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Worker and Restaurant Characteristics Associated with Food Safety Culture: An Environmental Health Specialists Network Study

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Abstract

More than 800 foodborne illness outbreaks have been reported to the United States Centers for Disease Control and Prevention (CDC) annually. Researchers have suggested that improving food safety culture in restaurants (i.e., shared values, beliefs, and norms about food safety) is an important way to reduce foodborne outbreaks. However, we know relatively little about the

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Authors' Contributions

A.J.K.: Conceptualization, methodology, analysis, writing—original draft, project administration. N.H., B.V., L.D., D.J.I., D.C.N., W.M., J.A.M., J.T.: Conceptualization, investigation, writing—reviewing and editing, project administration. L.G.B.: Conceptualization, writing—original draft.

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The authors have no interests to disclose.

Disclaimer

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connections between food safety culture and food safety outcomes in restaurants. To bridge these gaps in knowledge, state and local health department staff with CDC's Environmental Health Specialists Network (EHS-Net) conducted a study in which they interviewed managers and administered written surveys to food workers in 321 restaurants across eight EHS-Net jurisdictions. Data on restaurant characteristics (e.g., the existence of food safety policies) were collected through interviews with restaurant managers. Data on food worker characteristics (e.g., food safety knowledge) were collected through a worker survey. The survey also assessed worker beliefs about food safety in their restaurants (i.e., food safety culture). Analyses showed that several restaurant characteristics, including the existence of food safety policies and methods for monitoring policy implementation, were significantly and positively associated with workers' perceptions of their restaurant's food safety culture. The worker characteristics of having had food safety training and possessing food safety knowledge were also significantly and positively related to worker food safety culture beliefs. These findings suggest that management actions, such as providing food safety training, implementing food safety policies, and monitoring compliance with those policies, are associated with a strong food safety culture.

Keywords

food safety culture; restaurant food safety; food safety management systems

Introduction

Foodborne illness remains a public health challenge in the United States. Health departments report over 800 foodborne outbreaks to the Centers for Disease Control and Prevention (CDC) annually (Dewey-Mattia et al., 2018). Over 60% of these outbreaks are associated with restaurants. Recent efforts to combat restaurant-related outbreaks have focused on food safety culture (i.e., shared values, beliefs, and norms about food safety). For example, the U.S. Food and Drug Administration (FDA) identified strengthening food safety culture in food facilities as a core element of their food safety plan (U.S. Food and Drug Administration, 2020). A 2022 FDA literature review concluded that current research suggests that a strong food safety culture has positive effects on food safety; the review found that a strong food safety culture has been linked with good employee food safety practices, fewer inspection violations, and less pathogen contamination (U.S. Food and Drug Administration, 2022). The review also concluded that more empirical studies are needed to understand the connections between restaurant food safety culture and food safety outcomes.

To help address this data gap, the CDC conducted a study on food safety culture in 331 restaurants (U.S. Centers for Disease Control and Prevention, 2020). The goals of this study were to assess: 1) a survey measure of restaurant worker beliefs about their restaurant's food safety culture; and 2) relationships between food safety culture as measured by this survey and restaurant characteristics, policies, and practices. In 2023, the CDC published a paper on the first goal of the study describing the findings from the analysis of the survey data on the food safety culture of workers (Kramer et al., 2023). This analysis found that the survey assessed four primary constructs of worker beliefs about food safety culture. These were leadership (Does management provide food safety policies and training),

management commitment (Does management prioritize food safety), employee commitment (Are workers committed to food safety), and resource availability (Does the restaurant have the resources needed to maintain good hand hygiene).

In this paper, we present data on the second goal of the study. This paper examines relationships between the four aspects of food safety culture assessed by our measure and restaurant characteristics, policies, and practices. These analyses can help fill gaps in our understanding of the relationships between food safety culture and restaurant food safety.

