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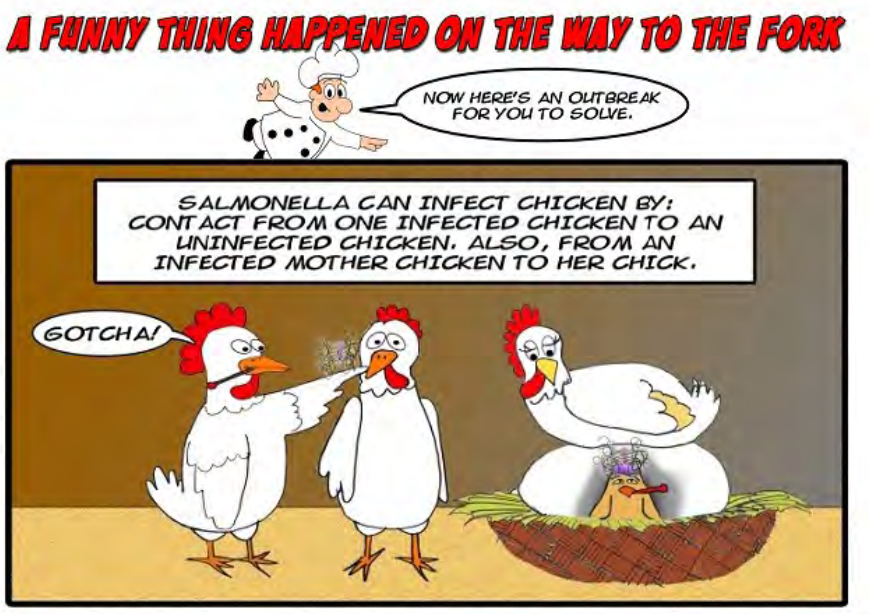

High School Students as the Target of an Integrated Food Safety Educational Intervention: Successful Results of a Pilot Study

ABSTRACT

High school students represent an important population for food safety knowledge intervention. The objective of this pilot study was to perform and assess a low-cost, feasible, reproducible food safety and hand hygiene curriculum and instructional comic book to demonstrate preliminary efficacy at increasing knowledge in high school students. A 34-question survey instrument was administered to 195 students at baseline and 171 students following the curriculum to determine knowledge, behaviors, and personal hygiene of the students. Frequencies of correct answers to each knowledge question and self-reported behavioral changes were examined to determine changes associated with the intervention. Student knowledge increased significantly, from 37% to 62% of 29 knowledge questions. Knowledge related to proper mechanisms for storing, thawing, and checking food temperature and cross contamination increased substantially. Commonly reported areas of behavioral change included washing hands for a longer period of time, sanitizing surfaces, cooking meat to the correct temperatures, thawing meat appropriately, and avoiding cross-contamination. These data demonstrate an association of an educational intervention and substantial knowledge increases and behavioral change in a predominantly minority high school student population. Further research enhancing the curriculum based on lessons learned, determining efficacy in other high school populations, and maximizing efficacy is needed.

INTRODUCTION

Young adults are particularly likely to engage in risky eating behaviors that may put them and others at risk for foodborne disease *(1, 2)*. This is of special concern because teenagers make up a substantial portion of the food service workforce. The Bureau of Labor Statistics has estimated that 21% of all food and beverage service workers are 16–19 years old *(29)*. In addition, 40.8% of employment for teenage workers is in the food service industry *(17)*. When improper food safe-

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ty-behavior is utilized in these circumstances, young people not only are putting themselves at risk for illness but also may be putting family members or restaurant patrons with increased susceptibility to foodborne diseases at greater risk. However, only one study of food safety knowledge in U.S. high school students has been published to date *(5)*. To identify knowledge gaps in this population, we surveyed 195 11th and 12th grade students from a Chicago high school to determine their baseline food safety-related knowledge and behaviors, and personal hygiene. Overall knowledge was low *(7)*.

Most states do not require family and consumer science (home economics) education in high schools, and some schools have removed it entirely *(3, 8, 20, 21)*. When a home economics course is offered, knowledge of food safety is one of 70 content areas that students are expected to have mastered upon completion of the course *(9)*. A USDA/FDA Education Initiative determined that food safety can be effectively taught in science courses in order to reinforce scientific concepts and provide them with a practical application *(20)*. Approaches integrating food safety information with core curriculum have previously been utilized in middle school and collegiate settings to successfully increase knowledge *(19, 26, 27, 31)*. Comic books present a novel mechanism for relaying food safety knowledge to high school students in an integrated manner. Comic books are becoming more widely used, both as a teaching tool in high schools and as a mechanism for health intervention *(6, 30)*. Additionally, comic books have been successfully utilized to increase food handler knowledge in a restaurant setting in Chicago proper and suburban Chicago *(11, 22)*.

The objective of this pilot study was to perform and assess a low-cost, feasible, reproducible food safety and hand hygiene curriculum and comic book based on input from instructors and students to demonstrate preliminary efficacy at increasing knowledge in high school students. This curriculum was based on elements of published food safety and hygiene interventions, including the modification of an existing educational comic book originally designed for restaurant food handlers *(22)*.

