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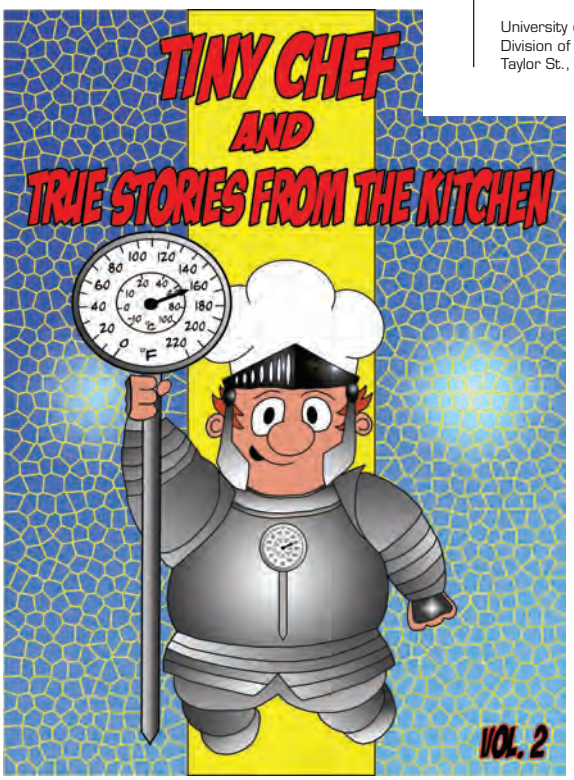

Food for Thought: Effective Evidence-based Brochure and Comic Book Interventions Designed for Restaurant Food Handlers

ABSTRACT

Foodborne disease outbreaks are frequently attributed to restaurants in the United States. A lack of food safety knowledge can lead to unsafe food handling behaviors that put customers at risk for food poisoning. We compared a straightforward brochure and illustrated story-based comic book to determine if one of these educational interventions was superior to the other in improving restaurant food handler knowledge relevant to prevention of foodborne illness outbreaks. A cross-sectional study was conducted to determine baseline knowledge and identify which knowledge questions were most frequently answered incorrectly. An educational brochure and a comic book were then created in English and Spanish, targeting the knowledge gaps identified from the baseline knowledge study. Ninety-eight restaurants (220 food handlers) participated in the follow-up knowledge survey and were randomized into the comic book, brochure or control groups. Overall knowledge score increased significantly by 10 percentage points (from 73% to 83%) for the comic book group and by 6 percentage points (from 75% to 81%) for the brochure group, whereas no significant increase occurred in the control group. English-speaking food handlers in the comic book and brochure groups and Spanish-speaking food handlers in the comic book group showed significant improvement. Nearly 100% of the participants in the intervention groups stated that the restaurant should provide the educational materials to staff. These data demonstrate that an educational brochure and comic book can improve food safety knowledge; however, they are not equally effective among all restaurant food handlers.

INTRODUCTION

Each year in the United States, millions of illnesses and thousands of deaths can be attributed to the consumption of unsafe food *(25, 26)*. Restaurants are often reported as the source of foodborne outbreaks *(27)*. A lack of restaurant food worker knowledge can lead to unsafe food handling behaviors that put customers at risk for illness. Food safety knowledge among restaurant food handlers has been shown to be low *(11, 13, 14, 22, 23)*. A study performed in

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the suburbs of Chicago determined that the average restaurant food handler knowledge score was 72% on a survey of 40 knowledge questions that tested knowledge of food safety topics including cross contamination, the temperature range of the danger zone and appropriate temperatures for heating and cooling foods. Although certified food managers scored higher than non-certified food handlers, their score was only 79% *(22)*. Similar results have been reported from the city of Chicago *(23)*.

Currently, there are no federal food safety training requirements for restaurant food handlers in the United States. Instead, states, counties or cities set training and certification standards independently. As a result, food safety education and training varies throughout the country and a wide variety of food handler resources have been developed to satisfy local regulations. Classroom and on-line food handler training programs are offered by governmental and private organizations throughout the United States. Nevertheless, few data are available concerning the evaluation of the effectiveness of food handler training programs or restaurant food safety reference materials.

Evaluation of the effectiveness of educational materials and food handler training is difficult, and results have been inconsistent *(1, 7, 8, 12, 15, 17, 24, 30)*. In Chicago, the CHEF (Chicago Educational Food Handler) Project revealed promising results when a combination of educationally similar material (a straightforward brochure and a story-based comic book style booklet) was studied as a passive intervention in English and Spanish formats *(12)*. Food handler knowledge, as the number of correct answers out of 41 food safety knowledge questions, increased significantly although modestly (6 percentage points overall score increase, from 67% to 73%).

Food safety educators need evidence-based food safety resources targeting knowledge and behavior gaps to improve restaurant food safety practices. To determine to what extent format makes a difference in efficacy, we studied the effectiveness of a straightforward brochure versus an illustrated story-based style comic book intervention designed to target knowledge gaps in restaurant food handlers relevant to prevention of foodborne illness outbreaks.

MATERIALS AND METHODS

Sample

We obtained a list of 2,087 food establishments in Lake, Kane and Suburban Cook counties from the business credibility provider Dun and Bradstreet [www.d&b.com] and a list of 1,782 restaurants in DuPage County from the DuPage County Health Department. A random sample of 668 restaurants (32%) in Lake, Kane and Suburban Cook counties and 101 restaurants (5.7%) in DuPage County were selected to be approached. The list was restricted to restaurants only and excluded banquet halls, caterers, and establishments that serve only non-perishable packaged foods or were otherwise considered low risk by the health department. Restaurant managers from all counties were approached in person for verbal approval to conduct interviews with the staff at each restaurant. Restaurants were randomly selected to receive an educational brochure, a comic book or no intervention. Post-intervention interviews were performed from June 2009 through February 2010 in Suburban Cook, Lake and Kane counties and from September 2010 through March 2012 in DuPage County. Post surveys occurred approximately one month after intervention distribution to the restaurant. We interviewed 809 food handlers from 226 participating restaurants to obtain baseline knowledge data and 220 food handlers from 98 restaurants during the intervention phase of the study. Thirty-three restaurants were randomized into the comic book intervention group, and 36 restaurants into the brochure intervention group; the remaining 29 restaurants served as the control group. Detailed information regarding the pre-intervention sample has been previously described *(22)*.