Methods

This paper is based on a study conducted by the Environmental Health Specialists Network (EHS-Net), a network comprised of the CDC, the FDA, the U.S. Department of Agriculture's Food Safety and Inspection Service, and eight health departments funded by the CDC to conduct this study. These were: California Department of Public Health, Harris County Public Health (Texas), Minnesota Department of Health, New York State Department of Health, New York City Department of Health and Mental Hygiene (New York), Rhode Island Department of Health, Southern Nevada Health District (Nevada), and Tennessee Department of Health.

Sample

The sample consisted of restaurants in the eight EHS-Net jurisdictions. Restaurants were defined as establishments that prepare and serve food or beverages to customers but are not institutions, mobile food units, temporary food stands, supermarkets, restaurants in supermarkets, or caterers. In each EHS-Net jurisdiction, health department staff chose a geographic area in which to recruit restaurants for study participation, based on a reasonable travel distance (mean = 88.1 min, range = 30 min–4 h). Staff called or visited randomly selected restaurants to recruit for the study and scheduled a data collection visit with managers who agreed to participate. Data were collected from March 2018 through March 2019.

Institutional review board approval

Each EHS-Net jurisdiction's institutional review board approved the study protocol.

Data collection

All data collectors (EHS-Net health department staff) participated in training focused on standardizing data collection methods. At each restaurant, data collectors obtained verbal informed consent from and conducted a standardized interview with, the manager (person with authority over the restaurant). They also recruited on-site food workers (people who prepare food in the restaurant) for study participation. They obtained verbal consent from participating workers and administered a written survey or provided a link to the survey online.

The worker survey included questions on worker characteristics (Table 1), including food safety knowledge (seven multiple choice items) (Box 1). The survey also included 28

items that assessed workers' perceptions of their restaurant's food safety culture (using a Likert-scale [1-strongly disagree to 5-strongly agree]) (Box 2). The online worker survey was available in both English and Spanish and was administered using SurveyMonkey, a user-friendly and widely used online survey platform (Momentive, San Mateo, CA, USA). See Kramer et al. (2023) for details on the development of the food safety culture measure. An identifier linked restaurant, manager, and worker data, but no data identified individual restaurants, managers, or workers. The manager interviews collected data on restaurant characteristics (e.g., seating capacity) (Tables 2 and 3).

Analysis

First, we conducted an exploratory factor analysis to determine if the food safety culture survey items measured multiple factors. We retained survey items in our analysis that loaded onto unique common factors, had a primary factor loading of ≥ 0.4 , and did not load onto another factor at ≥ 0.3 . Sixteen items composing four unique factors were retained in the model. We assessed the reliability of these four factors using Cronbach's alpha (alpha coefficient [α] of 0.65 or higher was considered acceptable). Study staff then reviewed the items and labeled the factors leadership: (6 items, $\alpha = 0.88$); management commitment (3 items, $\alpha = 0.73$); employee commitment (4 items, $\alpha = 0.87$); and resource availability (3 items, $\alpha = 0.72$). We then created a composite measure for each factor by averaging the item scores in the factor (negatively phrased questions were recoded so that higher scores would equate to positive agreement). These analyses were first reported by Kramer et al. (2023); additional details can be found there.

We calculated frequencies for the worker and restaurant characteristics obtained from the worker survey and manager interview. Then, we conducted hierarchical linear modeling (HLM) to determine how the four food safety culture constructs were related to worker and restaurant characteristics. We used two-level HLM to estimate the association of worker-level (e.g., years in food service) and restaurant-level (e.g., seating capacity) characteristics with the four food safety culture constructs, nesting worker-level data within restaurant-level data. This methodology allowed us to associate multiple workers within individual restaurants. We also calculated a variance partition coefficient (VPC), or intraclass correlation coefficient, to assess whether workers within the same restaurant were more likely to provide similar responses than those in different restaurants. This helped determine if our HLM analyses needed to account for correlations of worker responses within restaurants.