MATERIALS AND METHODS

Participants

Two hundred thirty-one students enrolled in health science classes in the 11th and 12th grades at Noble Street Charter School were invited to participate and provided with consent and parental permission forms. The Noble Street Charter School was selected because of its health science emphasis and pre-existing relationship with Univerity of Illinois at Champaign-Urbana Institutional Review Board. The UIC Institutional Review Board and the Chicago Public Schools Research Review Board approved the study protocol. Voluntary consent was obtained from students and their parents. Eligible participants were defined as students who returned signed parental permission and student consent forms and who provided complete answers on the post-intervention survey.

Instruments

Between July 2011 and February 2012, a comic book and curriculum were created with the objective of increasing food safety knowledge in high school students (curriculum, comic book, and surveys available at http://aburke2007.wix.com/uiccomic). The curriculum was designed to: (1) be suitable for high school students and require no substantial increase in school resources; (2) be easily adopted by instructors as their own curriculum; (3) be complementary to other core curriculum such as reading, math, oral communication and science and informed by local, state, and national learning standards; (4) be based on elements of published food safety and hygiene interventions, including two educational comic books originally designed for restaurant food handlers *(11, 22)*. Specific local, state, and national learning objectives were reviewed. The curriculum was designed to align with National Science Education Standards, Common Core Standards for Math and English Language Arts, and Illinois State Board Of Education Learning Standards for Physical Development and Health for students in late high school *(14, 18, 23, 24)*. The comic book and curriculum were drafted with the assistance of an artist, shared with two school health science faculty for feedback input, and pilot tested with two 12th grade students. The comic book and curriculum were modified based on this input from the health science instructors and student volunteers. A curriculum guide was created for the instructors.

The comic book consisted of short stories depicting real and fictitious foodborne disease outbreaks that targeted recognized knowledge gaps in restaurant food handlers. Two fictitious outbreaks were featured for instructional purposes. One outbreak featured the protagonist Tiny Chef preventing food handling errors in a restaurant setting *(Fig. 1)*. The other, which was designed to orient students to methods used to investigate a foodborne *Salmonella* outbreak, included work pages teaching epidemiological concepts such as 2 × 2 tables and food-specific attack rates *(Fig. 2)*. A curriculum 120–150 minutes long was created to accompany the comic book.

The curriculum was composed of two sessions, each lasting approximately 60 to 75 minutes. It consisted of reviews and discussions of information in the comic book, analysis of a National Outbreak Response System (NORS) report form of a fictitious Norovirus outbreak at their high school, and group presentations of several selected foodborne disease outbreaks published in the *Morbidity and Mortality Weekly Report* of one of several selected foodborne disease outbreaks *(4, 10, 15, 16, 28)*. Each report was selected to demonstrate an important food safety concept. These concepts included