A signed consent obtained for each survey required participants to be 18 years old or older. Confidentiality of food handler and restaurant name was assured. Each eligible participant was a food handler, defined as a restaurant employee who prepared food to be consumed by the patrons. Food preparation was defined as washing, cutting, cooking, and placing food onto a plate. Restaurant employees who only poured drinks or carried plates to tables were excluded. Eligible participants were also required to speak either English or Spanish, as the survey was administered in one of these two languages. Questionnaires were discretely administered at restaurants by University of Illinois at Chicago Survey Research Laboratory staff and public health trained graduate students. Intervention restaurant food handlers were instructed to read the intervention material. Participating food handlers were offered $15 compensation for completion of the pre-intervention survey and an additional $20 upon completion of the follow-up survey. Approval from the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects was received prior to initiation of the study.

Data collection

A 50-question survey instrument was developed to obtain restaurant characteristics and food handler knowledge, behavior, and personal hygiene information. Survey development included input from the City of Chicago, Cook County, DuPage County, Kane County, and Lake County health departments, Illinois Department of Public Health, and the University of Illinois at Chicago Survey Research Laboratory. Cognitive interviewing was conducted with both English and Spanish food handlers, using the cognitive probing methodology described by Collins (2003), and survey adjustments were made accordingly *(10)*. The final survey instrument was launched after a pre-test had been

completed. Of the 50 total pre-intervention survey questions, the 40 food safety knowledge questions included true-false, multiple-choice, and fill-in-the-blank format and tested knowledge of the optimal temperatures for bacterial growth, appropriate temperatures for heating and cooling foods, cross contamination and when to discard food. Participants were also asked about behavior practices, including hand hygiene and working while ill. Food handler demographic information was collected during the pre-intervention survey and included primary language (English, Spanish with or without the ability to speak English, and other language with the ability to speak English), race/ethnicity, history of food safety training and certification, years of food handling experience, and frequency of specific food handling tasks (including handling and cooking raw meat/poultry, seafood, eggs and vegetables/fruits). Information on restaurant characteristics was obtained, including service style, food type and average entrée price. Restaurants were categorized by size: small (≤ 10 tables or seating ≤ 40 seats), medium (11 to 29 tables or seating 41 to 119 seats), and large (≥ 30 tables or seating ≥ 120 seats).

The follow-up survey consisted of 42 food safety knowledge questions and was administered to the food handlers at intervention and non-intervention restaurants after distribution of the educational materials. The 40 knowledge questions were identical to those on the pre-intervention survey except for two additional knowledge questions (regarding the temperature range of the "Danger Zone" and storing hot food in the refrigerator), added on the basis of feedback provided by food safety experts at the 2011 International Association for Food Protection Annual Meeting *(21)*. Participants were also asked about involvement in food safety training or certification courses during the study period. Information about intervention reading frequency and opinions about the materials was collected from participants in the brochure and comic book groups.

Educational materials

An educational brochure and a comic book were created based on the most frequently identified knowledge gaps from the baseline knowledge study *(22)*. Among the more substantial knowledge gaps identified, several related to optimal temperatures for cooking, holding and refrigeration, cross contamination, and hygiene. Any knowledge question that was highly important to the prevention of foodborne illness based on literature review or was answered incorrectly by at least 20% of the food handlers was presented in both the brochure and comic book materials.

The colorful tri-fold brochure included a photograph of hand washing, food safety facts that demonstrated the public health importance of foodborne disease, examples and lessons learned from actual foodborne disease outbreaks, key points regarding the proper methods for storing, preparing and cooking food, and several "test yourself" questions accompanied by their answers *(Fig. 1)*. The 26-page comic book presented the same food safety information and "test yourself" questions in a story-format with engaging illustrations. In the first comic story, a tiny chef recognizes

Amazing Facts about Food Poisoning

- Approximately 5,000 people die and 325,000 people are hospitalized in the United States related to foodborne disease each year.
- On average, about 550 foodborne disease outbreaks occur each year in the United States and more than 40% of those outbreaks are from food service establishments.
- There are close to a million restaurants in the United States.
- Foodborne illness has been estimated to cost $23 billion annually in the United States.
- In a study of restaurant outbreaks of salmonellosis, about 1 out of 10 food handlers had *Salmonella* in their feces. Of those who were sick, they had the germ in their feces for an average of 30 days.
- The most common food implicated in foodborne outbreaks is poultry (in about 1 out of every 5 outbreaks).

Sources of these data: Centers of Disease Control and Prevention, Morbidity and Mortality Weekly Report, the National Restaurant Association, the Journal of Food Protection, Food and Drug Administration, United States Department of Agriculture.

Test Yourself on Food Safety Knowledge

1. Is this true or false?
   If you let fully cooked rice sit out at room temperature overnight and then use it to make fried rice the next morning, it might cause food poisoning.
2. Is this true or false?
   Bloody diarrhea can be caused from eating ground meat that is not completely cooked.
3. Cold food must be stored below what temperature until it is used for cooking or serving?
4. Hot food must be kept warm above what temperature until it is served?
5. What is the difference between cleaning and sanitizing?
6. Is this a safe food handling practice?
   A large portion of dessert is prepared in a large pot over a hot stove. Now the pot needs to cool so it is placed in the restaurant's refrigerator to speed up its cooling.
7. Is this true or false?
   If you only urinated and did not have a bowel movement, you do not need to wash your hands.

1.True, improperly stored cooked rice can result in a bacteria producing a toxin that can make people sick. 2.True 3. 41°F (5°C) 4. 135°F (57°C) 5. Cleaning removes food or other types of soil from a surface. Sanitizing reduces the number of germs on a clean surface to safe levels. 6. No, it may raise the refrigerator temperature to unsafe cold food storage levels. 7. False, you must always wash your hands after using the bathroom.

This educational brochure was created by the University of Illinois at Chicago School of Public Health with funding from the United States Department of Agriculture. The information selected for this brochure is based on a survey of restaurant food handlers who identified food safety-related questions that was least well known.

Food Safety Information for Restaurant Food Handlers

This information could save someone's life. Really!