We developed four separate multivariable models, one for each construct. We used tests to determine whether to include each of the 23 characteristics of interest (listed in Tables 1–3) in the models. The likelihood ratio test examines the goodness of fit of two competing models: in our case, a null model and a model containing the characteristic of interest. The higher the likelihood ratio tests (LRT) (>1), the stronger the evidence that the characteristic is related to the construct. Models that contained characteristics that were statistically significant were then included in an iterative approach to determine the best combination of characteristics to include in each of the four final models based on theoretical associations and statistical fit. We developed the four final models of the best fit of statistically

significant characteristics through an iterative approach. This process was guided by both theoretical considerations and statistical fit. We tested for interactions among all significant characteristics and included significant interactions in the models. We used a bootstrapping method to randomly resample our dataset 2000 times and create 2000 simulated samples (Roberts and Fan, 2004). This dataset was used to generate robust estimates of parameters and confidence intervals. We used SAS version 9.4 (SAS Institute Inc, Cary, NC, USA) to analyze the data.

Results

Sample

We contacted 990 managers of restaurants that met the requirements for study participation; 352 agreed to participate. We received 567 food worker survey responses from 321 of those restaurants. An average of 1.8 workers responded per restaurant (standard deviation [SD] = 1.4). Denominators vary for some analyses because of missing data.

Worker and restaurant characteristics

The majority of workers said they had 1–5 years of food service experience (41.7%). Most (77%) said they had received food safety training at their current restaurant. The mean worker food safety knowledge score was 70.8% (out of 100%). According to manager interview data, the majority of restaurants were independently owned (57.9%) and did not provide full service (62.3%). Tables 1–3 contain more data on worker and restaurant characteristics.

Food safety culture scores

The four food safety culture construct scores were relatively high (composite scores >3 on a 1–5 scale). The resource availability score was highest (mean = 4.7, SD = 0.7, $n = 557$), followed by employee commitment (mean = 4.5, SD = 0.6, $n = 557$), leadership (mean = 4.3, SD = 0.70, $n = 557$), and management commitment (mean = 3.9, SD = 1.2, $n = 557$) (See Box 2). A detailed discussion of these data can be found in Kramer et al. (2023).

Food safety leadership

Most (66%) variation in the leadership score was in workers within restaurants; 34% was in restaurants (VPC = 0.34), indicating that worker beliefs about food safety leadership vary across workers and restaurants. LRT indicated that all the characteristics of interest were significantly related to the leadership score and were thus considered for inclusion in the multivariable model, except the worker food safety knowledge score (Table 4). The final multivariable model for leadership included the characteristics of whether the surveyed worker had received food safety training at their restaurant, employee turnover (number of food employees replaced monthly), and percentage of food safety policies that were written (Table 5). Leadership scores were higher for workers who received food safety training compared to those who did not. Leadership scores increased as the percentage of policies that were written increased. However, leadership scores decreased as employee turnover increased.

Management commitment to food safety

Most (65%) variation in the management commitment score was in workers within restaurants; 35% was in restaurants ($VPC = 0.35$), indicating that worker beliefs about management commitment to food safety vary across workers and restaurants. LRT indicated that all characteristics were significantly related to the management commitment score; thus, they were considered for inclusion in the multivariable model (Table 4). The final multivariable model for management commitment included the characteristics of worker food safety knowledge score, number of certified food protection managers in the restaurant, number of methods used for employee training on policies, and number of methods used for verifying that employees follow policies (Table 5). Management commitment scores increased as worker food safety knowledge scores increased and as the number of methods for training and verifying policies increased. Management commitment scores decreased as the number of certified food protection managers increased.