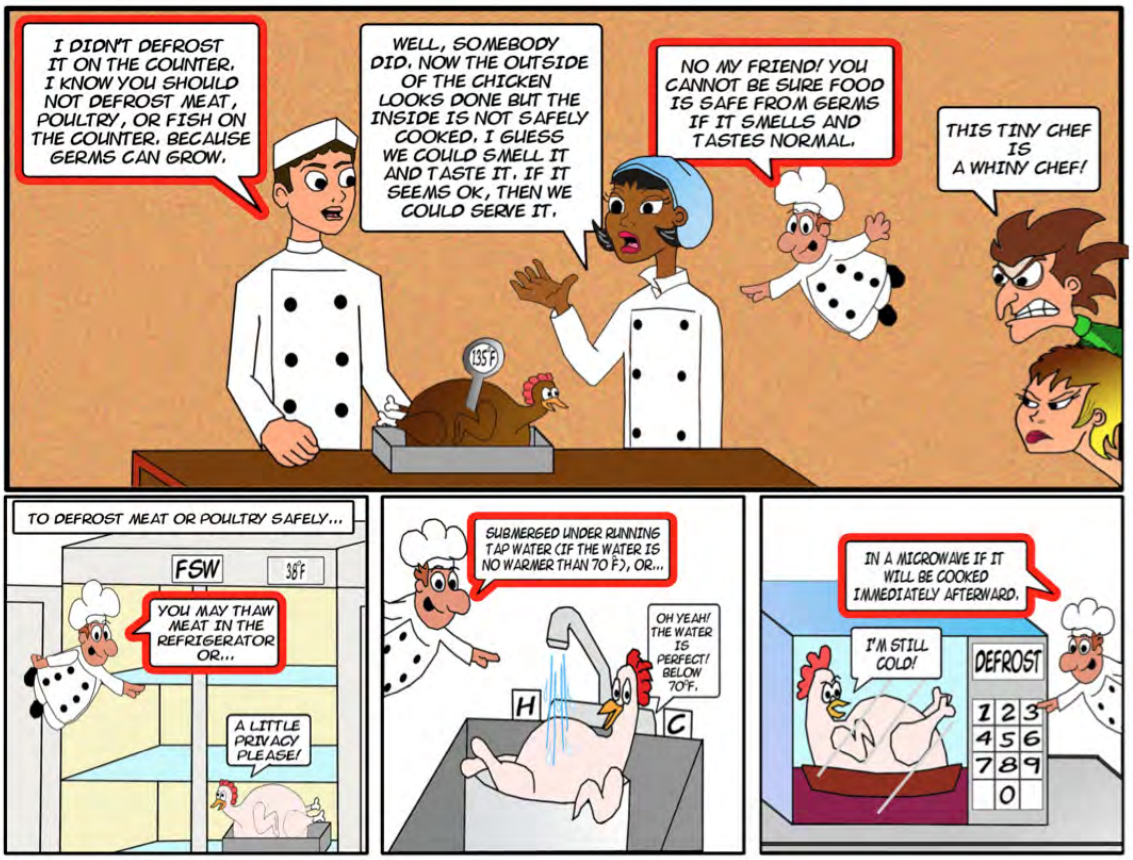

Figure 1. Panels of the comic book that illustrate proper thawing methods, 2012

Figure 2. Panel of the comic book portraying epidemiologic methods for foodborne outbreak investigation

cross-contamination, as illustrated in an outbreak of *Listeria*-contaminated hogshead cheese and an outbreak of campylobacteriosis caused by lettuce contaminated by raw chicken juice; the importance of avoiding preparing food while ill, as illustrated by an outbreak of Norovirus associated with ill food handlers; proper cooking of ground beef and avoidance of risky food consumption, as illustrated by illness caused by *Salmonella* Typhimurium associated with consuming a raw ground beef dish; and populations at risk for foodborne disease, as illustrated by an outbreak of foodborne illness among immunocompromised participants in the transplant games.

By the end of the curriculum, students were expected to: (1) generate hypotheses based on the presentation of a foodborne disease outbreak and be familiar with determinants of foodborne disease; (2) define and interpret terms related to food safety, hand hygiene, outbreak investigation, and epidemiology; (3) calculate food-specific attack rates and relative risks; (4) be familiar with the NORS form; and (5) demonstrate an understanding of how food safety and hand hygiene can be applied in the kitchen to prevent the transmission of foodborne disease.

A 34-question survey instrument was developed to obtain baseline information about the knowledge, behaviors, and personal hygiene of the students *(5)*. There were 29 food safety knowledge questions, including true-false, multiple-choice, fill-in-the-blank, and short answer formats. Knowledge items included optimal temperatures for bacterial growth, proper mechanisms for storing and thawing foods, cross-contamination, and foodborne disease epidemiology. Participants were also asked about their handwashing behaviors. Student demographic information was collected, including grade, gender, cooking experience, history of restaurant employment, and frequency of specific food handling tasks (including handling and cooking raw meat/poultry, seafood, eggs, and vegetables/fruits).

Procedure

Students completed the baseline survey as previously described *(7)*. Following the baseline knowledge survey, the curriculum was implemented. Consenting students were instructed to read the educational comic book and participate in the classroom activities over two class sessions. In the next consecutive class period, students completed the post-intervention survey. The time from pre- to post-intervention survey was two weeks. The follow-up survey consisted of the same 29 baseline knowledge questions to which 10 questions designed to evaluate the student's exposure to the curriculum and the degree of post-intervention behavioral change were added. Students were asked if they shared information they had learned from the curriculum with family and/or friends and if they believed that these individuals had learned new information and changed their food handling behaviors. Students were encouraged to provide further elaboration on these answers through comments. Students and instructors were asked to provide feedback about the comic book and curriculum.

Data analysis

Statistical analysis was performed using SAS 9.2 for Windows (SAS, Chicago, Il). Increase in knowledge score was determined by the number of correctly answered questions on the baseline survey subtracted from the number of correctly answered identical questions from the follow-up survey. Frequencies of correct answers to each knowledge question pre- and post-intervention were compared. Bivariate analyses were performed to identify student variables associated with increase in knowledge score. T-tests were performed to compare the mean knowledge increase between two category variables and analysis of variance models were employed to compare the mean knowledge increase for variables with more than two categories. Reported behavioral change and perception of the comic book and curriculum were examined quantitatively and qualitatively through survey responses.

RESULTS

Among the 195 students who participated in the baseline knowledge survey (baseline participation rate = 84.4%), 171 participated in the educational intervention and were in attendance for the follow-up knowledge survey (intervention participation rate = 88%). For the remainder of the results, all analyses refer to the 171 students participating in the entire intervention unless otherwise specified. One hundred forty-three (84%) of the students and both (100%) of the instructors completed an evaluation of the curriculum. Of the 143 students who completed the evaluation, 70 (49%) reported reading all of the comic book. Of the students surveyed, 62% were female, 38% were male, 75% were in the 11th grade, and 25% were in the 12th grade *(Table 1)*. The majority of students described themselves as Hispanic/Latino (71%) or Non-Hispanic Black (15%). Generally, no significant difference was seen in the frequency of cooking experience or restaurant employment between the baseline and follow-up participants.

