-of-fit than the model including training.

The training variable used in the model measures only whether the manager had ever taken any type of food safety training, not whether the manager had taken training along with a certification examination. Most managers who were certified had taken training along with the certification examination. Training provided with certification examinations may be more likely to include knowledge measured on certification examinations than other types of training; this training may lead to greater food safety knowledge scores. The certification examination itself may also lead to greater food safety knowledge- those who know they have to pass the examination to get or keep their jobs may be more motivated to learn and retain food safety information.

Two manager characteristics other than certification were also related to food safety knowledge. Managers whose primary language was English were more likely to pass the assessment. Those whose primary language is not English may have difficulty learning in an English-only environment. Additionally, they may have limited English reading comprehension, which would likely impact their assessment score. English was not the primary language of more than a quarter of the managers in this study. We can assume that these managers had fairly good verbal English skills; only managers with English verbal skills sufficient for an

interview were able to participate in the study. However, these managers' proficiency in written English is unknown. Our language findings are consistent with others (Manes *et al*., 2013), and highlight the need for food safety training programs that adequately address the needs of workers with limited English speaking and reading skills.

More experienced managers were more likely to pass the assessment also. These managers likely had more opportunity to learn about food safety on the job. These data align with other data suggesting that restaurants with experienced managers have better food safety practices (Lynch *et al*., 2003; Sumner *et al*., 2011), and highlight the importance of hiring well-qualified, knowledgeable, experienced managers.

Our data also suggest that restaurant characteristics influence managers' food safety knowledge. Managers in chain restaurants and larger restaurants were more likely to pass the assessment. These data are consistent with other data suggesting that food safety practices in independent restaurants are inferior to their counterparts' (chain restaurants) (Lee *et al*., 2004; Green *et al*., 2005; Green *et al*., 2007). Chain and larger restaurants may have more resources for food safety training; they may also emphasize food safety more than independent restaurants.

Characteristics associated with worker knowledge assessment scores

As with managers, certified workers were more likely to pass the assessment than were non-certified workers, suggesting that the relationship between certification and knowledge is similar for both managers and workers. Other characteristics of workers were related to the assessment score also. Findings concerning language mirrored the manager findings—workers whose primary language was English were more likely to pass the assessment. Workers who had more job duties were more likely to pass the assessment also. Multiple job duties may lead to greater food safety knowledge (possibly through on-the-job training for each duty). Alternatively, workers with multiple job duties may have (or aspire to) positions of greater responsibility (e.g., line supervisor), and those positions may require greater food safety knowledge.

One manager characteristic was related to worker food safety knowledge. Workers whose managers passed the assessment were more likely to pass the assessment themselves, suggesting that manager food safety knowledge directly affects worker food safety knowledge. Managers are often responsible for training and supervising workers; managers with more food safety knowledge necessarily have more to share with their workers.

No restaurant characteristics were related to worker food safety knowledge, suggesting that the restaurant environment may not influence worker food safety knowledge greatly. This finding, along with the finding that manager food safety knowledge was related to worker food safety knowledge, highlights the important role that managers likely play in worker food safety knowledge.

Limitations

Our study is limited in that we collected self-report data. These data may be impacted by a bias in which socially desirable behavior, such as being certified, is over-reported by respondents. Additionally, because interviewed workers were chosen by managers, and not randomly, the worker data may not be representative of the full range of workers. Similarly, because we collected data from English-speaking managers and workers only, our data may

not represent managers and workers who are not English-speaking.

Conclusions

The findings from this study are valuable because they support previous findings that food safety certification improves food safety knowledge. Additionally, our findings suggest that food safety certification is one of the few easily modifiable factors related to food safety knowledge. Other factors related to food safety knowledge, such as restaurant ownership and language skills, are harder to change than certification status. Moreover, our findings suggest that complex relationships exist among manager, restaurant, and worker characteristics and food safety knowledge. These relationships can best be explored through a socio-ecological framework in which manager, restaurant, and worker characteristics are presumed to directly and indirectly influence each other. To fully understand these relationships, we must examinationine how these characteristics are related to both food preparation practices and food safety knowledge. Our next step is to analyze the data from the portion of this study in which we observed food preparation practices to better understand these relationships.

