ARTICLES

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Food Safety Knowledge is Lower among Spanish-speaking Than among English-speaking Restaurant Food Handlers in Chicago

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ABSTRACT

Between January and July 2009, 508 food handlers were interviewed at 125 Chicago restaurants to determine baseline food safety knowledge, using an oral 51-question survey. Data analysis was performed to identify risk factors associated with the knowledge scores. The surveys were administered in English or Spanish, based on the preference of the participants. The mean knowledge score for the food handlers was 71% overall. Food handlers most frequently answered incorrectly on questions concerning adequate temperatures for cooking and holding foods. Bivariate analysis revealed that food handlers in restaurants located in areas with ≥ 31.3% of local residents living below the poverty level scored lower than food handlers working in other areas (66% versus 71%; $P < 0.0145$). One finding in the multivariate model was that Spanish-speaking food handlers scored lower than English-speaking food handlers, after confounding variables had been controlled for ($P < 0.0001$). Data from this project revealed substantial gaps in food safety knowledge overall, and specifically a difference between English-speaking and Spanish-speaking food handlers. Knowledge of some specific food safety facts differed by language as well. These data emphasize the need to create targeted educational food safety materials in English and Spanish.

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INTRODUCTION

Each year, foodborne diseases cause an estimated 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths, with an annual economic impact of \$6.5–\$34.9 billion in the United States *(15, 17)*. Eating establishments are the source of a large number of foodborne outbreaks. In 2007, of the 1,097 outbreaks reported to the Centers for Disease Control and Prevention (CDC), 41% were associated with restaurants or delicatessens *(3)*. It has been reported that 4 out of 10 Americans eat in a restaurant on any given day *(10)*. Restaurants are therefore important venues to consider in the prevention of foodborne illnesses and outbreaks.

A report by the U.S. Food and Drug Administration (FDA) in 2004 revealed important areas in need of attention in full-service restaurants. These areas included inadequate cooking, improper holding temperatures, contamination of equipment, and poor personal hygiene *(21)*. In a restaurant food handler knowledge survey performed in two counties in Oregon during 2000, the average scores of 407 food handlers was 68% on questions involving food safety, correct hand washing, and hygiene *(6)*. Often, foodborne outbreaks are caused by a single food worker directly infecting restaurant customers or an infected worker shedding fecal germs that contaminate food and then reproduce as a consequence of inadequate cooking temperatures *(18, 20)*.

Limited knowledge of English among restaurant food handlers may contribute to restaurant-associated foodborne illness if it interferes with communication of educational food safety information or is associated with cultural food safety practices different from those expected in the United States. In Los Angeles county, a survey of 262 restaurant workers during 2002 through 2003 demonstrated that 91% of the workers who agreed to participate were foreign born, 55% were Hispanic, and 53% could read little or no English. The report also revealed that food establishments with high proportions of Spanish-speaking workers tended to have more violations during restaurant inspections *(8)*. In Oregon, Spanish-speaking Hispanics scored 18% lower than non-Hispanic Whites in their knowledge of food safety and foodborne illnesses prevention. That study emphasized the need for food safety training in Spanish for the Spanish-speaking Hispanic food handlers *(6)*. To our knowledge, no study in the United States has reported the specific differences in food safety knowledge between English and Spanish-speaking restaurant food handlers.

We sought to investigate gaps in food safety knowledge among Chicago restaurant food handlers to identify priorities for education. We hypothesized that, overall, Spanish-speaking food handlers would score lower than English-speaking food handlers and that food safety knowledge may be particularly low among food handlers working in restaurants located in low socioeconomic status areas. We also sought to identify risk factors associated with food safety knowledge scores.

MATERIALS AND METHODS

Sample

We obtained, through a Freedom of Information Act (FOIA) request, a list of 5,935 food establishments inspected by the Chicago Department of Public Health. Of these, 5,584 (94%) were commercial restaurants based on restaurant Standard Industrial Classification (SIC) codes. A random sample of 650 restaurants was then selected to be approached. To limit the study to dining-in restaurants, we excluded banquet halls, caterers, and establishments that serve non-perishable packaged foods and those considered low risk by the health department *(4)*. Five hundred eight food handlers were interviewed betweenJanuary and July 2009. Restaurant managers were approached for verbal approval to interview food handlers at each restaurant. A signed consent form was obtained from each participant and confidentiality of food handler and restaurant name was assured. Food handlers who did not speak either English or Spanish and were less than 18 years of age were excluded from participation. Food handlers were asked, "Which of the following best describes you?" Responses could be "English is your primary language," "Spanish is your primary language but you also speak English well," "Spanish is your primary language and you speak English but not well," or "Something else? (Specify)." For the purpose of the analysis, if the food handlers' primary language was Spanish, they were categorized as Spanish-speaking even if they stated that they could speak English well.

Instrument development and data collection

A 58-question survey instrument was developed to obtain baseline information on restaurants and food handler knowledge, behaviors, and personal hygiene practices of the food handlers. The survey development used input from the Chicago Department of Public Health, Cook County Department of Public Health, DuPage County Health Department, Kane County Health Department, Lake County Health Department, Illinois Department of Public Health, and the University of Illinois at Chicago Survey Research Laboratory. Cognitive interviews were performed with both English and Spanish food handlers at the University of Illinois at Chicago, and survey adjustments were made following these meetings. The final survey instrument was launched after pilot testing was completed. Spanish language surveys were translated and back-translated to ensure consistency. The 41 knowledge questions included true-false, multiple-choice, and fill-in-the-blank formats. The primary subject areas for inclusion were optimal temperatures for bacterial growth, appropriate temperatures for heating and cooling foods, cross contamination, and relevant behavior such as practices related to working while ill and hand hygiene. The survey instrument was designed to reflect the temperatures required by the Chicago Municipal Code, which might not be identical to those in other U.S. jurisdictions. Participants were asked for information on ethnicity, history of food safety training, and years of food handling experience. Data on restaurant characteristics such as type of service style (for example, fast food or formal) and average entrée price were also collected. Restaurants were categorized by size: small (≤ 10 tables or ≤ 40 seats), medium (11 to 29 tables or 41 to 119 seats), and large (≥ 30 tables or ≥ 120 seats), and food courts.