Overall, the student knowledge score increased by 6.5 questions (23 percentage points rise, from 37% to 60%) compared to the baseline score ($P < 0.05$). Among the more substantial increases in knowledge, several related to the proper mechanisms for storing, thawing, and checking the temperature of food and cross contamination *(Table 2)*. Students were significantly more likely to recognize that reaching a high enough temperature as measured on a metal stem thermometer is the only way to determine that a frozen chicken breast is safe to eat (increase from 12% to 55%; $P < 0.05$). Knowledge about bloody diarrhea being a potential manifestation of eating undercooked ground meat increased from 47 to 83% ($P < 0.05$). After exposure to the curriculum,

Table 1. Characteristics of high school students participating in a knowledge survey in Chicago, Illinois, 2012 (n = 171) and score out of 29 knowledge questions

				Bivariate Analysis	
Characteristic	**n (%)**	**Baseline Score[a] (%)**	**Follow-up Score (%)**	**Increase in Score (%)**	***P*-value**
Grade					< 0.0001
11th	126 (75)	10.3 (36)	17.9 (62)	7.6 (26)	
12th	43 (25)	12.0 (41)	15.1 (52)	3.1 (11)	
Gender					0.6974
Males	65 (38)	10.2 (35)	16.8 (58)	6.6 (23)	
Females	104 (62)	11.1 (38)	17.4 (60)	6.3 (22)	
Race/Ethnicity					0.0072
Non-Hispanic White	6 (4)	12.4 (43)	17.4 (60)	5.0 (17)	
Hispanic/Latino	121 (71)	10.1 (35)	17.5 (60)	7.4 (26)	
Non-Hispanic Black	26 (15)	12.2 (42)	15.9 (55)	3.7 (13)	
Asian/Pacific Islander	3 (2)	9.7 (33)	16.3 (56)	6.6 (23)	
Other/Multiracial	15 (9)	12.2 (42)	16.5 (57)	4.3 (15)	
Restaurant Employment					0.9071
Currently Employed	7 (4)	12.1 (42)	19.1 (66)	7.0 (24)	
Formerly Employed	14 (8)	11.3 (39)	18.1 (62)	6.8 (23)	
Never Employed	146 (88)	10.7 (37)	17.0 (59)	6.3 (22)	
Fast-Food Employment (Former or Current)					0.7598
Yes	10 (6)	10.7 (37)	17.7 (61)	7.0 (24)	
No	161 (94)	10.7 (37)	17.2 (59)	6.5 (22)	
Frequency of Cooking with Parents					0.7328
Never	25 (14)	9.3 (32)	16.2 (56)	6.9 (24)	
Rarely	46 (31)	11.4 (39)	18.4 (63)	7.0 (24)	
Sometimes	51 (30)	10.7 (37)	17.9 (62)	7.2 (25)	
Often	29 (17)	11.0 (38)	18.1 (62)	7.1 (24)	
Always	13 (8)	10.6 (37)	15.4 (53)	4.8 (17)	
Frequency of Cooking on Own					0.4746
Never	13 (8)	9.8 (34)	16.3 (56)	6.5 (22)	
Rarely	32 (19)	10.6 (37)	16.6 (57)	6.0 (21)	
Sometimes	68 (41)	10.3 (36)	17.6 (61)	7.3 (25)	
Often	41 (25)	11.3 (39)	19.0 (66)	7.7 (27)	
Always	12 (7)	12.6 (43)	18.2 (63)	5.6 (19)	

(continued)

Table 1. Characteristics of high school students participating in a knowledge survey in Chicago, Illinois, 2012 (n = 171) and score out of 29 knowledge questions (cont.)

				Bivariate Analysis	
Characteristic	**n (%)**	**Baseline Score[a] (%)**	**Follow-up Score (%)**	**Increase in Score (%)**	***P*-value**
Experience Handling Raw Meat or Poultry					0.6048
Not at all	60 (39)	10.1 (35)	16.6 (57)	6.5 (22)	
Sometimes	73 (47)	11.0 (38)	18.2 (63)	7.2 (25	
Often	22 (14)	13.0 (45)	19.8 (68)	6.8 (23)	
Experience Handling Raw Seafood					0.0078
Not at all	104 (68)	11.0 (38)	17.9 (62)	6.9 (24)	
Sometimes	39 (26)	11.0 (38)	19.0 (66)	8.0 (28)	
Often	9 (6)	9.8 (34)	12.4 (43)	2.6 (9)	
Experience Handling Raw Eggs					0.0538
Not at all	34 (22)	10.7 (37)	16.0 (55)	5.3 (18)	
Sometimes	77 (50)	10.6 (37)	18.3 (63)	7.7 (27)	
Often	44 (28)	11.5 (40)	18.2 (63)	6.7 (23)	
Experience Handling Raw Vegetables or Fruit					0.0956
Not at all	29 (19)	10.0 (35)	15.3 (53)	5.3 (18)	
Sometimes	72 (46)	10.6 (37)	17.5 (60)	6.9 (24)	
Often	54 (35)	11.7 (40)	19.3 (67)	7.6 (26)	
Experience Cooking Meat or Poultry					0.9768
Not at all	68 (45)	10.2 (35)	17.1 (59)	6.9 (24)	
Sometimes	58 (28)	11.3 (39)	18.1 (62)	6.8 (23)	
Often	26 (17)	11.8 (41)	18.7 (64)	6.9 (24)	
Experience Cooking Seafood					0.1416
Not at all	120 (77)	11.2 (39)	18.2 (63)	7.0 (24)	
Sometimes	29 (19)	10.5 (36)	17.5 (60)	7.0 (24)	
Often	6 (4)	10.4 (36)	13.5 (47)	3.1 (11)	
Experience Cooking Raw Eggs					0.1285
Not at all	46 (30)	10.4 (36)	16.2 (56)	5.8 (20)	
Sometimes	70 (45)	11.0 (38)	18.7 (64)	7.7 (27)	
Often	38 (25)	11.5 (40)	18.4 (63)	6.9 (24)	