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Disclosure Statement

No competing financial interests exist.

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FIG. 1. Manager food safety knowledge assessment (self-administered)

Please choose the best answer and circle your answer choice.

1. What symptom(s) are most likely to indicate an employee has a disease that may be passed through food?

A. Pink eye

B. Runny nose and sneezing

C. Vomiting and diarrhea*

D. All of the above

2. Raw hamburger patties should be cooked to an internal temperature of

A. 135°F (57°C).

B. 140°F (60°C).

C. 150°F (66°C).

D. 155°F (68°C) / 158°F (70°C).*+

3. What should you do to ensure that the sanitizing solution you are using on a food preparation surface will work properly?

A. When mixing the solution, use a test kit to check its concentration.*

B. When using the solution, rinse it from the surface and then let it air dry.

C. After using the solution, test the surface to confirm that no more microorganisms are present.

D. None of the above.

4. What is the proper procedure for washing your hands?

A. Wet hands with warm water. Apply soap. Vigorously scrub hands and arms for 10-15 seconds. Rinse hands. Dry hands.*

B. Wet hands with warm water. Apply soap. Vigorously scrub hands and arms for 2-5 seconds. Apply a hand antiseptic. Dry hands.

C. Wet hands with warm water. Apply soap. Rinse hands. Dry hands.

D. None of the above.

5. At what maximum internal temperature should cold potentially hazardous foods (PHF) be held?

A. O°F (-17°C)

B. 32°F (0°C)

C. 41°F (5°C) / 45°F (7°C)*+

D. 60°F (16°C)

6. Food handlers should change their gloves:

A. When they become soiled or torn

B. After taking out the trash

C. After handling raw meat and before handling ready-to-eat foods

D. All of the above*

7. At what minimum internal temperature should hot potentially hazardous foods (PHF) be held?

A. 115°F (46°C)

B. 125°F (52°C)

C. 135°F (57°C) / 140°F (60°C)*+

D. 155°F (68°C)

8. What is the correct way to clean and sanitize a prep table?

A. Rinse, wash, sanitize

B. Wash, rinse, sanitize*

C. Sanitize, wash, rinse

D. Rinse, sanitize, wash

9. Poultry, stuffed meat, and all stuffing should be cooked to a minimum internal temperature of:

A. 165° F (74°C)*

B. 150° F (66°C)

C. 145° F (63°C)

D. 155° F (68°C)

10. Food handlers must wash their hands before they start work and after:

A. Using the restroom.

B. Sneezing, coughing, or using a tissue.

C. Handling raw meat, poultry, or seafood.

D. All of the above.*

* Indicates the correct answer. + For three questions, the correct answer varied because the EHS-Net site's local regulations varied. Thus, we created different versions of the survey for different EHS-Net sites. All correct answers are shown here.

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FIG. 2. Worker food safety knowledge assessment (interview).

For the following statements, please tell me if you think the statement is correct by saying Yes, No, or Not Sure.

It's okay to dry your hands on your apron after washing them when you are really busy.

❍ Yes ❍ No* ❍ Unsure ❍ Refused

It's okay to thaw frozen raw chicken on the counter at room temperature.

❍ Yes ❍ No* ❍ Unsure ❍ Refused

Hamburger patties should be cooked to an internal temperature of 155/158 degrees Fahrenheit or higher. +

❍ Yes* ❍ No ❍ Unsure ❍ Refused

During hand washing, food workers must scrub their hands and arms for 4 or 5 seconds.

❍ Yes ❍ No* ❍ Unsure ❍ Refused

Food workers should wash hands between glove changes.

❍ Yes* ❍ No ❍ Unsure ❍ Refused

Wiping cloths used to clean food spills should be stored in a sanitizer solution.