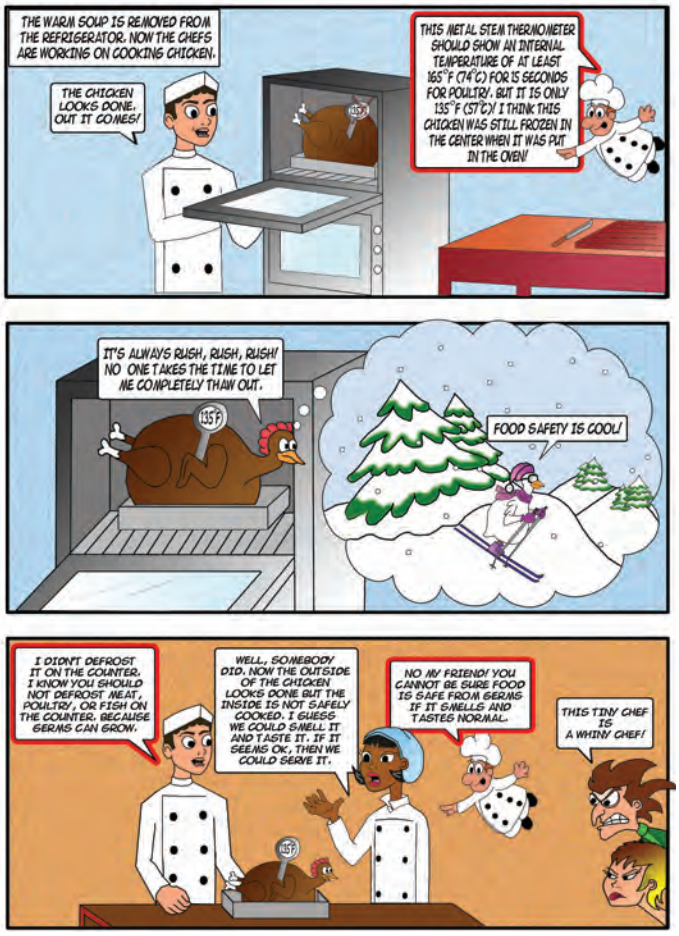
Did you know...

Raw meat, poultry and eggs can have germs that can make people sick.

Food can smell and taste normal, but still make people sick. You cannot rely on smell and taste to be certain.

Know the facts...read this brochure.

FIGURE 1. Side 1 of the English language brochure educational intervention, 2013



food safety threats in a restaurant and instructs on their remediation *(Fig. 2)*. This story is followed by shorter story-based presentations that illustrate proper hand washing technique, cooking temperatures, and sanitization methods and two summaries of actual foodborne illness outbreaks, consisting of an unpublished report of an outbreak caused by inappropriate thawing of turkeys and a report of a substantial number of illnesses due to noro-virus as a consequence of food handlers working while ill *(3)* *(Fig. 3)*. Some concepts, such as the temperature range of the "Danger Zone," were repeated on different pages to increase the likelihood that a reader might recall this information.

The brochure and comic book materials were translated and back-translated into Spanish and reviewed by university researchers and local and state health department staff. Focus groups were conducted with English- and Spanish-speaking food handlers for feedback on the educational materials. The food handlers offered suggestions regarding clarity, receptivity, and recommendations for improvement of the materials. The focus group participants (n = 25) were selected on the basis of convenience, from restaurants located near

FIGURE 2. A page of the English language comic book intervention that illustrates proper thawing methods and cooking temperatures, 2013

FIGURE 3. Example of the English language comic book portraying an actual foodborne outbreak associated with a restaurant, 2013

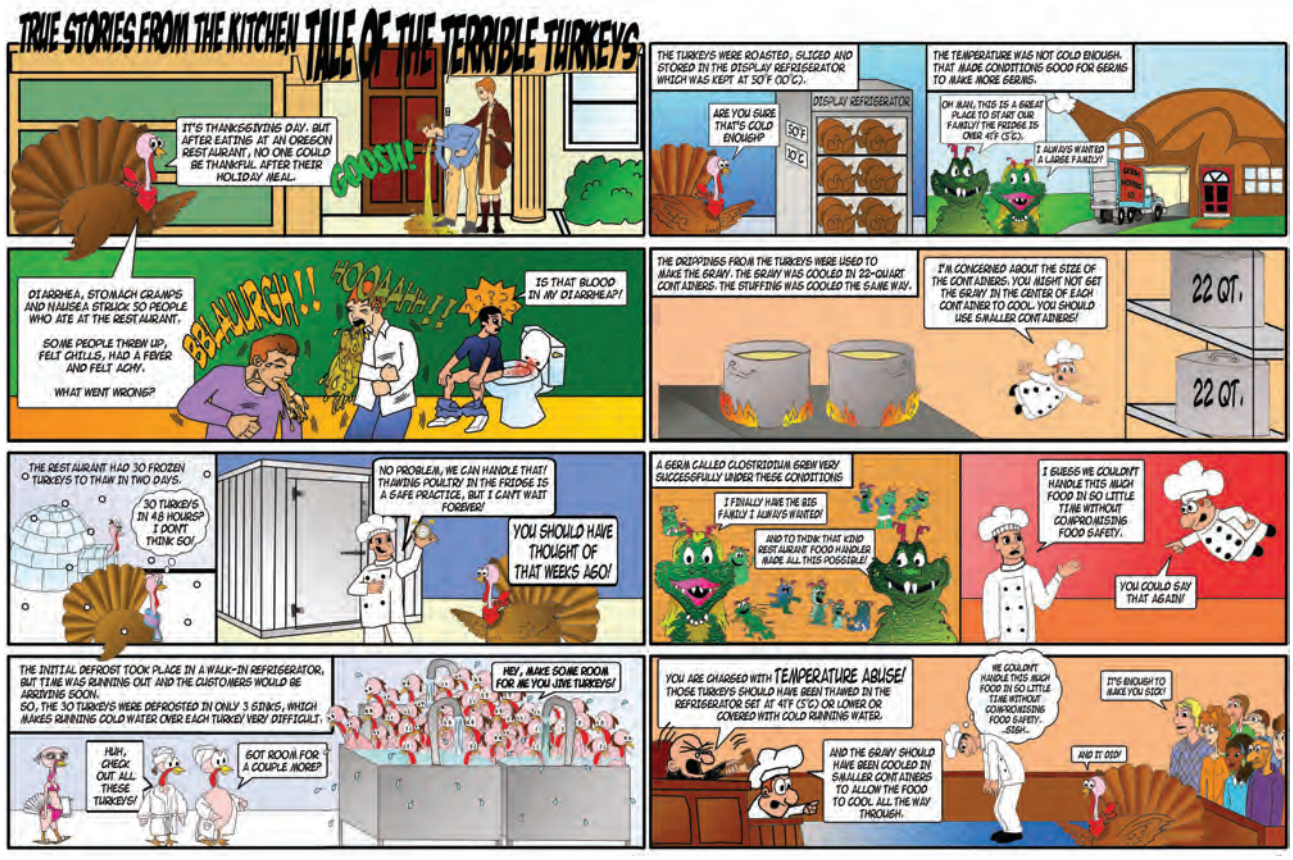


TABLE 1. Characteristics and knowledge scores of Suburban Chicago restaurant food handlers randomized by intervention group, 2012 (N = 220)