To account for a potential association of food handlers working in restaurants in areas of very low socioeconomic

TABLE 1. Characteristics of participating Chicago restaurants (N = 125) and score out of 41 knowledge questions

Characteristic	Frequencies N	%	Bivariate Analysis Score (%)	P value
Restaurant size				0.0006
Small (≤ 10 tables or seating ≤ 40 seats)	53	42.4	28 (68)	
Medium (> 10 tables or seating > 40 seats but < 30 tables or seating <120 seats)	40	32.0	30 (73)	
Large (≥ 30 tables or seating ≥ 120 seats)	30	24.0	30 (73)	
Food court	2	1.6	23 (56)	
Food service style				0.0001
Fast food	38	30.4	28 (68)	
Informal (diner, delicatessen, other casual)	59	47.2	29 (71)	
Formal	28	22.4	30 (73)	
Cuisine				0.4395
American (no primary ethnic focus)	60	48.0	29 (71)	
Italian	20	16.0	29 (71)	
Mexican	26	20.8	29 (71)	
Other	19	15.2	29 (71)	
Food specialization				0.0078
Meat or poultry	29	23.2	28 (68)	
Seafood	4	3.2	31 (76)	
No specialization but meat, poultry, and/or seafood served	92	73.6	29 (71)	
Buffet served at least 2 days / week				0.0003
Yes	8	6.4	29 (71)	
No	117	93.6	31 (76)	
Chain or Independent				0.0001
Chain	42	33.6	28 (68)	
Independent	83	66.4	30 (73)	
Average entrée price				0.0001
≤ $10	83	66.4	28 (68)	
>$10 but <$20	34	27.2	29 (71)	
≥$20	8	6.4	33 (80)	
Proportion of local residents living below poverty level				
0 – 31.2% below poverty	111	88.80	29 (71%)	0.0145
31.3 – 100% below poverty	14	11.20	27 (66%)	

status with the knowledge score, we created a binary variable based on the proportion of local residents living below the poverty level set by the U.S census bureau *(22)*. The surveys were administered by research staff in English or Spanish, based on the preference of the participants, and were completed discreetly at the restaurants. The participating food handlers were offered compensation of $20.00. Approval from the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects was received before the initiation of the study.

Statistical methods

Statistical analysis was performed using SAS 9.2 for Windows (SAS, Chicago, Ill.). The overall knowledge score was determined by the sum of correct answers to the 41 knowledge questions. Bivariate analysis was performed to identify potential food handler or restaurant variables associated with the knowledge score. T-tests were performed to compare the mean knowledge scores between categorical variables with two groups such as gender and language. Analysis of Variance (ANOVA) models were used to compare knowledge scores across levels of categorical variables with more than two groups. To identify knowledge gaps among restaurant food handlers, chi-

TABLE 2. Characteristics of participating Chicago food handlers (N = 508) and score out of 41 knowledge questions

Characteristic	Frequencies N	%	Bivariate Analysis Score (%)	P value
Age				0.0004
18–29 years	247	48.9	28 (68)	
30–39 years	149	29.5	30 (73)	
40–49 years	64	12.7	31 (76)	
≥ 50 years	45	8.9	31 (76)	
Gender				
Males				
Overall	334	65.9	29 (71)	0.2395
English-speaking	150	55.8	32 (78)	
Spanish-speaking	162	79.0	27 (66)	
Females				
Overall	173	34.1	29 (71)	0.2395
English-speaking	119	44.2	30 (73)	
Spanish-speaking	43	21.0	26 (63)	
Race/Ethnicity				0.0001
Hispanic	261	51.6	28 (68)	
White	137	27.1	32 (78)	
Black	62	12.3	29 (71)	
Asian or Pacific Islander	26	5.1	27 (66)	
Multi-racial	11	2.1	32 (78)	
Other	9	1.8	31 (76)	
Education				0.0001
Less than 8th grade	40	8.0	28 (68)	
8th–12th grade but no high school diploma	59	11.6	27 (66)	
High school diploma or general educational development	137	27.0	27 (66)	
Some college but no degree completed	103	20.3	30 (73)	
Two year college degree/Associate's degree	75	14.8	32 (78)	
Four year college degree or more	93	18.3	31 (76)	
Languages Spoken				
English only	269	53.2	31 (76)	0.0001
Spanish but speaks English well	105	20.7	28 (68)	
Spanish but does not speak English well	100	19.8	27 (66)	
Other (survey performed in English)	32	6.3	28 (68)	
Food Safety Training				
Yes, certified food handlers (managers)	178	35.1	32 (78)	0.0001
Yes, non-certified food handlers	130	25.6	30 (73)	
No, non-certified food handlers	199	39.3	26 (63)	

The following number of persons were missing from each category: Age (3), Gender (1), Race (2), Education (1), Languages Spoken (2), and Food Safety Training (1).

square tests were performed to compare the number of correct responses to questions across both English and Spanish language groups. To identify risk factors associated with the food handler knowledge score, multivariate analysis was performed, using linear regression models.

Potential correlation between the knowledge scores of food handlers from the same restaurant was examined by the use of a mixed-effects model with random restaurant effect. It was not found to be statistically significant at probability of type I error α =0.05 level (Likelihood Ratio Test of χ^2_1 (∞^2= 1.1515, P = 0.07). Therefore, a linear regression model assuming independent knowledge

TABLE 3. Food handler and restaurant characteristic associations with knowledge score, multivariable analysis (N = 451), 2009

	Multivariate Analysis Estimate (standard error)	P value
Food Handler Characteristics		
Intercept	35.77 (0.68)	< 0.0001
Language		
English	Ref	
Spanish	-2.14 (0.63)	0.0008
Other	-2.09 (0.89)	0.0190
Education	-0.33 (0.16)	0.0390
Number of years worked handling food	0.06 (0.03)	0.0219
Race/Ethnicity		
White	Ref	
Hispanic	-1.36 (0.67)	0.0422
Black	-2.57 (0.66)	< 0.0001
Other	-1.54 (0.77)	0.0471
History of food safety training		
Yes, certified food handler managers	Ref	
Yes, non-certified food handlers	-1.48 (0.51)	0.0038
No, non-certified food handlers	-3.98 (0.50)	< 0.0001
Restaurant characteristics		
Food specialization		
No specialization	Ref	
Meat and poultry	-2.02 (0.60)	0.0008
Seafood	2.79 (1.12)	0.0131
Restaurant Chain		
Yes	Ref	
No	-1.04 (0.41)	0.0119
Frequency of Food Handling Tasks	-0.38 (0.09)	< 0.0001

scores was used for multivariable analysis. A backward selection method with a probability of Type-I error = 0.10 was used to determine the food handler and restaurant characteristic variables that remained in the final multivariable model. Multivariate analysis was performed on 451 food handlers with no missing data, while frequency data on knowledge scores were derived from all 508 food handlers.

RESULTS

Between January and July 2009, 526 of the 650 randomly sampled Chicago restaurants were approached, and 125 restaurants participated (response rate = 24%). Reasons for restaurants not participating in our study included refusals (105; 20%), closures (73; 14%), exclusion due to changed management (25; 5%), meeting other exclusion criteria (14; 3%), and other reasons (primarily that the study concluded before a selected restaurant conclusively responded yes or no to our request to interview food handlers (184; 35%)).

The largest proportion of the participating restaurants seated 10 or fewer tables (42%), had informal dining (47%), served American cuisine (48%), had an average entrée price of $10.00 or less (66%), and were located in areas with a low percentage of local residents living below the poverty level (89%) (Table 1). The mean age of the participants was 32 years (range 18 to 68 years). More males (66%) than females (34%) participated (Table 2). Of the 508 participating food handlers, 261 (52%) described themselves as Hispanic, 137 (27%) as White, 62 (12%) as Black, 26 (5%) as Asian or Pacific Islander, 11 (2%) as multi-racial, and 9 (2%) as 'Other' races. The proportion of black food handlers working in fast food restaurants was approximately twice that of white food handlers (34% versus 16%).