(continued)

Table 1. Characteristics of high school students participating in a knowledge survey in Chicago, Illinois, 2012 (n = 171) and score out of 29 knowledge questions (cont.)

				Bivariate Analysis	
Characteristic	n (%)	Baseline Score[a] (%)	Follow-up Score (%)	Increase in Score (%)	*P*-value
Exposure to the Educational Comic Book					
Read some or all of the comic book					0.0027
Some			16.0 (55) 5.1 (18)		
All			18.4 (63) 7.8 (27)		

[a]Previously published data *(5)*

students were significantly more likely to identify as false the statement that raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic (increase from 30% to 63%; $P < 0.05$). With regard to proper mechanisms for thawing meat, students were significantly more likely to identify as false the statement that putting a frozen chicken breast on the counter at room temperature is a safe way to thaw it (increase from 32% to 70%, $P < 0.05$). Knowledge that vegetables for a salad splashed with a few drops of raw chicken juice will not be made safe to eat by rinsing it with water increased from 44 to 77% ($P < 0.05$). Knowledge that fully cooked rice and raw eggs can contain germs that can make people sick increased by 9 percentage points to 40% and 75 percentage points to 90%, respectively ($P < 0.05$). Knowledge that you cannot rely on smell and taste to be sure food is safe to eat increased from 66 to 87% ($P < 0.05$). The percentage of students who identified 20 seconds as the length of time they should wash their hands increased from 54 to 72% ($P < 0.05$).

Bivariate analysis revealed student characteristics that were significantly associated with the increase in knowledge score *(Table 1)*. Students in the 11th grade had an increase in score that was more than twice as great as students in the 12th grade (increase from 36% to 62% and 41% to 52%, respectively; $P < 0.05$). Hispanic students had a significantly greater increase in score than did students of other races or ethnicities (increase from 35% to 60% and 42% to 55%, respectively; $P = 0.05$). Among students who reported reading all of the comic book (n = 70), knowledge score increased by 7.8 points (27 percentage points rise from to 36% to 63%). In contrast, the knowledge score of students who reported reading only part of the comic book increased by 5.1 points (18 percentage points rise, from 38% to 55%). Community interaction was significantly associated with increase in knowledge score, with students who did not report speaking to their friends or family having a significantly lower increase in knowledge score than did students who reported speaking with friends or family about what they had learned ($P < 0.05$).

Among the 140 students with behavioral change information, 71 (51%) reported that they changed food safety behaviors after reading the comic book *(Table 3)*. Commonly reported areas of behavioral change included washing hands for a longer period of time (61% of students), avoiding cross-contamination and sanitizing surfaces after contact with potentially contaminated food (78% of students), and making sure to cook meat to the correct temperatures and thawing meat appropriately (74% of students).

Thirty-eight students (38% of those responding) stated that they had spoken with friends or family about the curriculum *(Table 3)*. Ten of these students (26%) believed that these individuals had learned new information from their discussion and 19 (50%) believed that their friends or family had changed their food safety behaviors as a result of these conversations. Commonly reported topics that students spoke about with their family or friends included proper methods of thawing, ensuring meat is cooked to the correct temperature, use of a metal stem thermometer and cross-contamination.

Most students thought that the comic book was enjoyable and understandable, that the classroom activities were beneficial, and that the schools should provide the comic book and curriculum *(Table 3)*. One student reported, "I thought it was funny. The jokes are clever and I really liked the Tiny Chef and the turkey. The curriculum was so much fun. I think I learned more from the comic than I have anything." In addition, the proportion of students reporting that they strongly or somewhat agreed that the curriculum had taught them information about food safety that they had not learned before was 94% (129 students). One student reported, "It was a fun way to remember the information.