Characteristic	Control N = 56	No Exposure[a] N = 27	Brochure N = 54	Comic book N = 83
	N (%) Pre Mean[b] (%) Post Mean (%)	N (%) Pre Mean (%) Post Mean (%)	N (%) Pre Mean (%) Post Mean (%)	N (%) Pre Mean (%) Post Mean (%)
Overall	56 (25) 30 (75) 31 (74)	27 (12) 30 (75) 31 (74)	54 (25) 30 (75) 34 (81)***	83 (38) 29 (73) 35 (83)***
Food Hander Characteristics				
Age				
18–29 years	18 (32) 30 (75) 33 (79)	9 (33) 28 (70) 31 (74)	23 (43) 29 (73) 33 (79)*	27 (33) 29 (73) 34 (81)**
30–49 years	27 (48) 29 (73) 30 (71)	17 (63) 30 (75) 31 (74)	20 (37) 30 (75) 34 (81)*	45 (54) 29 (73) 35 (83)***
≥50 years	11 (20) 32 (80) 33 (79)	1 (4) 31 (78) 37 (88)	11 (20) 31 (78) 35 (83)*	11 (13) 29 (73) 35 (83)**
Gender				
Male	36 (64) 30 (75) 33 (79)	14 (52) 31 (78) 31 (74)	34 (63) 30 (75) 34 (81)**	59 (71) 29 (73) 34 (81)***
Female	20 (36) 29 (73) 30 (71)	13 (48) 29 (73) 31 (74)	20 (37) 29 (73) 34 (81)**	24 (29) 30 (75) 37 (88)***
Race/Ethnicity				
Non-Hispanic White	26 (46) 30 (75) 32 (76)	10 (37) 30 (75) 32 (76)	14 (26) 31 (78) 36 (86)*	37 (45) 32 (80) 38 (90)***
Hispanic/Latino	16 (29) 29 (73) 32 (76)	9 (33) 28 (70) 28 (67)	21 (39) 30 (75) 32 (76)	26 (31) 27 (68) 32 (76)**
Other/Multiracial	14 (25) 30 (75) 32 (76)	8 (30) 31 (78) 32 (76)	19 (35) 29 (73) 35(83)***	20 (24) 28 (70) 34 (81)**
Education				
No HS diploma or graduate equivalent	7 (13) 28 (70) 29 (69)	5 (19) 28 (70) 28 (67)	13 (24) 29 (73) 31 (74)	19 (23) 26 (65) 31 (74)**
HS diploma or graduate equivalent	17 (30) 29 (73) 31 (74)	8 (29) 29 (73) 30 (71)	19 (35) 30 (75) 34 (81)*	31 (37) 29 (73) 34 (81)**
Any college	32 (57) 31 (78) 32 (76)	14 (52) 31 (78) 32 (76)	22 (41) 30 (75) 36 (86)**	33 (40) 33 (81) 39 (93)***

TABLE 1. Characteristics and knowledge scores of Suburban Chicago restaurant food handlers randomized by intervention group, 2012 (N = 220) (continued)

Primary Language				
English	29 (52) 31 (78) 33 (79)	10 (37) 31 (78) 33 (79)	23 (43) 31 (78) 36 (86)**	40(48) 32 (80) 38 (90)***
Spanish	22 (39) 28 (70) 31 (74)	14 (52) 28 (70) 30 (71)	25 (46) 29 (73) 32 (76)	35 (42) 27 (68) 33 (79)***
Other (survey performed in English)	5 (9) 31 (78) 31 (74)	3 (11) 30 (75) 30 (71)	6 (11) 28 (70) 32 (76)	8 (10) 29 (73) 36 (86)*
Food Safety Training				
Yes, certified managers	32 (57) 31 (78) 34 (81)	10 (37) 32 (80) 32 (76)	18 (33) 31 (78) 35 (83)**	30 (36) 32 (80) 36 (86)**
Yes, certified non-managers	5 (9) 30 (75) 32 (76)	11 (41) 30 (75) 31 (74)	11 (20) 31 (78) 35 (83)	20 (24) 31 (78) 37 (88)**
No, non-certified food handlers	19 (34) 27 (68) 28 (67)	6 (22) 26 (65) 29 (69)	25 (47) 28 (70) 32 (76)*	33 (40) 27 (68) 33 (79)***
Restaurant Characteristics				
Size				
Small (≤10 tables or seating ≤ 40 seats)	20 (36) 31 (77) 32 (76)	8 (30) 30 (75) 30 (71)	9 (17) 30 (75) 32 (76)	18 (22) 30 (75) 36 (86)**
Medium (>10 tables but <30 tables)	14 (25) 31 (77) 31 (73)	13 (48) 29 (73) 31 (74)	15 (28) 31 (77) 33 (79)	24 (29) 29 (68) 33 (79)*
Large (≥ 30 tables or seating ≥ 120 seats)	22 (39) 29 (73) 32 (76)*	6 (22) 30 (75) 32 (76)	30 (55) 29 (73) 35 (83)***	41 (49) 29 (68) 36 (86)***
Cuisine				
American (no primary ethnic focus)	36 (64) 30 (75) 31 (73)	17 (63) 30 (75) 31 (74)	34 (63) 30 (75) 34 (81)*	49 (59) 30 (75) 36 (86)***
Italian	7 (13) 29 (73) 32 (76)	3 (11) 28 (70) 33 (79)	8 (15) 30 (70) 37 (88)*	19 (23) 26 (65) 33 (79)**
Mexican	8 (14) 28 (70) 31 (73)	3 (11) 31 (78) 30 (71)	3 (5) 31 (78) 32 (76)	8 (10) 27 (68) 33 (79)*
Other	5 (9) 31 (78) 30 (71)	4 (15) 29 (73) 31 (74)	9 (17) 28 (70) 33 (79)*	7 (8) 31 (78) 37 (88)

[a]No Exposure group defined as food handlers assigned to brochure or comic intervention but reported not reading the materials.

[b]Knowledge score was determined by the proportion of correctly answered knowledge questions of the 40 from the pre-intervention survey and of the 42 for the post-intervention survey.

*Significant difference at $P < 0.05$,** Significant difference at $P < 0.001$,*** Significant difference at $P < 0.0001$.