❍ Yes ❍ No* ❍ Unsure ❍ Refused

Food held hot on a steam table should be maintained at 130 degrees Fahrenheit.

❍ Yes ❍ No* ❍ Unsure ❍ Refused

Cold held food should be maintained at 41/45 degrees Fahrenheit or lower. +

❍ Yes* ❍ No ❍ Unsure ❍ Refused

* Indicates the correct answer.

+ For two questions, the correct answer varied because the EHS-Net site's local regulations varied. Thus, we created different versions of the survey for different EHS-Net sites. The two versions of the questions are presented here. For example, in question 3, one version read 155 degrees Fahrenheit, and another read 158 degrees Fahrenheit.

TABLE 1. Restaurant, Manager, and Worker Characteristics Data Obtained from Interviews with Kitchen Managers and Food Workers

Restaurant characteristics[a]	N (%)
Ownership type	
Chain	159 (41.1)
Independent	228 (58.9)
Menu type (*N* = 384)	
American	254 (66.2)
Other	130 (33.9)
Restaurant required certification *(N* = 376)	
Yes	268 (71.3)
No	108 (28.7)
Restaurant cooked raw animal products	
No	72 (18.6)
Yes	315 (81.4)
Seating capacity	
0–49	146 (37.7)
50–99	93 (24.0)
≥ 100	148 (38.2)
Meals served (on busiest day of week)	
0–199	134 (34.6)
200–399	104 (26.9)
≥ 400	149 (38.5)
Manager characteristics[a]	
Sex	
Male	264 (68.2)
Female	123 (31.8)
Age (y) (*N* = 386)	
≤ 30	86 (22.3)
31–40	109 (28.2)
41–49	113 (29.3)
≥ 50	78 (20.2)
Education (*N* = 383)	
High school or less	119 (31.1)
Some community college or a community college degree	145 (37.9)
College degree or more	119 (31.1)
Primary language	
English	284 (73.4)
Other	103 (26.6)
Experience as kitchen manager	
≤ 2 y	139 (36.3)
> 2 y	244 (63.7)
Worker characteristics[b]	
Sex	
Male	219 (60.0)
Female	146 (40.0)
Age (y)	
≤ 30	170 (46.6)
31–40	96 (26.3)
41–49	61 (16.7)
≥ 50	38 (10.4)
Education (*N* = 361)	

High school or less	196 (54.3)
Some community college or a community college degree	115 (31.9)
College degree or more	50 (13.9)
Primary language	
English	240 (65.8)
Other	125 (34.2)
Experience in food service industry	
≤ 2 y	45 (12.3)
> 2 y	320 (87.7)
Number of job duties (food prep, food storage, cooking, cleaning, dishwashing)	
≤ 3	177 (48.5)
4 or 5	188 (51.5)

[a]*N*, 387 unless otherwise noted; *N* differs from 387 because of missing data from nonresponse.
[b]*N*, 365 unless otherwise noted; *N* differs from 365 because of missing data from nonresponse.

TABLE 2. Manager and Worker Food Safety Training and Certification Data Obtained from Interviews with Kitchen Managers and Food Workers

	Managers		*Workers*	
	N	**n (%)**	**N**	**n (%)**
Ever received food safety training	386		376	
Yes		366 (94.8)		340 (90.4)
No		20 (5.2)		36 (9.6)
Ever certified in food safety	381		356	
Yes		300 (78.7)		128 (36.0)
No		81 (21.3)		228 (64.0)
Currently hold a current food safety certificate	381		NA	
Yes		269 (70.6)		NA
No		112 (29.4)		NA
Certification from an accredited organization[a]	269		118	
Yes		210 (78.1)		90 (76.3)
No		59 (21.9)		28 (23.7)
Received food safety training immediately before taking certification test[a]	273		364	
Yes		270 (98.9)		328 (90.1)
No		3 (1.1)		36 (9.9)
Types of training received[b]	270		328	
Classroom		243 (90.0)		87 (26.5)
On the job		140 (51.9)		309 (94.2)
Manual or employee handbook		233 (86.9)		185 (56.9)
Videos or DVDs		205 (76.5)		139 (42.6)
Other kind of written materials		180 (67.7)		116 (36.0)
Online		86 (32.0)		91 (28.0)

NA, Not asked.