The final model included two interactions. The first interaction, between the number of certified food protection managers and worker food safety knowledge score, indicated that management commitment scores were highest when there were fewer certified food protection managers and workers who were more knowledgeable in food safety. The second interaction, between the number of methods for training employees on food safety policies and the number of methods for verifying that employees follow those policies, indicated that management commitment increased as the number of employee training methods increased and, independently, as the number of methods for verifying that policies were followed increased. However, management commitment decreased when a high number of both types of methods were used simultaneously.

Employee commitment to food safety

Most (78%) variation in the employee commitment score was in workers within restaurants; 22% was in restaurants ($VPC = 0.22$), indicating that worker beliefs about employee commitment to food safety vary across workers and restaurants. LRT indicated that all characteristics were significantly related to the employee commitment score and were thus considered for inclusion in the multivariable model, except the worker food safety knowledge score (Table 4). The final multivariable model for employee commitment included the characteristics of whether the surveyed worker received food safety training at their restaurant, whether manager pay was affected by the restaurant's food safety performance (e.g., inspection scores), and the interaction of these two characteristics (Table 5). Employee commitment scores were higher when the surveyed worker had received food safety training and lower when manager pay was affected by restaurant food safety performance. The interaction indicated that employee commitment scores were lowest when manager pay was affected by food safety performance and when workers did not receive training at their restaurant. Employee commitment scores were highest when manager pay was not affected by food safety performance and when workers received training at their restaurant.

Food safety resource availability

Most (86%) variation in the resource availability score was in workers within restaurants; 14% was in restaurants ($VPC = 0.14$), indicating that worker beliefs about food safety resource availability vary across workers and restaurants. LRT indicated that all characteristics were significantly related to the resource availability score; thus, they were considered for inclusion in the multivariable model (Table 4). The final multivariable model for resource availability included the worker-level characteristics of food safety training at the restaurant, having a high school degree, and food safety knowledge scores, and the restaurant-level characteristics of the percentage of food safety policies that were written and employee turnover ratio (number of food employees replaced monthly divided by number of food employees). (Table 5). The final model also included the interaction of worker food safety training and food safety knowledge scores. Resource availability scores were higher if the surveyed worker had received food safety training at their restaurant and had a high school degree. Resource availability scores increased with worker food safety knowledge scores, the percentage of policies that were written, and the employee turnover ratio. The interaction indicated that although resource availability scores were higher when workers received training at their restaurant and, independently, as their food safety knowledge scores increased, they were highest when workers received training at their restaurant and were knowledgeable in food safety.

Discussion

We found that management actions, such as the provision of food safety training, policies, and monitoring, were positively associated with a strong food safety culture. The worker characteristic of having received food safety training was positively associated with three of the four food safety culture components—leadership, employee commitment, and resource availability. The interaction between food safety training and manager compensation for food safety performance for employee commitment to food safety also showed that not only did food safety training have a positive correlation with worker beliefs of food safety culture, but it also mitigated the negative relationship between manager compensation for food safety performance and employee commitment to food safety. Previous research indicated that food safety training is related to positive food safety outcomes such as food safety practices, inspection scores, and foodborne outbreak size (Brown, 2021). Our data suggest that food safety training has a significant positive influence on food safety culture. Along with improving knowledge of food safety and its importance, training can contribute to worker beliefs that management provides leadership and resources in food safety.

Having written food safety policies was positively associated with the food safety culture constructs of food safety leadership and resource availability. The existence of food safety policies and procedures has been linked with better food safety practices in restaurants (Brown, 2021). Our findings suggest that food safety policies, particularly written ones, are also positively related to food safety culture. The existence of written policies likely contributes to worker beliefs that management provides leadership and resources for food safety.

Employee turnover was also related to leadership and resource availability, but the relationship was not clear-cut. The number of employees replaced monthly was negatively related to worker beliefs about leadership, suggesting that good leadership may lead to less turnover. However, the ratio measure of turnover, which measures the proportion of employees replaced monthly, was positively related to resource availability. Because this measure accounts for restaurant size (as measured by the number of employees), this finding suggests that larger restaurants may have more resources and higher turnover rates. More research is needed on these relationships.