TABLE 2. Percent of food safety knowledge questions answered correctly by restaurant food handlers before and after educational intervention, 2012 (N = 220)

Questions (Answers)		Control N = 56	No Exposure[a] N = 27	Brochure N = 54	Comic Book N = 83
	Question Type	Pre N (%) Post N (%) % Change	Pre N (%) Post N (%) % Change	Pre N (%) Post N (%) % Change	Pre N (%) Post N (%) % Change
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	13 (23) 13 (23) +0%	0 (0) 5 (18) +18%	18 (33) 24 (44) +11	17 (21) 4 (49) +24%***
Germs that make people sick grow well between which temperatures? (40°F or 41°F to 135°F or 140°F)[b]	Fill-in-the-blank	11 (19) 2 (4) -15%**	0 (0) 2 (7) +7%	3 (6) 10 (19) +13%*	14 (17) 41 (49) +32%***
What is the proper minimum internal temperature to cook a chicken for at least 15 seconds? (165°F)	Fill-in-the-blank	16 (28) 16 (28) +0%	10 (37) 10 (37) +0%	9 (16) 27 (50) +34%***	20 (24) 49 (59) +35%***
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	38 (68) 40 (71) +3%	17 (63) 20 (74) +11%	38 (70) 46 (85) +15%	54 (65) 73 (88) +23%**
Which type of thermometer is best to check the temperature of a chicken breast…? (Metal stem thermometer)	Multiple choice	51 (91) 49 (88) -3%	22 (81) 21 (78) -3%	45 (83) 48 (89) +6%	63 (76) 73 (88) +13%*
Food storage					
Raw meat can be stored on foil-lined shelves to prevent dripping onto other foods. (False)	True/false	29 (51) 28 (50) -1%	16 (59) 15 (56) -3%	24 (44) 31 (57) +13%	36 (43) 57 (69) +26%***
Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic. (False)	True/false	34 (61) 41 (73) +12%	17 (63) 18 (67) +4%	32 (59) 40 (74) +15%*	47 (57) 66 (80) +23%**
Storing products with the earliest expiration dates in front of products with later dates is a safe food storage practice. (True)	True/false	43 (77) 44 (79) +2%	22 (81) 20 (74) +7%	42 (78) 48 (89) +11%*	66 (80) 62 (75) -5%
Thawing food					
It is safe to put frozen chicken breast on the counter to thaw. (False)	True/false	40 (71) 48 (85) +14%*	24 (89) 22 (81) -9%	46 (85) 49 (91) +6%	68 (82) 75 (90) +8%

TABLE 2. Percent of food safety knowledge questions answered correctly by restaurant food handlers before and after educational intervention, 2012 (N = 220) (continued)

Beef may be placed on the counter to defrost. (False)	True/false	47 (84) 51 (91) +7%	23 (85) 24 (89) +4%	47 (87) 50 (93) +6%	71 (85) 74 (89) +4%
Beef may be placed in cold water to defrost. (True, cold running water)	True/false	32 (57) 31 (55) -2%	13 (48) 18 (66) +18%*	34 (63) 36 (67) +4%	55 (66) 63 (76) +10%
Germs					
You can be sure food is safe to eat when it smells and tastes normal. (False)	True/false	39 (70) 38 (68) -2%	23 (85) 25 (92) +7%	37 (69) 47 (87) +18%**	50 (60) 68 (82) 22%**
Raw eggs can have germs that can make people sick. (True)	True/false	47 (84) 49 (88) +4%	23 (85) 25 (93) +8%	44 (81) 53 (98) +17%**	66 (80) 81 (98) +18%**
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	45 (80) 51 (91) +11%*	23 (85) 24 (89) +4%	46 (85) 52 (96) +11%*	76 (92) 76 (92) +0%
Eating ground meat that is not completely cooked can cause bloody diarrhea. (True)	True/false	42 (75) 46 (82) +7%	17 (63) 16 (59) -4%*	40 (74) 50 (93) +19%**	54 (65) 74 (89) +24%***
Cooked rice can have germs that can make people sick. (True)	True/false	20 (36) 30 (54) +18%**	12 (44) 13 (48) +4%	17 (31) 31 (57) +26%**	27 (33) 59 (71) +38%***
The difference between cleaning and sanitizing is … ? (Cleaning is to remove dirt 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	41 (73) 43 (77) +4%	21 (78) 23 (85) +7%	47 (87) 44 (82) -5%	64 (77) 72 (87) +10%*
Hand washing					
At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands. (False)	True/false	46 (82) 55 (98) +16%**	21 (77) 27 (100) +23%**	47 (87) 54 (100) +13%**	70 (84) 81 (98) +15%**

[a]No Exposure group defined as food handlers assigned to brochure or comic intervention but reported not reading the materials.

[b]Guidance for Illinois has recently changed from 40°F and 140°F to 41°F and 135°F and from 155°F to 160°F for holding food and cooking temperatures.

*Significant difference at $P < 0.05$, **Significant difference at $P < 0.001$, ***Significant difference at $P < 0.0001$.

the University of Illinois at Chicago School of Public Health and were not part of the study sample. Each received $20 compensation for their time. Afterwards, the materials were further edited and then approved by the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects.

Statistical analysis

Statistical analysis was performed using SAS 9.2 for Windows (SAS, Chicago, Ill.) with data from the 220 (27%) food handlers who completed both the pre- and post-intervention surveys. For analysis of the effect of the intervention, we compared food handlers who read the materials to those in the control group. If food handlers in the intervention groups stated that they had not read or had only looked at, rather than read, the materials, they were grouped as a separate intervention group for this analysis. Overall knowledge score was determined by the proportion of correctly answered knowledge questions of the 40 in the pre-intervention survey and of the 42 in the post-intervention survey. A score difference was calculated by subtracting the percent correct from the pre-intervention survey from percent correct for the post-intervention survey. Bivariate analyses were performed to identify food handler or restaurant variables associated with knowledge scores. *T*-tests were performed to compare the mean percent knowledge score difference between two category variables, and Analysis of Variance models with Tukey's pairwise comparisons were employed to compare the mean percent knowledge score difference for variables with more than two categories. To evaluate the intervention effect on an individual knowledge question, McNemar's test of paired dichotomous data (correct/incorrect answer) was employed. To identify risk factors associated with the food handler percent change in knowledge score, multivariable analysis was performed, using mixed-effects regression models predicting percent knowledge score difference. A random restaurant effect was used to account for the potential correlations between food handlers from the same restaurant. Variables of primary research interest such as primary language and those that had a statistically significant association with the knowledge score were included in the multivariate analysis. All hypothesis tests were performed using a 2-sided probability of Type I error of $\alpha = 0.05$. Effects with *P*-value of less than 0.01 were noted as marginal. The initial regression model included all significant food handler and restaurant characteristics to predict the percent knowledge score difference. A backward elimination method with $\alpha = 0.10$ was used to determine the significant food handler characteristic variables to remain in the final mixed-effects regression model.