[a]These questions were only asked of those managers and workers who said they were certified.

[b]These questions were only asked of those managers and workers who said they were certified and had received food safety training.

TABLE 3. Manager and Worker Food Safety Knowledge Assessment Score Data Obtained from Self-Administered (Manager) or Interview (Worker Food Safety Knowledge Assessments

	Managers N (%)	*Workers* N (%)
Total Score (dichotomized)		
Passed	214 (55.3)	191 (52.3)
Failed	173 (44.7)	174 (47.7)
	Mean (SD)	*Mean (SD)*
Total mean percent correct score	74.9 (14.0)	68.6 (17.3)
Mean percent correct sub-part scores		
Hand hygiene	91.5 (15.7)	82.2 (21.2)
Cooking temperatures	72.6 (35.4)	84.1 (36.7)
Hot and cold holding temperatures	74.2 (31.4)	75.2 (22.5)
Cross-contamination	86.6 (20.1)	16.6 (37.2)
Foodborne illness	15.0 (3.6)	NA

NA, not asked.

TABLE 4: Bivariate Analyses on Restaurant and Manager Characteristics Associated with Manager Food Safety Knowledge Assessment Scores (*N* = 387)

Variables	*Passing food safety knowledge assessment*	
Restaurant characteristics	*OR (95% CI)*	p *Value*
Ownership type		
Chain	1.69 (1.12–2.56)	0.01
Independent	--	
Menu type		
American	1.33 (0.87–2.04)	0.19
Other	--	
Restaurant required certification		
Yes	1.98 (1.27–3.11)	0.01
No	--	
Restaurant cooks raw animal products		
Yes	1.49 (0.89–2.50)	0.13
No	--	
Seating capacity		
0–49	--	0.01
50–99	2.01 (1.18–3.42)	
≥100	1.88 (1.18–3.00)	
Meals served (on busiest day of week)		
0–199	--	0.01
200–399	1.60 (0.96--2.69)	
≥ 400	2.37 (1.47--3.84)	
Manager characteristics		
Sex		
Male	0.91 (0.59–1.40)	0.66
Female	--	
Age (y)		
≤ 30	--	0.52
31–40	0.89 (0.50–1.56)	
41–49	1.26 (0.72–2.24)	
≥ 50	1.25 (0.67–2.33)	
Education		
High school or less	--	0.03
Some community college or community college	1.89 (1.15–3.09)	
College degree or more	1.18 (0.71–1.97)	
Primary language		
English	2.00 (1.26–3.16)	0.01
Other	--	
Experience as kitchen manager		
≤ 2 y	--	0.03
> 2 y	1.62 (1.06–2.47)	
Ever received food safety training		
Yes	5.39 (1.75–16.53)	0.01
No	--	
Ever certified in food safety		
Yes	2.59 (1.56–4.30)	0.01
No	--	
Hold a current food safety certificate		
Yes	**1.85 (1.18–2.89)**	**0.01**
No	**--**	
Certification from an accredited organization		
Yes	**2.74 (1.52–4.93)**	**0.01**
No	**--**	

TABLE 5. Bivariate Analyses on Restaurant, Manager, and Food Worker Characteristics Associated with Food Worker Food Safety Knowledge Assessment Scores (*N* = 365)

