ARTICLES

Food Protection Trends, Vol. 32, No. 1, Pages 16–25
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International Association for Food Protection

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.

A peer-reviewed article

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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 coworkers 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 overestimation 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.

ACKNOWLEDGMENTS

This study was supported by the National Institute of Food and Agriculture of the United States Department of Agriculture (Award Number 2008-51110-04343). The authors thank the Chicago Health Department, Cook County Health Department, Lake County Health Department, Kane County Health Department, DuPage County Health Department, and the Illinois Department of Public Health for advice related to survey development and project feedback.

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