Table 2. Frequencies of correct responses to knowledge questions asked of high school students participating in a follow-up knowledge survey in Chicago, Illinois, 2012 (n =171)

Questions *(Answers)*	Question Type	Pre-intervention number correct[a] n = 195	Post-intervention number correct n = 171	Knowledge Change	*P*-value
Time and Temperature					
Hamburger and other ground beef mixtures, such as meatloaf, should be cooked to at least what temperature on a meat thermometer? *(160°F)*	Fill-in-the-blank	1 (0.5)	24 (14.0)	+13.5%	< 0.0001
You can be certain that a frozen chicken breast is safe to eat if… *(It reaches a high enough temperature as measured on a metal stem thermometer)*	Multiple-choice	24 (12.3)	94 (55.0)	+42.7%	< 0.0001
Cold food must be kept between 50°F and 60°F. *(False)*	True/False	52 (26.7)	89 (52.1)	+25.4%	< 0.0001
Food Storage					
Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic. *(False)*	True/False	58 (29.7)	107 (62.6)	+32.9%	< 0.0001
It is NOT a safe food practice to transfer a large pot of hot soup into several smaller containers and then place all of those smaller containers in the refrigerator to cool. *(False)*	True/False	80 (41.0)	102 (59.7)	+18.7%	0.0008
Thawing Food					
Putting a frozen chicken breast on the counter at room temperature is a safe way to get it to thaw (defrost). *(False)*	True/False	62 (31.8)	120 (70.2)	+38.4%	< 0.0001
Which of the following are acceptable methods to thaw (defrost) beef?	Multiple-answer Multiple-choice				
Beef may be placed in cold water to defrost. *(True, cold running water)*		58 (29.8)	81 (47.4)	+17.6%	< 0.0001
Beef may be placed in the microwave to defrost if it will be cooked right away. *(True)*		22 (11.3)	70 (40.9)	+29.6%	< 0.0001
Beef may be placed in the refrigerator to defrost. *(True)*		30 (15.4)	60 (35.1)	+19.7%	< 0.0001
Germs					
You can be sure food is safe to eat when it smells and tastes normal. *(False)*	True/False	128 (65.6)	149 (87.1)	+21.5%	< 0.0001
Uncooked meat (such as beef or chicken) is potentially contaminated with germs that can cause people to be hospitalized. *(True)*	True/False	184 (94.4)	166 (97.1)	+2.7%	0.2850

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Table 2. Frequencies of correct responses to knowledge questions asked of high school students participating in a follow-up knowledge survey in Chicago, Illinois, 2012 (n =171) (cont.)

Questions (Answers)	Question Type	Pre-intervention number correct[a] n = 195	Post-intervention number correct n = 171	Knowledge Change	*P*-value
You can be sure frozen chicken breast is safe to eat because the freezing process kills any germs potentially contaminating the meat. *(False)*	True/False	105 (53.9)	118 (69.0)	+15.1%	0.0023
Raw eggs can have germs that can make people sick. *(True)*	True/False	137 (75.3)	154 (90.1)	+14.8%	< 0.0001
If vegetables for a salad were splashed with a few drops of raw chicken juice, they will be made safe to eat by rinsing with water. *(False)*	True/False	86 (44.1)	132 (77.2)	+33.1%	< 0.0001
Eating ground meat that is not completely cooked can cause bloody diarrhea. *(True)*	True/False	92 (47.2)	142 (83.0)	+35.8%	< 0.0001
Fully cooked rice can have germs that can make people sick. *(True)*	True/False	17 (8.8)	69 (40.4)	+31.6%	< 0.0001
Salmonella can infect a chicken by contact from one chicken to another. *(True)*	True/False	22 (11.3)	21 (12.3)	+1.0%	< 0.0001
Salmonella can infect a chicken from an infected mother hen to her unhatched chick. *(True)*	True/False	12 (6.2)	17 (9.9)	+3.7%	< 0.0001
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	141 (72.3)	140 (81.9)	+9.6%	0.0026
Hand Washing					
Is the temperature of the water important when washing your hands? *(Yes, and it should be warm)*	Multiple-choice	116 (59.5)	111 (64.9)	+5.4%	0.1161
For how many seconds should you lather your hands with soap? *(20 seconds is enough)*	Multiple-choice	105 (53.9)	123 (71.9)	+18.0%	< 0.0001
How should you turn off the water? *(Using the paper towel)*	Multiple-choice	131 (67.2)	152 (88.9)	+21.7%	< 0.0001
Restaurant food handlers do not need to wash their hands after using the bathroom if they only urinated (and did not have a bowel movement). *(False)*	True/False	187 (95.9)	160 (93.6)	-2.3%	0.4669
Cross-contamination					
In one or two sentences, explain cross-contamination in the kitchen. *(2 points, one for germ transfer, one for mechanism within the kitchen)*	Short answer (2 points)	9 (4.6)	56 (32.6)	+28.0%	< 0.0001
Foodborne Disease Epidemiology					
Which of the following four terms represent the four major ways to prevent the transmission of foodborne disease? *(Clean, separate, cook, chill)*	Multiple-choice	35 (18.0)	48 (28.1)	+10.1%	0.0026

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Table 2. Frequencies of correct responses to knowledge questions asked of high school students participating in a follow-up knowledge survey in Chicago, Illinois, 2012 (n =171) (cont.)