Two hundred thirty-six (47%) of the food handlers had an educational level no higher than a high school diploma or equivalent, including 159 (78%) of the Spanish-speaking food handlers and 66 (25%) of the English-speaking food handlers. The proportion of food handlers who had at least some college education was substantially higher for certified food handlers with a history of food safety training than for non-certified food handlers (70% versus 44%). A history of any college education was more common among English-speaking than Spanish-speaking certified managers and certified non-managing food handlers (87% versus 40%, and 78%

versus 29%, respectively; $P < 0.0001$). The primary language was English for 269 (53%) food handlers, Spanish for 205 (41%), and 'Other' for 32 (6%). Many food handlers (199; 39%) had no history of ever taking a food safety training course.

Identifying knowledge gaps

Overall, the mean knowledge score was 29.0 of a possible 41 (71%). Bivariate analysis indicated that several restaurant characteristics were significantly associated with the knowledge score. "Medium and large-sized restaurants had a higher proportion of knowledge questions answered correctly than did small-sized restaurants (73%, 73% versus 68%) (Table 1)." Restaurants with a formal service style had a higher proportion of knowledge questions answered correctly than did fast food and informal service style restaurants (73%, 68% and 71%, respectively). Restaurants located in areas with at least 31.3% of residents living below the poverty level answered a lower proportion of knowledge questions correctly than did restaurants located in areas with fewer residents living below the poverty level (66% versus 71%, respectively). However, restaurants serving American cuisine had a higher proportion of knowledge questions answered correctly than did restaurants serving Italian, Mexican, and 'Other' cuisine (73%, 71%, 68%, and 71%, respectively), but these cuisine-related differences were neither statistically significant nor substantial.

Food handler characteristics significantly associated with knowledge scores included age, race/ethnicity, education, primary language, and food safety training. Food handlers age 40–49 years and over 50 years had higher mean knowledge scores than those in the age ranges of 18–29 years and 30–39 years (76%, 76%, 68% and 73% correct, respectively). White food handlers scored higher than those who identified themselves as Hispanic, Black, Asian or Pacific Islander, or 'Other' (78%, 68%, 71%, 66%, and 76% correct, respectively) and equal to persons identified as multi-racial (78%). Food handlers primarily speaking English scored higher than those who spoke primarily Spanish (with or without the ability to speak fluent English) or other languages (76%, 68%, 66%, and 68% correct, respectively).

There was no significant difference in the scores between males and females; however, when these data were examined by language, English-speaking males and Spanish-speaking males scored higher than their female counterparts (Table 2). The knowledge score was higher among those who took the survey in English than among those who took it in Spanish (73% versus 63%, $P < 0.05$). Food handlers with at least some college education scored higher than those who did not have any college education (76% versus 66%, $P < 0.05$). Food handler managers and non-managers with a history of having taken a food safety training course scored higher than those who did not have such training (76% versus 63%, $P < 0.05$). Of the 308 food handlers with food safety training, only 17% knew the range of the temperature danger zone. In a subanalysis of only certified managers (n = 178) who were asked if they were aware of several important conditions that warrant closure of a restaurant in Illinois, the proportion of managers who knew that the restaurant had to be closed when there is no running water, during a sewage back-up, during a power outage, and when there is cold but not hot water was 96%, 89%, 89%, and 75%, respectively.

Factors associated with the knowledge score

Eight variables selected in the final multivariable model from a backward selection method were significantly associated with the knowledge score ($R^2 = 0.4984$) (Table 3). Age and number of years a food handler worked were correlated; therefore, age was excluded from the multivariate analysis. When other variables were controlled for, Spanish-speaking food handlers had statistically significant lower scores than English-speaking food handlers. For each additional year of food handling work experience, the knowledge score increased significantly by 0.06. Food handlers scored 0.33 less for each lower level of education ($P = 0.0390$). Hispanic and black food handlers scored significantly lower than White food handlers (score difference 1.36 and 2.57, respectively). Food handlers who were certified managers with a history of taking a food safety training course scored significantly higher than both non-certified food handlers with a history of taking a food safety training course and non-certified food handlers with no history of food safety training. Food handlers who handled or cooked food less frequently scored lower than those who handled or cooked food often.

Significant differences between English-speaking and Spanish-speaking food handlers were observed in knowledge of optimal temperatures for cooking, holding, and refrigerating foods, of cross-contamination, and of hygiene (Table 4). Both English-speaking and Spanish-speaking food handlers performed poorly when asked to identify the range of the danger zone for pathogen growth; however, English-speaking food handlers responded correctly more often than Spanish-speaking food handlers (16% versus 5% respectively; $P < 0.05$). Fifty percent of the English-speaking and 70% of the Spanish-speaking food handlers knew that eating ground meat that is not completely cooked can cause bloody diarrhea ($P < 0.05$) and 84% of the English-speaking and 54% of the Spanish-speaking food handlers recognized that the statement, "You can be sure food is safe to eat when it smells and tastes normal" is false ($P < 0.05$). Sixty-five percent of the English-speaking and 40% of the Spanish-speaking food handlers correctly identified the statement, "Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic" as false ($P < 0.05$). Among the questions concerning cross contamination, 86% of the English-speaking and 76% of the Spanish-speaking food handlers knew that when vegetables for a salad were splashed with raw chicken juice, they should not be rinsed but instead must be thrown away ($P < 0.05$).

English-speaking food handlers were more likely to respond correctly to hygiene questions. For example, more English-speaking than Spanish-speaking food handlers said it was not okay to dry washed-hands with a kitchen towel or apron (93% versus 77%, $P < 0.05$) and that hands need to be thoroughly washed when using single-use gloves to handle food (94% versus 76%, $P < 0.05$). We hypothesized that fast food workers might have a higher knowledge of hand

TABLE 4. Frequencies of correct responses to knowledge questions asked of Chicago restaurant food handlers, overall and by primary language, 2009 (N = 508). Questions marked by an asterisk indicate statistical significance at *P* < 0.05