The fact that the number of methods for training employees on food safety policies and the number of methods for verifying that employees follow food safety policies were each independently associated with worker beliefs about management commitment to food safety suggests that ensuring that food safety policies are followed is important for this food safety culture component. However, when both the numbers of training and verification methods were higher, management commitment scores decreased. Similarly, a higher number of certified food protection managers was associated with lower management commitment scores. It is possible that workers perceive excessive training and verification methods, along with a large number of managers, as micromanagement, signaling a focus on control rather than food safety. Further research is needed to explore this phenomenon.

This study has several limitations:

- The worker survey was in written form and was provided only in English and Spanish. Our data might not be representative of workers who cannot read English or Spanish.
- Because worker survey and manager interview responses were self-reported, they were subject to social desirability bias which can lead to overreporting of socially desirable responses (e.g., positive views of food safety).
- Only a third of the contacted restaurants participated in the study. These restaurants might differ systematically from non-participating restaurants.
- Because of the study's limited geographical areas, findings might not be representative of restaurants nationally.
- This study is cross-sectional and does not allow causal inferences about relationships between restaurant characteristics and food safety culture scores.

These data are some of the first to examine relationships between worker beliefs about their restaurant's food safety culture and staff and restaurant characteristics. Our findings suggest that the decisions and actions of restaurant management are linked with worker beliefs about food safety culture. This aligns with previous studies showing that strong food safety management systems—food safety procedures and policies, training, and monitoring—are linked with restaurant food safety (Brown, 2021; U.S. Food and Drug Administration, 2018). Although research is ongoing, our data indicate that food safety management system components are integrally linked with worker beliefs about food safety culture.

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References

- Brown L. Using data to improve practice: Looking back on 20 years of restaurant food safety research. *J Env Health* 2021;83:40–42; doi: 10.15585/mmwr.ss6710a1 [PubMed: 37181150]
- Dewey-Mattia D, Manikonda K, Hall A, et al. Surveillance for foodborne disease outbreaks—United States, 2009–2015. *MMWR Surv Summ* 2018;67:1–11; doi: 10.15585/mmwr.ss6710a1
- Kramer A, Hoover ER, Hedeem N, et al. Development of an empirically derived measure of food safety culture in restaurants. *J Food Prot* 2023;86(3):100043–100047; doi: 10.1016/j.jfp.2023.100043 [PubMed: 36916550]
- Roberts JK, Fan X. Bootstrapping within the multilevel/hierarchical linear modeling framework: A primer for use with SAS and SPLUS. *Multiple Linear Regression Viewpoint* 2004;30: 23–34.
- U.S. Centers for Disease Control and Prevention. Environmental Health Services. Environmental Health Specialists Network (EHS-Net). 2020. Available from: <https://www.cdc.gov/restaurant-food-safety/php/data-research/accomplishments/> [Last accessed: June 14, 2024].
- U.S. Food and Drug Administration. Food Safety Culture Systematic Literature Review. A report prepared by Westat, Inc. in collaboration with FDA Food Safety Culture Research Subgroup. 2022. Available from: <https://www.fda.gov/media/163588/download> [Last accessed: June 14, 2024].
- U.S. Food and Drug Administration. New Era of Smarter Food Safety. 2020. Available from: <https://www.fda.gov/media/139868/download?attachment> [Last accessed: June 14, 2024].
- U.S. Food and Drug Administration. Technical Report: FDA Report on the Occurrence of Foodborne Illness Risk Factors in Fast Food and Full-service Restaurants, 2013–2014. 2018. Available from: <https://www.fda.gov/media/117509/download?attachment> [Last accessed: June 14, 2024].

Box 1.**Food worker food safety knowledge questions***

Hands should be washed prior to handling food, plates, or utensils: [Check all that apply]

- After using the toilet
- Between handling raw and cooked foods
- After coughing or sneezing into their hands
- Hands only need to be washed before handling food not before handling plates or utensils.
- If an employee uses gloves, they don't need to wash their hands.