Questions (Answers)	Question Type	Pre-intervention number correct[a] n = 195	Post-intervention number correct n = 171	Knowledge Change	*P*-value
Salmonella causes an estimated 1.4 to 3 million cases and more than 500 deaths in the United States annually. *(True)*	True/False	49 (25.1)	41 (24.0)	-1.1%	0.2850
During an outbreak of illness at a restaurant, health department investigators interview individuals who have eaten at the restaurant in order to… *(Compare what was eaten by sick individuals to what was eaten by individuals who did not become sick)*	Multiple-choice	112 (57.4)	119 (69.6)	+12.2%	0.0111
Vulnerable Populations for Foodborne Disease					
Meat or poultry that is not cooked well enough is of relatively high risk to cause disease in which of the following groups?	Multiple-answer Multiple-choice				
Meat or poultry that is not well done is of relatively high risk to cause disease in those infected with HIV/AIDS. *(True)*		18 (9.2)	66 (38.6)	+29.4%	< 0.0001
Meat or poultry that is not well done is of relatively high risk to cause disease in pregnant women. *(True)*		39 (20.0)	84 (49.1)	+29.1%	< 0.0001
Meat or poultry that is not well done is of relatively high risk to cause disease in the elderly. *(True)*		42 (21.5)	87 (50.9)	+29.4%	< 0.0001
Meat or poultry that is not well done is of relatively high risk to cause disease in young children. *(True)*		87 (44.6)	114 (66.7)	+22.1%	< 0.0001

[a]Previously published data *(5)*

For example, during the survey when I was asked if germs can live in cold temperatures, the picture of the scary-looking germ popped into my head and I answered yes." The instructors perceived the comic book to be a novel and feasible mechanism to provide information in the classroom setting. One instructor commented, "Initially, I was hesitant about the comic book idea. Perhaps this is just because it was a very new and different vehicle for delivering health information. I was definitely intrigued though. When I actually sat down to read the entire thing, beginning to end, I was very surprised at how it exceeded my expectations. It was both engaging and informative and the combination of a narrative story format and visual images seemed to do well in making the information 'sink in.'"

CONCLUSIONS

The results of this preliminary study demonstrate efficacy of an educational comic book and curriculum designed to increase food safety-related knowledge in high school student populations. Post-intervention, students demonstrated a significant increase in knowledge score. The majority of students began with a low level of knowledge (knowledge score of 26%–50%) and increased to a moderate level (51%–75% knowledge score) on the follow-up assessment.

Since there is no literature on the efficacy of a food safety high school curriculum, we can only compare our study to those in younger and older student populations. The increase in knowledge observed is similar in magnitude to results reported from interventions of middle school and undergraduate college students *(19, 26, 27)* and twice as great as that found in a previous intervention for undergraduate college students *(31)*. Studies in middle school students performed in Tennessee and South Korea have demonstrated efficacy of a food safety curriculum *(19, 26)*. The Tennessee study was similar to ours in that

Table 3. Relative frequencies of responses to behavioral change and belief questions by high school students without missing information on a knowledge survey in Chicago, Illinois, 2012 (n ≤ 155)

Reported Behavior or Belief	Frequencies n (%)
Washing hands for a longer period of time	
Yes	101 (69)
No	46 (31)
Amount of time now spent washing hands	
5 seconds	5 (4)
10 seconds	13 (11)
20 seconds	80 (68)
Until student sees bubbles	19 (17)
Frequency of washing hands for a longer period of time	
All of the time since completing the unit	57 (42)
Most of the time since completing the unit	54 (39)
Sometimes since completing the unit	20 (15)
Rarely since completing the unit	6 (4)
Being more careful to prevent raw meat from contaminating other foods	
Yes	99 (78)
No	28 (22)
Frequency of being more careful to prevent raw meat from contaminating other foods	
All of the time since completing the unit	36 (35)
Most of the time since completing the unit	52 (40)
Sometimes since completing the unit	18 (14)
Rarely since completing the unit	15 (11)
Being more careful to cook meat to the proper internal temperature	
Yes	86 (74)
No	30 (26)
Frequency of being more careful to cook meat to the proper temperature	
All of the time since completing the unit	41 (36)
Most of the time since completing the unit	41 (36)
Sometimes since completing the unit	13 (11)
Rarely since completing the unit	19 (17)

(continued)

Table 3. Relative frequencies of responses to behavioral change and belief questions by high school students without missing information on a knowledge survey in Chicago, Illinois, 2012 (n ≤ 155) (cont.)

Reported Behavior or Belief	Frequencies n (%)
Changed behaviors related to food as a result of being taught this curriculum	
Yes	71 (51)
No	21 (15)
Unsure	48 (34)
Spoke with friends or family about curriculum	
Yes	45 (28)
No	118 (72)
Friends or family learned new information about food safety	
Yes	30 (33)
No	33 (36)
Don't know	28 (31)
Friends or family engaging in new food safety behaviors	
Yes	19 (23)
No	30 (36)
Don't know	34 (41)
Enjoyed reading the comic book	
Yes	128 (91)
No	13 (9)
Believes high schools should provide students with the comic book and curriculum	
Yes	129 (93)
No	10 (7)
The information in the curriculum was taught in a manner that the student could understand	
Strongly agree	71 (51)
Somewhat agree	58 (42)
Neither agree nor disagree	7 (5)
Somewhat disagree	1 (1)
Strongly disagree	2 (1)

(continued)

Table 3. Relative frequencies of responses to behavioral change and belief questions by high school students without missing information on a knowledge survey in Chicago, Illinois, 2012 (n ≤ 155) (cont.)