Questions *(Answers)*	Question Types	Correct Responses: Overall n = 508 (%)	English n = 269 (%)	Spanish n = 206 (%)
Time and Temperature				
Hamburger and other ground beef mixtures such as meatloaf should be cooked to at least what temperature on a meat thermometer? *(155°F or 160°F)*[a]	Fill-in-the-blank	85 (16.7)	46 (17.1)	31 (15.1)
Germs that make people sick grow well between which temperatures? Minimum* *(40°F or 41°F)*[a]	Fill-in-the-blank	87(17.1)	64 (23.8)	19 (9.3)
Germs that make people sick grow well between which temperatures? Maximum* *(135°F or 140°F)*[a]	Fill-in-the-blank	119 (23.4)	78 (29.0)	38 (18.5)
What is the proper minimum internal temperature to cook chicken for at least 15 seconds? *(165°F)*	Fill-in-the-blank	101 (19.8)	61 (22.7)	34 (16.6)
Cold food must be kept at 55°F or lower. *(False)*	True/False	263 (51.8)	148 (55.2)	99 (48.8)
If hot, roast beef has been held in a steam table below 135°F for over 4 hours, it should be* *(Thrown away)*	Multiple-choice	291 (57.3)	180 (67.2)	99 (48.3)
Which type of thermometer is best to check the temperature of a chicken breast?* *(A metal stem thermometer)*	Multipe-choice	343 (67.5)	197 (73.5)	124 (60.5)
Where should meat thermometers be inserted to accurately check the meat's temperature?* *(The thickest part of the meat)*	Multiple-choice	444 (87.4)	249 (92.9)	172 (83.9)
Hygiene				
Is it okay to put ice in a glass by using tongs?* *(Yes)*	Yes/No	370 (72.8)	209 (77.7)	136 (66.3)
Is it okay to put ice in a glass by using an ice-scoop?* *(Yes)*	Yes/No	457 (90.0)	255 (94.8)	171 (83.8)
Is it okay to put ice in a glass by scooping the glass into the ice?* *(No)*	Yes/No	444 (87.4)	245 (91.4)	170 (83.3)
Is it okay to put ice in a glass by picking up ice with your bare hands? *(No)*	Yes/No	500 (98.4)	267 (99.3)	200 (98.1)
Hand Washing Steps				
Wet your hands with warm running water* *(Okay)*	Okay/ Not Okay	373 (73.4)	188 (69.9)	159 (78.3)
Lather with soap and scrub between fingers, on the backs of your hands, and under nails for at least 20 seconds. *(Okay)*	Okay/ Not Okay	500 (98.4)	266 (99.3)	201 (98.5)
Dry hands using a kitchen towel or your apron* *(Not okay)*	Okay/ Not okay	431 (84.8)	248 (92.5)	156 (76.6)
Turn off the water using your bare hands* *(Not okay)*	Okay/ Not okay	379 (74.6)	218 (81.3)	141 (69.5)
Do you need to have thoroughly washed hands if you use deli tissue to handle food?* *(Yes)*	Yes/No	470 (92.5)	254 (94.4)	184 (89.8)
Do you need to have thoroughly washed hands if you use a spatula or tongs to handle food?* *(Yes)*	Yes/No	454 (89.4)	251 (93.3)	174 (84.9)
Do you need to have thoroughly washed hands if you use single-use gloves to handle food?* *(Yes)*	Yes/No	437 (86.0)	253 (94.1)	155 (75.6)
A food handler who has a small infected cut on his or her finger prepares a sandwich that is kept warm but not hot. The person who eats that sandwich could become ill with vomiting and diarrhea. *(True)*	True/False	426 (83.9)	226 (84.3)	173 (84.4)

TABLE 4. Frequencies of correct responses to knowledge questions asked of Chicago restaurant food handlers, overall and by primary language, 2009 (N = 508). Questions marked by an asterisk indicate statistical significance at $P < 0.05$ *(continued)*

Questions *(Answers)*	Question Types	Correct Responses Overall n = 508 (%)	 English n = 269 (%)	 Spanish n = 206 (%)
At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands.* *(False)*	True/False	486 (95.7)	263 (97.8)	191 (93.2)
Gloves used to handle ready-to-eat food should be thrown in the trash when interruptions occur in operations *(True)*	True/ False	494 (97.2)	264 (98.1)	198 (96.6)
Cleaning and Sanitizing				
The difference between cleaning and sanitizing is: (Cleaning is to remove food or other types of soil from a surface but sanitizing is to reduce the number of germs on a clean surface to safe levels)*	Multiple -choice	375 (73.4)	230 (85.8)	125 (61.0)
Other				
Beef may be placed in the microwave to defrost.* *(True)*	True/False	178 (35.0)	121 (45.0)	44 (21.6)
Cooked rice can have germs that can make people sick.* *(True)*	True/False	181 (35.6)	107 (39.8)	62 (30.2)
Raw meat can be stored on foil-lined shelves to prevent dripping onto other foods. *(False)*	True/False	199 (39.2)	105 (39.3)	79 (38.5)
Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic.* *(False)*	True/False	270 (53.2)	174 (64.7)	81 (39.7)
Eating ground meat that is not completely cooked can cause bloody diarrhea.* *(True)*	True/False	299 (58.9)	134 (49.8)	144 (70.2)
Raw meat can be stored below ready to serve food.* *(True)*	True/False	324 (63.8)	199 (74.0)	107 (52.2)
You can be sure food is safe to eat when it smells and tastes normal.* *(False)*	True/False	337 (66.3)	227 (84.4)	95 (53.9)
Storing products with the earliest expiration dates in front of products with later dates is a safe food storage practice.* *(True)*	True/False	343 (67.5)	218 (81.0)	101 (49.3)
Beef may be placed in cold water to defrost. *(True)*	True/False	347 (68.3)	190 (70.6)	134 (65.7)
Raw eggs in shells may be stored above a prepared salad in the refrigerator. *(False)*	True/False	346 (68.1)	191 (71.0)	140 (68.6)
If fish (such as raw tuna) has been stored at a temperature that is too warm, but then is properly cooked to the correct internal temperature, it becomes safe to eat.**(False)*	True/False	388 (76.4)	206 (76.6)	139 (68.5)
It is safe to put frozen chicken breast on the counter to thaw.* *(False)*	True/False	381 (75.0)	222 (82.5)	137 (67.2)
Raw eggs can have germs that can make people sick.* *(True)*	True/False	388 (76.4)	219 (81.4)	144 (70.6)
Beef may be placed on the counter to defrost. *(False)*	True/False	398 (78.4)	216 (80.3)	156 (76.5)
Vegetables for a salad splashed with a few drops of raw chicken juice should not be rinsed, but instead must be thrown away.* *(True)*	True/False	418 (82.3)	232 (86.3)	157 (77.0)
Beef may be placed in the refrigerator to defrost. *(True)*	True/False	420 (82.7)	227 (84.4)	168 (82.4)
Uncooked beef is potentially contaminated with germs that can cause people to be hospitalized or die. *(True)*	True/False	464 (91.2)	250 (92.9)	186 (90.7)
Raw meat can be stored above ready to serve food.* *(False)*	True/False	467 (91.9)	258 (95.9)	181 (88.7)
Uncooked chicken is potentially contaminated with germs that can cause people to become very ill. *(True)*	True/False/	489 (96.3)	260 (96.7)	197 (96.1)

[a]Guidance for Illinois has changed or is in the process of changing from 40°F and 140°F to 41 and 135°F (57°C) and from 155°F to 160°F for holding food and cooking temperatures.

hygiene information than other food handlers because of corporate promotion of this issue. However, we found that food handlers working in fast food restaurants scored as well as other food handlers on the five hand hygiene knowledge questions (86% versus 88%; $P = 0.20$).

DISCUSSION

To decrease restaurant-associated foodborne diseases, it is critical to determine food handler food safety knowledge gaps in order to guide effective educational and behavioral interventions. The food handlers in our study had an average knowledge score of 71%. The main knowledge gaps identified in our study involved hygiene practices and temperatures for cooking, storing, and holding foods. Significant differences in knowledge were also identified between English-speaking and Spanish-speaking food handlers. This is the first published study in the United States to describe specific food safety knowledge differences by language.