Cold-held meats or other refrigerated items should be kept at or below this temperature: [Check only one]

- 32°F (0°C)
- 41°F (5°C)
- 45°F (7°C)
- 50°F (10°C)

Hot-held meats or other hot items should be kept at or above this temperature: [Check only one]

- 120°F (49°C)
- 135°F (57°C)
- 140°F (60°C)
- 150°F (66°C)

What symptoms are most likely to show that an employee has an illness that can be passed through food? [Check only one]

- Pink eye
- Runny nose and sneezing
- Vomiting and diarrhea
- All of the above

What is the proper procedure for washing your hands? [Check only one]

- Wet hands with warm water. Apply soap. Vigorously scrub hands and arms for 10 to 20 seconds. Rinse hands. Dry hands.
- Wet hands with warm water. Apply soap. Vigorously scrub hands and arms for 2 to 5 seconds. Apply a hand anti-septic (such as hand sanitizer). Dry hands.

- Wet hands with warm water. Apply soap. Rinse hands. Dry hands.
- None of the above

Food that is cooked and then cooled must be cooled down within the following timeframe: [Check only one]

- 135°F / 140°F to 70°F within 2 h and then reach 41°F / 45°F within an additional 4 h (6 h total)
- 135°F / 140°F to 70 °F within 4 hours and then reach 41°F / 45°F within an additional 8 h (12 h total)
- It doesn't matter if the food has been cooked thoroughly.
- None of the above

The proper order for dishwashing (either manually in a three-compartment sink or using a dishwasher) is: [Check only one]

- Rinse, wash with soapy water, sanitize, air dry
- Wash with soapy water, rinse with clean water, sanitize, air dry
- Wash with soapy water, sanitize, towel dry
- None of the above

*Correct answer is in bold

Box 2.**Final worker food safety culture survey items*****Leadership**

The restaurant provides sufficient food safety training for me to do my job.

Managers get feedback from employees to improve food safety.

Food safety is stressed with signs, posters, or in-shift meetings.

Employees are positively recognized for following food safety rules.

My manager explains what is expected of me.

Employees know the restaurant's food safety expectations.

Employee commitment

Employees follow food safety rules, even when no one is looking.

Employees encourage each other to follow food safety rules.

Employees take responsibility for food safety in their areas.

Employees wash their hands when they are supposed to.

Resources

There are enough gloves or utensils to use to avoid touching the food with my bare hands.

Sinks are nearby and are easy to get to for handwashing.

Sinks for handwashing have hot water, soap, and paper towels or another way to dry my hands.

Management commitment

Employees have to cut corners because there is too much work to do. (Reverse coded)

When the restaurant is busy, managers prioritize serving food over following food safety rules. (Reverse coded)

Managers ignore when employees are not following food safety rules. (Reverse coded)

*Response scale: Strongly agree (5), agree (4), neither agree nor disagree (3), disagree (2), strongly disagree (1)

Table 1.
Worker Characteristics, Collected by Worker Survey

<i>Characteristic^a</i>	n	%^b
Years worked in food service (<i>n</i> = 537)		
<1 year	52	9.7
1–5 years	224	41.7
6–10 years	105	19.6
11–15 years	59	11.0
>15 years	97	18.1
Received food safety training at the current restaurant (<i>n</i> = 557)		
Yes	429	77.0
No	128	23.0
Ever been certified in food safety (<i>n</i> = 557)		
Yes, current	320	57.5
Yes, not current	53	9.5
No	184	33.0
Ever been a certified food protection manager (<i>n</i> = 557)		
Yes	166	29.8
No	391	70.2
Described themselves as (<i>n</i> = 532) ^c		
Male	283	52.9
Female	249	46.5
Obtained high school degree (<i>n</i> = 557)		
Yes	277	49.7
No	280	50.3
Culinary program experience (<i>n</i> = 557)		
Completed or enrolled	103	18.5
No	454	81.5
Mean (standard deviation)		
Food safety knowledge score (out of 100) (<i>n</i> = 557)	70.8 (15.1)	

^aDenominators vary because of missing data.