Reported Behavior or Belief	Frequencies n (%)
The classroom activities helped the student to better understand the concepts taught in the curriculum	
Strongly agree	62 (45)
Somewhat agree	56 (41)
Neither agree nor disagree	15 (11)
Somewhat disagree	0 (0)
Strongly disagree	5 (4)
The comic book and curriculum taught me new information about food safety that the student did not know before	
Strongly agree	91 (66)
Somewhat agree	38 (28)
Neither agree nor disagree	6 (4)
Somewhat disagree	0 (0)
Strongly disagree	3 (2)
The comic book and curriculum taught me new information about epidemiology that the student did not know before	
Strongly agree	49 (36)
Somewhat agree	56 (41)
Neither agree nor disagree	24 (17)
Somewhat disagree	5 (4)
Strongly disagree	4 (3)

it utilized an interdisciplinary curriculum consisting of elements from science, math, social studies, and language arts to increase food safety knowledge *(26)*. Among undergraduate college students, studies at Rutgers University and Kansas State University have reported successful interventions *(27, 31)*. At Kansas State University, an interactive web-based intervention was used to increase food safety knowledge in health and non-health majors, with greater success in health majors *(31)*. As in our study, student knowledge about the correct temperature to cook ground beef and how to determine doneness of eggs and ground beef all significantly improved; accordingly, self-reported practices associated with this knowledge improved significantly. The results of this study suggest that while food safety interventions can be effective for all students, they may be particularly successful with students who already have a health sciences background.

Several factors were significantly and independently associated with an increase in knowledge score. These factors included race/ethnicity, degree of exposure to the comic book, and having spoken with friends or family about what they learned in the curriculum. The intervention was particularly effective at increasing food safety knowledge in Hispanic students, who had an average increase of almost two points greater on the follow-up survey than did students of other races/ethnicities. Consistent with this finding, an analysis of efficacious interventions to promote healthful behavioral strategies in Latinas suggested that narrative interventions containing colorful illustrations and personalized information may be particularly effective *(12, 13)*. Results of studies in suburban Chicago and Chicago proper also support the contention that narrative, colorful comic books with stories designed to reflect daily activities in a restaurant kitchen are effective in increasing food safety knowledge within Hispanic food handler populations *(11, 22)*. However, Hispanic students also scored significantly lower at baseline, and therefore had the potential for a larger increase in score. Future research should determine

what other elements can make food safety interventions particularly efficacious in this population.

Another factor significantly associated with increase in knowledge score was having communicated with family and friends about the curriculum. Students who reported speaking with family and friends had an average score increase almost two points higher on the follow-up survey. This suggests that sharing information can be effective in increasing knowledge not only throughout the community, but in the students as well. This is consistent the concept of peer learning. In the book *Peer Learning in Higher Education: Learning from and with Each Other*, Bould et al. propose that peer learning promotes working with others; critical inquiry and reflection; communication and articulation of knowledge, understanding, and skills; managing learning and how to learn; and self and peer assessment *(5)*. Through discussing the food safety and disease investigation concepts with family and friends, greater understanding may have been facilitated. Our students elected to share food safety knowledge with their family and friends despite the lack of any requirement to do so. The impact of teaching as a learning tool could be further emphasized by explicitly including that expectation in the curriculum: research suggests that students learn more when there is an expectation that they will later need to teach the information to others *(25)*.

Although the intervention was effective in this population, the utilization of only one school limits the generalizability of these results. However, this pilot study was designed to establish feasibility and preliminary efficacy, not generalizability. While there was no control group, such a large change in knowledge would be highly unlikely in a control population. One important consideration is that the school utilized in this study had a health sciences focus; as evidenced in the study at Kansas State University, students with a health background may demonstrate greater knowledge gains than would be seen in the general high school student population *(31)*. Additionally, the results suggest that, because an increase in knowledge score was associated with interacting with family and friends about the curriculum, a greater amount of community interaction built into the curriculum may also increase effectiveness. Future studies utilizing other high school populations and a greater community interaction emphasis may provide further evidence of the effectiveness of this comic book and curriculum.

Our study demonstrated the preliminary efficacy of an educational comic book and curriculum targeting food safety knowledge in high school students. Knowledge gains in this study were greatest in Hispanic students and students who shared the study information. Overall, students perceived the intervention positively and demonstrated not only increased knowledge but also safer reported food handling behaviors. Further research is needed to determine within a wider context the ability of a low-cost, feasible, reproducible food safety and hand hygiene curriculum and comic book to increase knowledge, enhance the curriculum based on lessons learned, and maximize the intervention's efficacy at increasing food safety knowledge within high school student populations.

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