RESULTS

Among the 226 restaurants (809 participating food handlers) for whom baseline knowledge data had been collected *(Table 1)*, 98 restaurants (220 food handlers) participated in the intervention phase of the study, with 33 restaurants (83 food handlers) randomized into the comic book intervention group, 36 restaurants (54 food handlers) randomized into the brochure intervention group, and the remaining 29 restaurants (56 food handlers) making up the control group. Twenty-seven (12%) food handlers employed at an intervention restaurant, referred to hereafter as the intervention without exposure group, did not read the educational materials. Loss of restaurants occurred because 55 (24%) restaurants no longer had any of the originally participating food handlers, 22 (10%) were unavailable despite having been approached up to 10 times, 20 (9%) closed, 19 (8%) refused, and 12 (5%) were no longer eligible because they had moved location or changed names. Loss of food handlers occurred because 352 (44%) no longer worked at the restaurant, 72 (9%) worked at a restaurant that refused, 59 (7%) worked at a restaurant that had closed, 44 (6%) worked at a restaurant that was unavailable, 39 (5%) worked at a restaurant that was not eligible and 20 (3%) refused.

Of the 98 participating restaurants, 30% (29) were small (≤10 tables or seating ≤ 40 seats), 41% (40) were medium sized (>10 tables or seating > 40 seats but < 30 tables or seating <120 seats), and 30% (29) were larger. The majority of restaurants were informal (66, 67%), while 27% (26) were fast food and only 6% (6) offered formal dining. Over half of the restaurants served American-style cuisine (54, 55%) and the rest served Italian, Mexican or "Other" (including Chinese, Indian, Thai and Latin foods) cuisines (13%, 14% and 17%, respectively). Sixty-two percent (61) of the restaurants served meals that cost less than $10, 34% (33) served meals between $10 and $20, and 4% (4) served more expensive meals. Among the 220 food handlers participating in the intervention phase of the study, English was the primary language for 46% (102), Spanish for 43% (96) and other language for 10% (22). Forty (39%) of the English-speaking food handlers read the comic book, 23 (23%) read the brochure, 29 (28%) were in the control group and 10 (10%) were in the intervention without exposure group. Similar group distributions were observed for the Spanish-speaking food handlers (36% in the comic book group, 26% in the brochure group, 23% in the control group and 15% in the intervention without exposure group). Eighty-seven (40%) food handlers described themselves as Non-Hispanic White, 72 (33%) as Hispanic/Latino (regardless of primary language), and 61 (27%) as Multi-racial or Other race/ethnicity. Most food handlers were male (143, 65%), and approximately half had no more than a high school education (119, 54%). Among all food handlers, 41% (90) identified themselves as certified food managers, 21% (47) as certified food handlers and 38% (83) as non-certified food handlers. The proportion of non-certified food handlers who read the comic book (30, 40%) was higher than the proportion of non-certified food

handlers in the brochure, control and intervention without exposure groups (30%, 23% and 7%, respectively).

Among the 137 food handlers in the intervention groups, the overall knowledge score increased significantly compared to the baseline score for those who read the comic book or the brochure (10 percentage points score increase, from 73% to 83%, $P < 0.0001$ and 6 percentage points increase, from 75% to 81%, $P < 0.0001$, respectively). The knowledge score of food handlers in the control and intervention without exposure groups showed no significant change (1 percentage point decrease for both groups, $P = 0.5$ and $P = 1.0$, respectively) *(Table 1)*. A significant score improvement was observed for both males and females and for food handlers of all age groups in both the comic book and brochure intervention groups, but not for those in the control groups. Among the English-speaking food handlers, the knowledge score increased by 10 percentage points ($P < 0.0001$) for the comic book group and 8 percentage points ($P < 0.0001$) for the brochure group. Among the Spanish-speaking food handlers, the knowledge score increased significantly only for those who read the comic book (11 percentage points increase, $P < 0.0001$). Similarly, the knowledge score for Hispanic/Latino food handlers increased only among those in the comic book group (10 percentage points increase, $P < 0.0001$). Food handlers of all educational levels in the comic book group showed significant improvement in knowledge, whereas only food handlers with less than a high school diploma in the brochure group showed such an improvement. Certified managers, certified food handlers and non-certified food handlers in the comic book group all showed significant improvement in scores compared to baseline (9 percentage points increase, $P = 0.0003$, 10 percentage points increase, $P = 0.005$ and 11 percentage points increase, $P < 0.0001$, respectively). Only certified managers and non-certified food handlers in the brochure group had increases in knowledge score (5 percentage points increase, $P = 0.008$ and 6 percentage points increase, $P = 0.013$, respectively). Although intervention group sizes for the restaurant characteristic variables tended to be small, significant improvements in scores were observed for food handlers in the comic book group working in restaurants of all sizes and cuisines. Post-intervention study results were similar when analyzing knowledge scores calculated from all 42 knowledge questions or when calculated from only the 40 questions from the pre-survey (data not shown).

Significant increases were observed for many of the food safety knowledge questions among both intervention groups, with the greatest improvements made by food handlers who read the comic book *(Table 2)*. Substantial increases were observed for questions regarding time and temperature. The proportion of food handlers to correctly identify the temperature range of the danger zone for pathogen growth increased by 32 percentage points ($P < 0.0001$) for the comic book group and by 13 percentage points ($P = 0.05$) for the brochure group. Knowledge regarding the correct internal temperature to which to cook chicken (165°F) also increased significantly for both groups (comic book, 35 percentage points $P < 0.0001$ and brochure, 34 percentage points $P < 0.0001$). Improvements were observed for questions regarding food storage; for example, the proportion of food handlers correctly answering "false" to the question "raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic" increased by 23 percentage points ($P = 0.0004$) for the comic book group and by 15 percentage points ($P = 0.05$) for the brochure group. Several of the germ-specific questions also showed statistically significant increases. Knowledge that bloody diarrhea is a possible manifestation of disease caused by eating ground meat that was not completely cooked increased significantly (comic book, 24 percentage points, $P < 0.0001$ and brochure, 19 percentage points, $P = 0.008$). Improvement in correctly identifying the difference between cleaning and sanitizing was observed only for food handlers who read the comic book (increase of 10 percentage points, $P = 0.033$). No significant improvements were observed among any of the groups for questions regarding the proper methods to thaw frozen foods (beef or chicken). Baseline knowledge of hand hygiene, and specifically questions involving proper hand washing technique, was relatively high (> 85%) on both the baseline and follow-up surveys, and no significant increases were observed for these questions. However, there were significant increases in the proportion of food handlers correctly answering "false" to the question "at work if you only urinated, and did not have a bowel movement, you do not need to wash your hands" for all groups, regardless of intervention (comic book, 15 percentage points, $P = 0.0009$, brochure, 13 percentage points, $P = 0.008$, control, 16 percentage points, $P = 0.007$ and intervention without exposure, 23 percentage points, $P < 0.0001$).