^bTotals may not round up to 100 due to rounding.

^cOther responses (*n* = 3) were removed from analysis.

Table 2.
Restaurant Characteristics (Categorical Variables), Collected by Manager Interview

<i>Characteristic</i>	N	%
Chain ownership ($n = 321$)		
Yes	135	42.1
No	186	57.9
Full service (i.e., restaurant provides table service) ($n = 321$)		
Yes	121	37.7
No	200	62.3
Manager pay affected by food safety performance rating ($n = 321$)		
Yes	31	9.7
No	290	90.3
Restaurant has a certified food protection manager present for all hours of operation ($n = 321$)		
Yes	180	56.1
No	141	43.9

Table 3.
Restaurant Characteristics (Continuous Variables), Collected by Manager Interview

Characteristic ^a	Mean	Standard deviation
Seating capacity (<i>n</i> = 286)	102.1	99.2
Approximate number of meals served/day (<i>n</i> = 259)	470.8	141.4
Number of employees who handle food (<i>n</i> = 309)	17.4	22.1
Employee turnover (number of employees who handle food replaced monthly) (<i>n</i> = 321)	0.9	3.2
Employee turnover ratio (number of employees who handle food replaced monthly/number of employees who handle food) (<i>n</i> = 321)	0.1	0.1
Number of certified food protection managers (<i>n</i> = 321)	3.4	5.8
Percentage of recommended food safety policies the restaurant has (<i>n</i> = 321)	88.0	20.9
Percentage of food safety policies that were written (<i>n</i> = 321)	50.6	39.6
Number of methods used for training employees on policies (<i>n</i> = 321)	1.9	1.0
Number of methods used for training employees on food safety (<i>n</i> = 321)	1.6	1.0
Number of methods used for verifying employees follow food safety policies (<i>n</i> = 321)	1.9	1.1

^aDenominators vary because of missing data.

Table 4.
Likelihood Ratio Tests for Relationships Between Worker and Restaurant Characteristics and Food Safety Culture Scores^a

Characteristics ^b	Leader-Ship	Employee commitment	Resource availability	Management commitment
Worker-level characteristics				
Number of years worked in food service (<i>n</i> = 533)	47.6	27.1	29.6	64.2
Received food safety training at the current restaurant (yes vs. no) (<i>n</i> = 516)	148.0	83.9	71.9	137.2
Ever been certified in food safety (yes vs. no) (<i>n</i> = 539)	26.2	12.8	25.9	57.4
Ever been a certified food protection manager (yes vs. no) (<i>n</i> = 534)	39.2	30.7	43.6	78.3
Male (yes vs. female) (<i>n</i> = 532)	56.9	39.2	40.2	77.4
Obtained high school degree (yes vs. no) (<i>n</i> = 554)	577.3	7.7	23.6	20.5
Attended culinary program (yes vs. no) (<i>n</i> = 535)	31.9	33.0	79.3	81.6
Food safety knowledge score (% correct out of 14 items) (<i>n</i> = 554)	— ⁺	— ⁺	28.2	59.5
Restaurant-level characteristics^c				
Chain ownership (yes vs. no) (<i>n</i> = 550)	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺
Full service (yes vs. no) (<i>n</i> = 514)	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺
Manager pay affected by food safety performance (yes vs. no) (<i>n</i> = 506)	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺
Certified food protection manager present during all hours of operation (yes vs. no) (<i>n</i> = 530)	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺	<0.0001 ⁺
Seating capacity (<i>n</i> = 512)	77.5	67.5	45.9	114.9
Approximate number of meals served/day (<i>n</i> = 442)	238.6	226.4	192.1	365.0
Number of employees who handle food (<i>n</i> = 515)	76.6	86.8	46.4	143.0
Employee turnover (number of employees who handle food replaced monthly) (<i>n</i> = 462)	192.9	164.0	117.7	319.4
Employee turnover ratio (number of employees who handle food replaced monthly/number of employees who handle food) (<i>n</i> = 443)	236.2	213.3	157.5	404.1
Number of certified food protection managers (<i>n</i> = 512)	82.1	86.6	72.6	128.6
Percentage of recommended food safety policies the restaurant has (<i>n</i> = 554)	13.0	23.3	5.5	18.3
Percentage of food safety policies that are written (<i>n</i> = 547)	27.3	39.3	30.6	46.8
Number of methods used for training employees on policies (<i>n</i> = 550)	73.9	74.9	51.3	127.4
Number of methods for training employees on food safety (<i>n</i> = 523)	17.7	24.6	11.1	27.1
Number of methods for verifying employees follow food safety policies (<i>n</i> = 545)	30.7	31.3	21.6	43.2