Race/ethnicity was independently associated with the knowledge score. We observed that Hispanic and Black food handlers scored lower than Whites even when other factors were controlled for, including highest level of education. Our data does not explain a specific cause for this disparity; however, it might be related in part to differences in quality of education each group received. We hypothesized that some of the lower scoring food handlers may have been educated in economically disadvantaged school districts, which may hold back urban students *(12)*.

Certified food handlers had an average score of 32 (78%), compared to 27 (66%) for non-certified food handlers. In Illinois, to be certified, food handlers are required to achieve a 75% score on the state food certification exam *(11)*. In Chicago, the food handler must attend and pass an approved course such as the ServSafe® program offered through the Illinois Restaurant Association *(4).* Food handlers with certification may work as managers or as staff under managers. However, there is no requirement that all food handlers be certified. When our knowledge results are compared to a minimum score needed for certification, it should be noted that our study focused on knowledge relevant to prevention of most foodborne outbreaks, but not on issues such as food allergens and pest management, which may be part of food safety certification exam. Therefore, a direct comparison to state exam scores is inappropriate.

Inadequate practices related to temperatures have contributed to many foodborne outbreaks *(16)*. In our study, the questions about the range of the temperature danger zone at which pathogens proliferate and the internal temperature to which hamburger and ground meat should be cooked were answered correctly by fewer than 20% of the food handlers. We expected certified food handlers to achieve much higher than 20% correct in the question asking for the temperature danger zone, but they did not; only 17% knew the correct temperature danger zone. Data reported from two counties in Oregon by Debess and colleagues also identified inadequate knowledge of safe temperatures among restaurant food handlers; for example, only 20% of the food handlers knew the minimum temperatures for cooking beef and 49% knew the minimum internal temperatures for cooking poultry *(6)*. Unlike in Illinois, all food handlers are required to have food handler certification within 30 days of employment in Oregon. In Illinois, state regulations require at least one certified responsible individual to be on-site at all times at restaurants when potentially hazardous food such as eggs, poultry, beef, and shellfish are being prepared or served *(personal communication, Chicago Department of Public Health, 1, 4, 11).* Thus, it is important that the certified food handler(s) provide food safety training to all other food handlers. Despite the mandatory training in Oregon, their restaurant food handlers and food handlers in Chicago scored similarly low, which suggests that food handler certification as currently implemented may not be adequate to provide lasting food safety knowledge.

Hygiene knowledge and behavior is poor among many restaurant food handlers and has contributed to a large number of foodborne illness outbreaks *(2, 5, 7, 9, 13, 17).* According to an FDA study, 76% of fast food and 59% of full service restaurants were not fully compliant with hygiene practices *(17)*. Overall, the Chicago food handlers participating in our survey and working in fast food and full service restaurants scored relatively well in the hygiene knowledge questions (86% and 88%, respectively). However, only 75% found it unacceptable to turn off the water with washed bare hands, and 85% found it unacceptable to dry hands using a kitchen towel or apron. It is possible that cultural differences, increased workload, and insufficient time may be factors interfering with hygiene practices despite extensive knowledge *(7, 14).* Clayton and colleagues in the United Kingdom demonstrated that many food handlers were aware of the majority of the recommended food safety practices; however, two-thirds of these food handlers admitted that they did not always carry out these behaviors *(5)*. Sumner and colleagues, in a study performed by the Environmental Health Specialist Network, identified several factors associated with food handlers working while ill with vomiting and diarrhea, including high volume of meals served and lack of restaurant policies requiring reporting illness to managers *(19)*. Additional studies are needed to examine these factors, elucidate the discordance between knowledge of proper hand hygiene and actual hand washing practices, and develop interventions.

English-speaking and Spanish-speaking restaurant food handlers differed significantly in knowledge scores. Controlling for other variables, Spanish-speaking food handlers had a lower mean knowledge score than English-speaking food handlers, and the results were significantly different. There was at least a 15% difference in questions concerning temperatures for holding and storing of foods, hygiene, and cross-contamination. Debess and colleagues also reported that Hispanics had lower mean knowledge scores than non-Hispanic whites (54% versus 72%, respectively *(6)*. These data support the conclusion that interventions such as food safety training programs that are linguistically and culturally appropriate need to be developed for Spanish-speaking food handlers.

One limitation of this study is generalizability. Although this was a random sample of restaurants, the participation rate was 24%. We observed that refusal by chain restaurants often occurred when restaurant managers requested but did not receive permission from corporate managers to participate in our study.

Additionally, it was not uncommon for restaurant food handlers at one restaurant to be interviewed on different days. Therefore, another possible limitation is that some food handlers may have shared questions in our survey with their co-workers who were yet to be interviewed. This may have led to foreknowledge of some questions, which may have caused an overestimation of food safety knowledge in our study. Finally, participation bias may also have led to a possible over-estimation of knowledge, because the more knowledgeable food handlers could have been more likely to participate.

CONCLUSION

The data from this survey provide insight into the lack of adequate food handler food safety knowledge and demonstrates language-specific differences. These data are important for the creation of targeted educational materials in English and Spanish. The next step in this USDA-funded project was to design and test the efficacy of educational brochures and story-based food safety messages for this food handler population. Analysis of the results of the intervention phase for this project is in progress.

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ARTICLES

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A Comparison of Overall Versus Duty-specific Food Poisoning Prevention Knowledge among Restaurant Food Handlers

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ABSTRACT

Data collected in a baseline knowledge survey of Chicago restaurant food handlers were analyzed to determine knowledge scores related to questions relevant to the food handler's job duties. It was hypothesized that food handler knowledge scores would be higher when only the score based on the questions more relevant to their duties was determined, rather than the overall score that included all knowledge questions in the score denominator. The mean knowledge score for the meat and poultry food handlers (n = 372) was 71% on the overall survey and 75% when the score based on only the questions specifically relevant to their duties was calculated. Among the findings in a multivariable model, meat or poultry handlers whose primary language was Spanish (with or without the ability to speak English) or other language (with the ability to speak English) scored significantly lower than persons for whom English was their primary language, after controlling for confounding variables. Despite the fact that a knowledge survey of meat and poultry restaurant food handlers was limited to meat and poultry relevant questions, the mean knowledge score was not substantially higher than their mean score on a more general food safety knowledge survey.

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INTRODUCTION

In the United States, foodborne disease causes millions of illnesses each year, resulting in thousands of deaths and substantial economic costs *(5)*. On any given day, it is estimated that 40% of the U.S. population eats food in a restaurant *(4)*. Restaurants or delicatessens are the most frequently reported sources of the food reported to have been eaten in foodborne outbreaks *(1)*. However, few data have been published on food safety knowledge of U.S. restaurant food handlers. DeBess and colleagues surveyed 407 food handlers working at 67 restaurants in two Oregon counties in 2000 *(3)*. This study reported a relatively low overall knowledge score (68%), similar to that found in studies we have performed in Chicago (71%) and the Chicago suburbs (72%) *(6)*. Although food safety behavior is an overriding concern and some restaurants have systems in place to minimize the influence of poor food handler food safety knowledge on risk to consumers, food safety knowledge remains a fundamental priority because knowledge influences behavior.