Variables	*Passing food safety knowledge assessment*	
Restaurant characteristics	*OR (95% CI)*	p *Value*
Ownership type		
Chain	1.35 (0.89–2.04)	0.16
Independent	--	
Menu type		
American	1.04 (0.67–1.61)	0.86
Other	--	
Restaurant required certification		
Yes	0.92 (0.58–1.46)	0.73
No	--	
Restaurant cooks raw animal products		
Yes	1.51 (0.89–2.56)	0.13
No	--	
Seating capacity		
0–49	--	0.08
50–99	1.14 (0.67–1.95)	
≥100	1.69 (1.05-2.71)	
Meals served (on busiest day)		
0–199	--	0.02
200–399	1.34 (0.79-2.29)	
≥400	1.99 (1.22–3.26)	
Manager characteristics	*OR (95% CI)*	p *Value*
Primary language spoken		
English	1.89 (1.17–3.06)	0.01
Other	--	
Experience as kitchen manager		
≤2 y	--	0.43
>2 y	1.19 (0.77–1.83)	
Ever received food safety training		
Yes	1.23 (0.49-3.10)	0.65
No	--	
Ever certified in food safety		
Yes	1.82 (1.09–3.04)	0.02
No	--	
Hold a current food safety certificate		
Yes	1.37 (0.86–2.16)	0.18
No	--	
Certification from an accredited organization		
Yes	1.62 (0.90–2.92)	0.11
No	--	
Manager food safety knowledge assessment		
Passed	2.01 (1.32-3.07)	0.01
Failed	--	

Worker characteristics	*OR (95% CI)*	p *Value*
Sex		
Male	1.13 (0.74–1.72)	0.58
Female	--	
Age (y)		
≤ 30	--	0.24
31–40	1.70 (1.02-2.83)	
41–49	1.31 (0.72-2.37)	
≥ 50	1.24 (0.61-2.51)	
Education		
High school or less	--	0.10
Some or community college	1.47 (0.92–2.35)	
College degree or more	1.81 (0.95–3.43)	
Primary language spoken		
English	2.05 (1.32–3.19)	0.01
Other	--	
Experience in food service industry		
≤ 2 y	--	0.03
> 2 y	2.11 (1.09–4.08)	
Number of job duties (food prep, food storage, cooking, cleaning, dishwashing)		
≤ 3	--	0.00
4 or 5	2.17 (1.42–3.30)	
Ever received food safety training		
Yes	.99 (0.50–1.98)	0.98
No	--	
Ever certified in food safety		
Yes	2.07 (1.33–3.23)	0.01
No	--	
Certification from an accredited organization		
Yes	1.82 (0.77–4.32)	0.17
No	--	

TABLE 6. Multivariable Analyses on Restaurant and Manager Characteristics Associated with Manager Food Safety Knowledge Assessment Scores (*N* = 378) and Restaurant, Manager, and Food Worker Characteristics Associated with Worker Food Safety Knowledge Assessment Scores (*N* = 355)

Manager		
Variables	*Passing food safety knowledge assessment*	
Restaurant characteristics	*OR (95% CI)*	p *Value*
Ownership type		
Chain	1.62 (1.02–2.59)	0.04
Independent	--	
Seating capacity		
0–49	--	0.02
50–99	2.07 (1.19-3.61)	
≥ 100	1.81 (1.09–3.01)	
Manager characteristics		
Primary language spoken		
English	1.80 (1.09–2.97)	0.02
Other	--	
Experience as kitchen manager		
≤ 2 y	--	0.01
> 2 y	1.82 (1.14–2.91)	
Ever certified in food safety		
Yes	2.20 (1.27–3.80)	0.01
No	--	
Worker		
Variables	*Passing food safety knowledge assessment*	
Manager characteristics	*OR (95% CI)*	p *Value*
Manager food safety knowledge assessment		
Passed	1.70 (1.08–2.80)	0.02
Failed	--	
Worker characteristics	*OR (95% CI)*	p *Value*
Worker primary language spoken		
English	1.77 (1.10–2.85)	0.02
Other	--	
Number of job duties		
≤ 3	--	0.01
4 or 5	1.97(1.25–3.11)	
Ever certified in food safety		
Yes	2.16 (1.35–3.45)	0.01
No	--	