In the final mixed-effects regression model predicting knowledge score difference, a significant correlation between knowledge scores of food handlers from the same restaurants was detected (random restaurant effect, $\sigma = 37.3$ [SE = 16.9], $P = 0.014$]). This suggested that the performances of the knowledge tests among food handlers working in the same restaurant tend to be similar. After controlling for confounding variables, the comic book intervention had a stronger effect on knowledge improvement (6.6 percentage points increase above baseline, $P = 0.011$) than the brochure group (2.2 percentage points increase above baseline, $P = 0.415$), compared to the control group *(Table 3)*. No score difference was observed when food handlers who did not read the intervention materials were compared with the control group ($P = 0.96$). After adjusting for other food handler and restaurant variables, food handlers whose primary language was Spanish (with or without the ability to speak English) and other primary language (with the ability to speak English) had a similar knowledge change,

TABLE 3. Food handler and restaurant characteristics associated with percent knowledge score difference, Mixed-effects regression analysis (N = 220)

	Multivariate Analysis Estimate (Standard Error)	*P*-value
Food Handler Characteristics		
Intercept	-4.66 (3.45)	0.1800
Language		
English	Ref	
Spanish	-1.71 (2.07)	0.4146
Other	-0.53 (3.24)	0.8703
Intervention		
Control	Ref	
Comic Book	6.64 (2.52)	0.0114
Brochure	2.17 (2.60)	0.4084
Did not read intervention	-0.15 (3.04)	0.9604
History of food safety training		
Yes, certified food handler managers	Ref	
Yes, non-certified food handlers	-4.26 (2.45)	0.0888
No, non-certified food handlers	-0.44 (1.88)	0.8133
Gender		
Male	Ref	
Female	4.14 (1.86)	0.0315
Restaurant Characteristics		
Restaurant Cuisine		
American (no ethnic focus)	Ref	
Italian	8.23 (3.18)	0.0129
Mexican	2.97 (2.82)	0.2967
Other	2.23 (3.34)	0.5082

compared with persons for whom English was their primary language ($P = 0.415$). There was a marginal score difference for certified non-managers and no score difference for non-certified food handlers compared with certified managers ($P = 0.088$ and $P = 0.813$, respectively). Although there was no baseline knowledge difference by gender, females improved in score by 4.1 percentage points compared with their male counterparts when intervention type and other factors were controlled for ($P = 0.032$). Food handlers working in a restaurant serving Italian food had a significant improvement in score compared with those working in a restaurant serving American food ($P = 0.013$).

Among the 137 participants in the intervention groups, 98% (134) enjoyed reading the materials, 99% (135) felt that they had learned important food safety information from the materials and 99% (136) stated that the restaurant should provide the educational materials to staff. Thirty-five participants in the comic book group and 20 in the brochure group provided feedback on topics or sections of intervention materials that they liked best. The temperature danger zone topic was the subject most preferred by both groups (23% and 30%, respectively). Qualitative information was also obtained regarding personal opinions of the intervention materials. The following general opinions are representative of those given for the comic book intervention. According to one food handler, "I think it's a very smart way to catch people's attention to a lot of the things people do to handle food, without knowing that some of what they do is dangerous. It is better than a lecture, because a lecture can be boring. No one is bored by a comic book." Another food handler stated, "I liked it. I thought it was good. It has basic information and it was funny. A great guide for food handlers. It's great for training with a great format." The following opinion is representative of those provided about the brochure. A restaurant manager stated, "I thought it was informative and I probably will hang up the copy you gave me on the bulletin board. The food outbreak facts were interesting. I didn't realize that many people get sick. A good refresher of temperatures and food handling."

DISCUSSION

This study evaluated the effectiveness of educational materials in two learning formats (a comic book and brochure) designed to target food safety knowledge gaps of restaurant food handlers. Although these data demonstrate knowledge improvement for both intervention groups compared to controls, the comic book was superior in improving overall knowledge and knowledge of specific food safety topics.

The rises in overall knowledge of 10 percentage points for the comic book group and 6 percentage points for the brochure group were statistically significant. After controlling for food handler and restaurant characteristics, the improvement effect was attenuated for both groups (6.6 percentage points and 2.2 percentage points increases, respectively) and the effect of only the comic book intervention remained significant in the final regression model. Regardless, there were consistent and substantial increases of knowledge in several important areas for both intervention groups, including questions regarding proper cooking and holding temperatures, cross contamination, and food associated with subsequent illness.

A lack of food safety knowledge, specifically regarding proper food holding and cooking temperatures, can lead to unsafe food handling behaviors that put customers at risk for food poisoning. According to an FDA report on foodborne illness risk factors (2009), the factors most in need of attention by restaurants included improper holding/time temperature, with 54.7% of restaurants out of compliance, and inadequate cooking, with 15.4% of restaurants out of compliance *(28)*. Significant improvements were seen for both intervention groups in identifying the temperature danger zone for pathogen growth. In the baseline knowledge survey of 729 food handlers in Suburban Cook, Kane and Lake counties, 98% of the participants did not know the correct temperature range *(22)*. Similarly poor results were reported from studies in Chicago and Oregon *(11, 13, 23)*. Among the food handlers who read the comic book and brochure, the proportion to correctly identify the temperature danger zone increased by 32 percentage points and 13 percentage points, respectively. Although these improvements were significant, this question was answered correctly by less than 50% of the food handlers, even after intervention. Similar results were found for questions regarding the proper temperatures to which to cook beef and chicken. The results of our study demonstrate poor baseline knowledge of proper food holding and cooking temperatures, suggesting inadequate training of restaurant food handlers regarding these topics. As shown with our comic book and brochure interventions, educational materials designed to target these knowledge gaps are effective. However, these data reveal that food holding and cooking temperatures remain an area for special emphasis, even after the use of the educational interventions designed in our study.

Another knowledge area with significant improvement involved questions regarding food associated with foodborne illness severity. Increases in knowledge that raw eggs and cooked rice can have germs that make people sick were observed for both intervention groups. Recognition that consuming under-cooked meat can cause illness with severe symptoms (bloody diarrhea) also showed significant improvement. Among the food handlers who read the comic book and brochure, correct responses increased by 24 percentage points and 19 percentage points, respectively. Distribution of a similar brochure and comic book simultaneously, rather than one versus the other, led to a proportional increase of 32 percentage points for this question *(12)*. We suspect that one reason for poor food

safety compliance in general may be that food handlers do not fully appreciate the harmful consequences that can result. Food safety behavior might improve if food handlers better understood the potentially alarming outcomes of foodborne illness. Although both of the educational materials in our study highlighted this topic, the comic book presented strong images of potential foodborne illness outcomes (including vomiting, bloody diarrhea and death). Several participants commented on these images and their impact; one food handler stated that the most memorable section of the comic book was "the boy on the toilet" and another food handler liked "the true stories and vomit pictures."