When food safety knowledge surveys are performed, a spectrum of questions may be asked and the overall knowledge score summarized. A critic of such studies may believe the surveys are biased toward showing poor results because each food handler's score is calculated from responses that include questions that are not relevant to that individual's routine duties as part of a general overview of food safety knowledge. For example, if a food handler who works in a restaurant where no seafood is served does not know the correct response to a seafood knowledge question, although this does reflect a lack of overall food safety knowledge, it may not reflect a potential risk to the consumer. An examination of food safety knowledge survey data that excludes survey questions not relevant to the food handler's duties might be more useful in understanding how to target educational interventions to reduce the risk of restaurant-related food poisoning. No study has examined food handler knowledge that was based only on questions relevant to the food handler's job duties. We analyzed data collected in a baseline knowledge survey of Chicago restaurant food handlers to determine knowledge scores related to questions relevant to the food handler's job duties. We hypothesized that food handler knowledge scores would be higher when the score based only on the questions more relevant to their duties was determined, rather than the overall score that included all knowledge questions in the score denominator.

MATERIALS AND METHODS

Sample

A list of 5,935 food establishments was provided by the Chicago Department of Public Health through a Freedom of Information Act (FOIA) request. Of these, 5,584 (94%) were commercial restaurants based on restaurant Standard Industrial Classification (SIC) codes. To limit the study to restaurants, banquet halls, caterers, and establishments that serve non-perishable packaged foods and those considered low risk by the health department were excluded *(2)*. A random sample of 650 restaurants was then selected to be approached. Restaurant managers were approached for verbal approval to consent food handlers at each restaurant. From a total of 125 participating restaurants, 508 food handlers were interviewed during January through July 2009. A signed consent form was obtained from each participant and confidentiality of food handler and restaurant name was assured. Food handlers who did not speak either English or Spanish or were less than 18 years of age were excluded from participation.

Data collection

A survey that asked 41 knowledge questions was developed and tested in a pilot study after review of USDA and FDA Internet sites, the National Restaurant Association's educational materials, expert opinion (in part derived from local and state health department input), and published literature of restaurant-associated foodborne outbreaks. The survey included true-false and multiple-choice questions. The primary knowledge subject areas were optimal temperatures for bacterial growth, appropriate temperatures for heating and cooling foods, cross contamination, and relevant behavior such as practices related to working while ill and hand hygiene. The food handlers could choose to have the survey administered in English or Spanish, based on their personal preference. Participants were asked for information on ethnicity, history of food safety training, and years of food handling experience. Data on restaurant characteristics such as type of service style (for example, fast food or formal) and average entrée price were also collected. All surveys were completed discreetly at the food handlers' place of employment. Each participating food handler was offered compensation of $20.00. Approval from the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects was obtained before initiation of the study. For this study, task-relevant knowledge scores for the 372 meat or poultry handlers were calculated and analyzed.

Outcome measurement

Among 41 knowledge questions on the food handler questionnaire, 13 questions were specific to meat or poultry handling or cooking and 18 questions were general knowledge questions relevant to any food handler. All 31 questions were considered relevant to a meat or poultry handler's duties, and therefore the task-relevant knowledge score was the number of correctly answered questions out of these 31 questions. The other 10 questions, specific to seafood, egg, vegetable, rice and fruit handling, were excluded. A question was considered incorrect and assigned a 0 value if the food handler answered with a wrong response or responded that he or she did not know the correct answer; 1 was assigned to a correctly answered question.

Statistical analysis

Bivariate analysis was performed to explore the association between

TABLE 1. Frequency of incorrect responses to meat or poultry food handling knowledge questions among 372 Chicago restaurant meat or poultry food handlers

Questions *(Answers)*	Incorrect Responses	
	Question types	N (%)
Uncooked chicken is potentially contaminated with germs that can cause people to become very ill. *(True)*	True/False	11 (3)
Raw meat can be stored above ready-to-serve food. *(False)*	True/False	28 (7.5)
Uncooked beef is potentially contaminated with germs that can cause people to be hospitalized or die. *(True)*	True/False	34 (9.1)
Beef may be placed in the refrigerator to defrost. *(True)*	True/False	60 (16.1)
Vegetables for a salad splashed with a few drops of raw chicken juice should not be served but must be thrown away. *(True)*	True/False	61 (16.4)
Beef may be placed on the counter to defrost. *(False)*	True/False	63 (16.9)
It is safe to put frozen chicken breast on the counter to thaw. *(False)*	True/False	91 (24.5)
Beef may be placed in cold water to defrost. *(True)*	True/False	112 (30.1)
Raw meat can be stored below ready-to-serve food. *(True)*	True/False	116 (31.2)
Eating ground meat that is not completely cooked can cause bloody diarrhea. *(True)*	True/False	137 (36.8)
Raw meat can be stored anywhere in a refrigerator when it is wrapped in plastic. *(False)*	True/False	169 (45.4)
Raw meat can be stored on foil-lined shelves to prevent dripping onto other foods. *(False)*	True/False	209 (56.2)
Beef may be placed in the microwave to defrost. *(True)*	True/False	243 (65.3)

mean task-relevant knowledge score and food handler or restaurant variables. *t*-tests were conducted to compare the mean knowledge scores between levels of binary variables. Analysis of variance models and Tukey's pairwise comparisons were employed to compare the mean knowledge scores for categorical variables with more than two categories. Pearson correlation coefficients were calculated to describe the relationship between the knowledge score and a continuous variable, such as age and number of food handling years. Variables of primary research interest, such as primary language, and those that had a statistically significant association ($P < 0.1$) with the knowledge score were included in the multivariate analysis. In the multivariate analysis, first, a mixed-effects regression model predicting the knowledge score with a random restaurant effect was employed. The use of a random restaurant effect allowed us to test and account for potential correlation between food handlers from the same restaurant. A significant within-restaurant correlation (β [SE] = 1.04 [0.59], $P = 0.04$) led to the choice of the mixed linear regression model using all food handler and restaurant characteristics predicting the knowledge score. Backward variable selections were performed for the regression model, using a Type I Error of $\alpha = 0.10$ to ensure the inclusion of any useful information. Statistical (bivariate and multivariate) analyses were performed using SAS software on data from 368 meat or poultry food handlers who had no missing data, while frequency data on knowledge scores were derived from all 372 of these food handlers.

RESULTS

Among 508 food handlers interviewed, 372 were meat or poultry handlers (73%), including 287 who both handled and cooked meat or poultry and 85 who only handled meat or poultry. Of the participating food handlers, 150 were certified managers (40.3%). The sum of the 31 task-relevant questions yielded a total knowledge score, ranging from 12 to 31, with a mean score of 75% (23.3/31) and a median of 77% (24.0/31). The mean score for only the meat and poultry specific questions was 72% (9.4/13) and for the general knowledge questions was 77% (13.9/18). As expected, the mean score of task-relevant questions was higher, but not substantially higher, than that of the original 41 knowledge questions (75% vs. 71%). Meat and poultry handlers who reported a history of any food safety training course (n = 245) had a mean total knowledge score of 24.5 (79%) compared to a score of 21.0 (68%) for those who did not (n = 127) ($P < 0.0001$).