^a; these values are not significant. The likelihood ratio test examines the goodness of fit of two competing models; in this case, a null model and a model containing the characteristic of interest. The higher the ratio (>1), the stronger the evidence that the characteristic is related to the food safety culture construct.

^cDenominators differ from those in Table 2 because the construct score is calculated at the worker level and workers are nested within the restaurants.

^bDenominators vary because of missing data.

^aAll test values are significant at $p < 0.05$, unless marked with +.

Table 5.
Multilevel Regression Results for Relationships Among Worker and Restaurant Characteristics and Food Safety Culture Scores ($n = 2000$ Random Resamples)

Characteristics	Regression coefficient level	Parameter estimate	95% Confidence intervals
Leadership			
Received food safety training at current restaurant	Worker	0.63	0.62, 0.63
Intercept	Restaurant	3.64	3.64, 3.65
Employee turnover (number of employees who handle food replaced monthly)	Restaurant	-0.02	-0.02, -0.02
Percent of food safety policies that are written	Restaurant	0.22	0.22, 0.22
Management commitment			
Food safety knowledge score (% correct out of 14 items)	Worker	1.56	1.55, 1.57
Intercept	Restaurant	1.99	1.98, 2.0
Number of certified food protection managers	Restaurant	-0.06	-0.06, -0.06
Number of methods for training employees on food safety policies	Restaurant	0.43	0.43, 0.43
Number of methods for verifying employees follow food safety policies	Restaurant	0.41	0.41, 0.42
Interaction of the number of certified food protection managers and Food safety knowledge score	Interaction	0.05	0.05, 0.05
Interaction of the number of methods for training employees on food safety policies and the number of methods for verifying employees follow food safety policies	Interaction	-0.15	-0.15, -0.15
Employee commitment			
Received food safety training at the current restaurant	Worker	0.24	0.24, 0.24
Intercept	Restaurant	4.28	4.28, 4.29
Manager pay affected by food safety performance	Restaurant	-0.72	-0.73, -0.71
Interaction of workers received food safety training at current restaurant and manager pay affected by food safety performance	Interaction	0.57	0.56, 0.58
Resource availability			
Received food safety training at the current restaurant	Worker	1.60	1.59, 1.61
Obtained high school degree	Worker	0.22	0.22, 0.23
Food safety knowledge score (% correct out of 14 items)	Worker	2.38	2.36, 2.39
Intercept	Restaurant	2.55	2.54, 2.56
Percent of food safety policies that are written	Restaurant	0.22	0.22, 0.23
Employee turnover ratio (number of employees who handle food replaced monthly/number of employees who handle food)	Restaurant	0.81	0.81, 0.82
Interaction of worker received food safety training at current restaurant and food safety knowledge score	Interaction	-2.01	-2.03, -2.0