In our study, the comic book intervention was superior to the brochure in improving food safety knowledge among restaurant food handlers. Research regarding the effectiveness of a comic book format in promoting health and safety have had mixed results *(2, 6, 19, 20)*. A literature review of nine comic book intervention studies (not concerned with food safety) concluded that comics may be a valuable tool for health promotion, but because of various limitations of previous studies, their efficacy should be further evaluated *(4)*. In contrast to strengths of previously reported comic book intervention studies, strengths of our study included the use of a control group and analysis of participants who did not read the intervention materials separately from the control group. These were research methods recommended in the aforementioned literature review *(4)*.

Effective food safety educational interventions that are both linguistically and culturally appropriate are needed. Our materials were produced in English and Spanish. Culturally tailored interventions have shown promising results in promoting knowledge and healthy behaviors, especially among Spanish-speaking research participants *(18, 19)*. A recent randomized pilot study by Larkey et al. (2009) suggests that storytelling may be an effective approach for changing colorectal cancer risk-related behavioral intentions among Latina women *(19)*. Liebman and colleagues (2007) reported significant improvement in knowledge about the signs and symptoms of pesticide poisonings and the ways to minimize pesticide exposures among farm workers after a culturally appropriate educational comic book intervention *(18)*. Branscum and Sharma (2009) suggest that interventions, like comics, should be multi-cultural and even multi-spiritual, have a varying cast of diverse characters and appeal to all different types of groups *(4)*. In our study, various methods were employed to produce culturally and linguistically acceptable products, including participation of English and Spanish speakers in the focus groups during the development of the surveys and educational interventions. Also, the comic book illustrations included characters and storylines designed to appeal to a diverse group of food handlers.

With regard to language, substantial differences were seen in baseline knowledge, as food handlers with English as their primary language scored higher than those with Spanish or other language as their primary languages (76%, 68%, and 68%, respectively, $P < 0.05$) *(22)*. After intervention, significant improvement in score was observed among all three language groups who read the comic book, but only among English-speakers who read the brochure. These findings suggest that the comic book format was a more effective learning tool than the brochure for Spanish and other primary language speakers in our food handler population. Buki and colleagues (2009) developed the Design Elements for the Development of Cancer Education Print Materials for a Latina/o Audience to assist health promotion educators in developing effective educational materials *(5)*. These researchers suggest developing health educational materials that go beyond translation and incorporate key stylistic components, including use of simple, eye-catching, and culturally meaningful pictures and illustrations. The comic book in our study utilized these components, while the brochure did not. Future research should focus on the development of educational materials that will be most effective for Spanish-speaking restaurant food handlers in a variety of formats, including the comic book style.

Food handling guides, brochures, posters and booklets are available in the United States from a variety of sources and can be acquired easily from the Internet. As one example, the U. S. Food and Drug Administration *Oral Culture Learner Project* provides educational posters and videos available in nine different languages for retail food handlers. The materials are not copyrighted, allowing them to be distributed freely on websites and in restaurants *(29)*. However, in a 2008 study of food handler focus group participants, Howells and colleagues reported inadequate training and resources as perceived barriers to proper food safety practices *(16)*. Despite availability, few studies have evaluated the effectiveness of food handler training programs and educational materials *(1, 7, 8, 13, 15, 17, 24, 30)*. In 2009, York and colleagues investigated the effectiveness of a four-hour ServSafe food-safety training and a Theory of Planned Behavior intervention program by assessing food handler knowledge and observed compliance with food safety guidelines. Despite a small sample size (n = 33), researchers concluded that hand washing knowledge improved after ServSafe training, but overall knowledge, including knowledge of thermometer usage and proper handling of work surfaces, did not improve *(30)*. In an intervention study by Chapman et al. (2010), food safety infosheets (one-page summaries of foodborne illness outbreaks or incidents, supplemented with surprising messages and graphics) were found to be effective, with significant increases in hand washing attempts and reductions in indirect cross-contamination events *(8)*.

Providing restaurants with proven effective training and educational materials may help to improve food safety knowledge and behavior among food handlers. As evidenced

by the food handler responses in our study, such materials would be well accepted. A future approach could be to provide health department sanitarians with educational materials like those created for this project, to distribute to restaurants during routine inspections. When a violation is observed in the restaurant, the inspector could use the facts and stories in the materials to provide a basic explanation of why the violation is important to remedy. Building a positive learning environment and using educational materials during an inspection may augment food safety education and raise its importance among some food handlers.

Important challenges were encountered during this intervention study, specifically with regard to restaurant recruitment and retention. Similar challenges with food handler populations in Kansas and Chicago have been reported *(12, 30)*. Although restaurants were randomized, participation rates and loss of restaurants should be considered when interpreting the results. A substantial number of restaurants were closed or moved in the period between the baseline survey and intervention distribution. Future studies designing intervention materials based upon baseline knowledge should consider that the time required to analyze baseline knowledge, develop intervention materials and obtain IRB-approval will likely result in the significant loss of restaurants and food handlers. A preferred sequence of events would be to perform focus groups to guide intervention creation, then to create the intervention, and finally to perform baseline and follow-up interviews. A limitation of our study is generalizability as group comparisons (control, intervention without exposure, brochure and comic book) for some study variables had small sample sizes ($N < 5$). Although intervention improvements were significant, they may not be generalizable to all suburban Chicago food handlers or to food handlers throughout the U.S. Finally, a limitation of any educational intervention is that an improvement in knowledge does not guarantee an improvement of behavior. As an example, Clayton and colleagues found that although food handlers were aware of recommended food safety practices, two-thirds reported not always exhibiting these behaviors *(9)*. Future research should further evaluate how to best motivate behavioral change with education.

Our evidence-based educational materials in brochure and comic book formats improved food safety knowledge among restaurant food handlers. The comic book format was more effective in improving overall knowledge and knowledge of specific food safety topics. Furthermore, knowledge significantly improved among Spanish-speaking food handlers only in the comic book group, whereas knowledge among English-speakers in both intervention groups increased. Future research should focus on enhancing the efficacy of these materials, with special attention to Spanish-speaking food handlers.

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