Examination of the data by primary language of the food handler revealed several findings relevant to planning prevention education. In a subanalysis of only those restaurants that had at least one non-manager meat or poultry food handler participating in the survey, we examined the data to determine how often there might be a

TABLE 2. Frequency of incorrect responses to general food safety knowledge questions among 372 Chicago restaurant meat or poultry food handlers

Questions *(Answers)*	Incorrect Responses	
	Question types	N (%)
Is it OK to put ice in a glass by picking up ice with your bare hand? *(No)*	Yes/No	6 (1.6)
Gloves used to handle ready-to-eat food should be thrown in the trash when interruptions occur in operations. *(True)*	True/False	10 (2.7)
At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands? *(False)*	True/False	19 (5.1)
Do you need to have thoroughly washed hands if you use deli tissue to handle food? *(Yes)*	Yes/No	29 (7.8)
It is OK to put ice in a glass by using an ice-scoop? *(Yes)*	Yes/No	37 (10)
It is OK to put ice in a glass by scooping the glass into the ice? *(No)*	Yes/No	44 (11.8)
Do you need to have thoroughly washed hands if you use a spatula or tongs to handle food? *(Yes)*	Yes/No	44 (11.8)
A food handler with a small infected cut on his/her finger prepares a sandwich that is kept warm but not hot. The person who eats that sandwich could become ill with vomiting or diarrhea. *(True)*	True/False	52 (14.0)
Do you need to have thoroughly washed hands if you use single-use gloves to handle food? *(Yes)*	Yes/No	55 (14.8)
Is it OK to dry your hands by using a kitchen towel or your apron after washing your hands? *(No)*	Yes/No	62 (16.7)
Is it OK to wet your hands with warm running water before washing your hands? *(Yes)*	Yes/No	95 (25.5)
Is it OK to turn off the water by using your bare hand after washing your hands? *(No)*	Yes/No	97 (26.1)
Is it okay to put ice in a glass by using tongs? *(Yes)*	Yes/No	100 (26.9)
What is the difference between cleaning and sanitizing? *(Cleaning is to remove food or other types of soil from a surface but sanitizing is to reduce the number of germs on a clean surface to safe levels)*	Multiple choice	107 (28.8)
We store products with the earliest expiration dates in front of products with later dates. *(True)*	True/False	124 (33.3)
You can be sure food is safe to eat when it smells and tastes normal. *(False)*	True/False	134 (36.0)
Cold food must be kept at 55°F or lower. *(False)*	True/False	171 (46.0)
Germs that make people sick grow well between which temperatures? *(Between 40° or 41° to 135° or 140°F)*	Fill-in-the-blank	324 (87.1)

language disconnect between the manager and the staff. Fifty-one percent of the Spanish-speaking meat or poultry handlers who worked under a manager, versus only 34% of the certified managers, spoke Spanish as their primary language. In other words, approximately one out of six of these manager-staff food handler pairs included a manager who did not speak the primary language of his or her staff. Restaurants that had an English and Spanish speaking (bilingual) manager (n = 8) and restaurants with English-speaking managers (n = 30) scored higher than those with Spanish speaking managers (n = 21) (overall 75%, 74%, and 68%, respectively, $P < 0.05$).

The responses to knowledge questions that were specific to meat or poultry handling demonstrated several important substantial knowledge gaps (Table 1). Knowledge of proper storage of raw meat was poor, as evidenced by 56% of the meat and poultry handlers being unaware of the need to avoid storing raw meat on foil-lined shelves and nearly 46% not knowing that just because raw meat is wrapped in plastic does not mean that it can be stored anywhere in a refrigerator. Also, almost 8% answered that raw meat can be stored above ready-to-serve food. Although this latter percentage is reassuringly below 10%, it still indicates that one out of approximately 12 of these restaurant meat or poultry han-

TABLE 3. Comparison of the mean scores for meat or poultry handling questions by demographics and other characteristics (N = 372)

Independent variables	N (%)	Mean[a] (SD)/ Range
Primary language (F test: $P < 0.0001$)		
Others	26 (7)	21.8* (3.6)/13–28
Spanish	163 (44)	21.7* (3.5)/12–30
English (Reference group)	183 (49)	25.0 (3.2)/14–31
Gender (F test: $P = 0.628$)		
Male	271 (73)	23.4 (3.8)/12–30
Female (Reference group)	101 (27)	23.2 (3.6)/12–31
Race (F test: $P < 0.0001$)		
Non Hispanic Black	50 (13)	24.3* (3.0)/17–29
Other	33 (9)	23.1*(3.2)/17–29
Hispanic	205 (55)	22.0* (3.7)/12–31
Non Hispanic White (Reference group)	83 (23)	26.0 (2.7)/19–30
Education (F test: $P < 0.0001$)		
Below high school	78 (21)	21.9* (3.1)/14–28
High school	106 (28)	21.8* (3.7)/12–30
Above high school (Reference group)	188 (51)	24.9 (3.3)/14–31
Certified manager (F test: $P < 0.0001$)		
No and not certified	127 (34)	21.0* (3.3)/12–28
No but certified	95 (26)	23.6* (3.6)/15–31
Yes and a manager (Reference group)	150 (40)	25.2 (3.0)/14–30

[a]Variables with mean scores that are statistically different from mean scores of the reference group are denoted

dlers might unhesitatingly place ready-to-serve food at such a risk. Such a number may still be unacceptably high, given the large volume of both meat and poultry handlers and customers that they serve.

Other revealing findings about food safety knowledge among these meat and poultry handlers included their lack of knowledge of the severity of illness that can result from incompletely cooked ground meat and of important unacceptable practices related to thawing and cross-contamination. More than one-third did not know that something as alarming as bloody diarrhea could result from incomplete cooking of ground meat. This raises the concern that they may not appreciate the rationale for (or even know about) the recommendations for checking temperatures in a menu item such as meatloaf. Similarly, lack of knowledge of appropriate thawing of beef and poultry (16.9% and 24.5% of these meat and poultry handlers, respectively) could lead to amplification of pathogen burden in contaminated meat products. Failure to discard ready-to-eat food (such as vegetables for a salad) that have recognizably been contaminated with raw poultry places consumers at clear risk of food poisoning caused by germs such as *Salmonella* and *Campylobacter* (16.4% of meat and poultry handlers answered the question on this topic incorrectly).

Several important and substantial knowledge gaps were also revealed by the responses to questions that were of general importance but not specific to meat and poultry handling alone (Table 2). Knowledge of the temperature "danger zone" in which foodborne pathogens may grow well (nearly 88% did not know one or both of these temperatures) and of best hygiene practices such as knowing not to use bare hands to turn off the water after washing hands (26% did not answer correctly) was unacceptably low. There was also poor understanding of the difference between cleaning and sanitizing and the unreliability of smell and taste to ensure that food is safe to eat (nearly 29% and 36% answered incorrectly, respectively).

TABLE 4. Comparison of the mean scores for meat or poultry handling by restaurant characteristics (N = 372)

Independent variables	N	Mean total score[a] (SD), range
Restaurant variables		
Size of restaurant (F test: $P = 0.01$)		
Small	135 (36)	22.6* (3.5)/12–30
Medium	97 (26)	23.6 (3.9)/13–31
Large (Reference group)	140 (38)	24.0 (3.7)/12–30
Food service (F test: $P < 0.0001$)		
Fast food	111 (30)	22.3* (3.9)/12–30
Informal	161 (43)	23.5* (3.6)/14–30
Formal (Reference group)	100 (27)	24.7 (3.3)/17–31
Type of food served (F test: $P = 0.014$)		
Other cuisine	47 (13)	22.8 (3.7)/14–30
Mexican	52 (14)	22.3* (3.7)/12–30
Italian	53 (14)	23.9 (3.6)/15–29
American (Reference group)	220 (59)	23.8 (3.7)/12–31
Restaurant specialty (F test: $P = 0.002$)		
Seafood	15 (4)	24.7* (2.9)/20–29
Non specific	289 (78)	23.6* (3.6)/12–31
Meat or Poultry (Reference group)	68 (18)	22.0 (4.3)/12–30
Restaurant chain (F test: $P = 0.0005$)		
Yes	155 (42)	22.6 (3.7)/12–29
No (Reference group)	217 (58)	23.9 (3.6)/12–31
Entrée price (F test: $P < 0.0001$)		
< $10	215 (58)	22.6* (3.8)/12–30
$10–$20	100 (27)	23.6* (3.4)/15–31
> $20 (Reference group)	57 (15)	25.8 (2.9)/18–30

[a]Variables with mean scores that are statistically different from mean scores of the reference group are denoted by an asterisk ($P < 0.05$).

The meat and poultry handler variables that were significantly associated ($P < 0.05$) with the mean knowledge score were age, primary language, race/ethnicity, education, number of years experience as a food handler, and history of a food safety training course, stratified by whether the food handler was or was not a manager (Table 3). The restaurant variables that were significantly associated with the mean knowledge score were restaurant size (small, medium or large), type of food service (formal, informal or fast food), type of food served (e.g., Italian cuisine or Mexican cuisine), specialization of food (seafood, meat or poultry, or not specialized), membership in a restaurant chain (yes or no), and entrée price (< $10, $10 – $20, or > $20) (Table 4).

In the final multivariable model, a significant correlation between knowledge scores of food handlers from the same restaurants was detected by use of a random restaurant effect (β [SE = 1.12 [0.57], $P = 0.02$]. Meat or poultry handlers whose primary language was Spanish (with or without the ability to speak English) or other language (with the ability to speak English) scored

TABLE 5. Multivariable model demonstrating food handler and restaurant characteristics associated with lower knowledge scores among 368 meat and poultry restaurant food handlers in Chicago

Predicting variables	Description	N (%)	Coefficient (SD)[a]	*P*-value
Race/ Ethnicity	Non Hispanic Black	50 (14)	–1.28 (0.54)	0.018
	Other	33 (9)	–0.75 (0.62)	0.23
	Hispanic	204 (55)	–1.74 (0.55)	0.0016
	Non Hispanic White	81 (22)	Ref	Ref
Primary language	Other	24 (7)	–2.25 (0.72)	0.002
	Spanish	163 (44)	–1.59 (0.48)	0.0010
	English	181 (49)	Ref	Ref
Certified manager	No but certified	127 (35)	–1.54 (0.39)	<0.0001
	No and not certified	93 (25)	–3.20 (0.36)	<0.0001
	Yes	148 (40)	Ref	Ref
Entrée price	< $10	212 (58)	–1.74 (0.63)	0.0061
	> $10 but < $20	99 (27)	–0.99 (0.68)	0.142
	> $20	57 (15)	Ref	Ref

[a]Coefficient results demonstrate how many knowledge questions greater or fewer than the reference group were answered correctly.

significantly lower than persons for whom English was their primary language, after controlling for confounding variables (Table 5). Other variables associated with lower scores were race/ethnicity (i.e., Black or Hispanic compared to White), and working as a certified meat or poultry handler, (certified managers scoring better than non-managers and noncertified non-managers). Among restaurant characteristics, meat or poultry handlers in low-priced restaurants significantly underperformed compared to those in higher priced restaurants.

DISCUSSION

Despite the fact that a knowledge survey of meat and poultry restaurant food handlers was limited to meat and poultry relevant questions, the mean knowledge score was not substantially higher than their mean score on a more general food safety knowledge survey. Food safety policy makers should consider these findings and determine if current training and certification requirements are adequate, given that some of the knowledge gaps identified were substantial. These and other published results of food safety knowledge may in part explain why restaurant foodborne disease outbreaks associated with food handler error continue to occur throughout the country despite food safety certification programs and health department inspections and requirements.

One policy change to consider is that food safety certification should require a higher score on the certification exam. Possibly, a near perfect score should be required on the questions that are associated with recognized risk factors for foodborne illness (such as those dealing with time and temperature, hand hygiene, cross contamination, and cleaning and sanitizing). When considering such a change, it may be worth asking oneself, "to which questions on the exam is it acceptable for a food handler to not know the correct responses and yet still be allowed to handle food for the public (including vulnerable populations?)" Another change to consider is whether restaurant inspectors from local health departments should focus more of their limited inspection time on questioning and educating food handlers, especially those without a history of training. It is not clear that food safety certified food handlers or other sources of on-the-job training are adequately teaching these food handlers, given that food handlers without a history of training were demonstrated in our study to have lower food safety knowledge relevant to their duties. Health department inspectors should also consider engaging restaurant managers in discussions of the need to ensure that food handler knowledge regarding their duties is no less than that of the managers and to identify language barriers to such education. If managers cannot communicate adequately with their food handler employees because of language barriers, health departments should explore whether resources are available to provide language-specific educational materials to these non-English food handlers in an attempt to minimize these knowledge gaps.

These data are derived from Chicago restaurant food handlers whose voluntary consent to participate was obtained only if their managers allowed it. For 28 of the restaurants, only certified managers who handled food performed the survey and no additional non-manager foodhandlers were available. Therefore, our data might over-represent the knowledge of food handlers, because participation bias may have occurred, in which food handlers with certification and/or other training were more likely to participate. Also, we suspect that some foreign-born food handlers may have been illegal immigrants who were unwilling to participate because they would have been required to sign a consent form. The proportion of food handlers who speak Spanish as their primary language may have also been underestimated for this same reason. Therefore, additional studies of this kind would be helpful to validate these findings.

The United States has many strong systems in place to prevent food poisoning, including public health surveillance systems designed to detect outbreaks and promote prevention practices in response to reported cases of foodborne disease; local, state and federal health department staff trained in outbreak investigation; government and nongovernment training programs to certify food handlers in food safety; and regular inspections to monitor compliance with important food safety practices. Despite these systems, typically more than 1,000 foodborne outbreaks are reported each year *(1)* and it is likely that many more go unrecognized. The data in this study demonstrate that while many food handlers are either certified or work with a certified manager, despite the fact that the survey questions were limited to the ones most relevant to the duties of these food handlers, their level of food safety knowledge is, on average, not very high. Novel educational methods to reach more food workers, including the uncertified ones, are needed.

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