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Assessing the Food Safety Knowledge of University of Maine Students

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Abstract: Foodborne illness is a global public health issue. Young adults may work in foodservice while they are university students, and their habits may later shape the practices and well-being of their children. The objective of this study was to establish baseline data and assess the food safety knowledge of 18- to 26-year-old Univ. of Maine students. Demographic questions and the previously validated Food Safety Knowledge Questionnaire (FSKQ) were placed online. Of 123 people who responded to the email recruitment notice, 104 Univ. of Maine undergraduates aged 18 to 26 years completed the survey. The average score among all participants was 60% correct (53 points out of a possible 89 points). Survey questions that required participants to identify common sources of foodborne pathogens had the lowest average percent correct (31%). Less than 50% of participants were able to correctly identify several high-risk foods, including sliced melon, raw sprouts, and unpasteurized fruit juice. Our findings indicate a need for educational programs for 18- to 26-year-old Univ. of Maine students in regards to common sources of foodborne pathogens and proper handling of fresh produce and that food safety knowledge among university students has not improved since publication of a national survey using the FSKQ in 2006. Effective educational programs are needed to ensure that young adults understand food risks and appropriate food handling practices.

Introduction

Foodborne illness is a global public health concern. Food preparation classes are not often part of basic educational curricula (Fischer and Frewer 2008). Young adults could be a new emerging "at-risk" population. Current consumer research indicates that individuals between 18 and 29 years of age are more likely to engage in risky eating behaviors than are older adults, as are individuals with education beyond high school (Patil and others 2005; McCarthy and others 2007; Byrd-Bredbenner and others 2008; Levy and others 2008). College students are traditionally within this age range and may have limited knowledge of food safety or safe food handling practices when they arrive to campus. The Univ. of Maine implemented a policy in 2012 to increase student retention by requiring that 1st and 2nd year students live on campus, and residence halls were consolidated in anticipation of reduced future demand due to smaller numbers of high school students in the state. These changes in policy meant that fewer dormitory rooms were available for students in their final years of college, and subsequently several private apartment complexes were constructed near campus to provide housing for displaced juniors and seniors. Students moving to off-campus housing may be inadequately educated about safe food preparation and storage practices.

Food consumption practices of college students

College students are not typically considered a high-risk group for foodborne illnesses. However, Morrone and Rathburn (2003) identified several gastrointestinal risk factors for this population, including excessive consumption of alcoholic beverages, stress and anxiety, use of antibiotics, and consumption of hydrophilic food additives such as polyols. When students move off campus, they may begin preparing their own food for the 1st time. A meta-analysis identified young adults as the group with the poorest safe food handling practices and knowledge (Patil and others 2005). McCarthy and others (2007) reported that among the Irish population "at risk" for foodborne illness, young men (ages 18 to 24 years) were most at risk. It was also likely that they would not engage in safe food preparation in their own kitchen. This risk could be even further complicated by the fact that many college students co-occupy a living space and prepare their meals in a shared kitchen. Danish men and women age 18 to 29 were found to be more likely to consume a risky meal than were older adults (Christensen and others 2005). Recent studies have found that young adults, ages 18 to 29 years, and individuals with education beyond high school are more likely to engage in risky eating

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behaviors, such as consumption of raw or undercooked meats, raw sprouts and raw, homemade cookie dough (Byrd-Bredbenner and others 2008; Fein and others 2011). Fischer and Frewer (2008) hypothesized that people that are more educated tend to worry less and may be more confident in the safety of their food preparation techniques. Food safety and other environmental health issues are typically overlooked in university health promotion classes (Christensen and others 2005). Byrd-Bredbenner and others (2008) stated that "the importance of young adult food handling behaviors becomes clear as their current and/or future roles as caregivers for household members at increased risk, such as young children and aging parents, is realized." College students may be forced to procure, purchase, and prepare their own meals for the 1st time, but safety may not be a priority for these students.

If people know how to cook, they will have healthier eating habits (Brown and Hermann 2005; Condrasky and Hegler 2010). Preparing meals in the home is often marketed as a way to save money. College students often live on very limited funds, and therefore may begin to prepare meals for themselves. Health professionals, such as registered dietitians, encourage consumers to limit the use of convenience foods, as these foods are typically high in calories and sodium. In order to make this practice sustainable, it is important that these students are able to prepare foods safely. Researchers at Rutgers Univ. conducted an in-home assessment of the homes in which students lived and found that these kitchens are supportive of foodborne pathogen growth and transport (Byrd-Bredbenner and others, 2007a). For that reason, it is reasonable to hypothesize that the majority of college students have not formed habits to insure food and contact surface cleanliness and proper food preparation skills. Therefore, college students appear to be a population that may need to be informed and educated on proper food preparation techniques and practices.

The purpose of this research was to survey 18- to 26-year-old Univ. of Maine students to assess the food safety knowledge and enhance the current literature of this population. This information will be used to develop future food safety programs for Univ. of Maine students, and potentially extend programs to other colleges and universities.

Materials and Methods

Survey instrument

We modified the previously validated Food Safety Knowledge Questionnaire (FSKQ) developed by Byrd-Bredbenner and others (2007c). The original questionnaire development encompassed 7 steps with the goal to be able to use the survey to find knowledge gaps within a target population, and then later implement an educational intervention to close those gaps. Once the survey had been completely developed and piloted, it was disseminated to 21 colleges and universities across the United States. The online survey was open for a total of ten months (January through October 2005) and attracted 4,548 respondents. The survey was successfully validated by the research team and the suggested use was to establish baseline data and measure effectiveness of educational interventions (Bryd-Bredbenner and others 2007c).

The original survey consisted of 39 questions that were divided into 5 different scales:

(1) Cross contamination prevention/sanitation procedures
(2) Safe times/temperatures for cooking/storing food
(3) Foods that increase risk of foodborne disease
(4) Groups at greatest risk for foodborne disease
(5) Common sources of foodborne disease pathogens

Fourteen questions, to characterize the demographics of survey respondents, were added to the FSKQ. The demographic questions and FSKQ were combined and entered into an online survey management website, SurveyMonkey (v. December 12, 2011, Palo Alto, Calif., U.S.A.). The complete survey consisted of 55 questions and took approximately 25–35 min to complete. The order of the FSKQ for this research study did vary from that of the original survey due to a data entry error when entering the questions into SurveyMonkey. The study received prior approval by the Univ. of Maine Review Board for the Protection of Human Subjects.

Participants

Participants were recruited through the Univ. of Maine's e-mail system, First Class (v 10.0, Open Text Corp., Waterloo, Ontario, Canada). The recruitment notice was initially posted on February 1, 2012, and then reposted 4, 7, and 13 d after the initial posting. A total of 123 people responded to the recruitment notices and started the survey. The informed consent was part of the e-mail recruitment notice, as well as the 1st page of the online survey. Respondents must have answered "Yes" to the questions "I have read the informed consent (above) and agree to participate in this research," "Are you a Univ. of Maine student," and "Are you 18–26 years of age" in order to continue with the survey. One respondent was excluded because s/he did not agree to the informed consent; 8 respondents were excluded because they were not Univ. of Maine students. An additional 10 respondents were excluded from analysis because they did not answer any of the Food Safety Knowledge Questionnaire, questions 14 to 52. Nineteen respondents were excluded, and thus the survey was completed by 104 participants. Participants who provided their e-mail address at the end of the survey, regardless of how many survey questions they answered, were entered into a drawing that randomly selected e-mail addresses to receive one of thirty $10.00 cash incentives. Participants who did not enter an e-mail address were not entered into the drawing. Of the 89 participants who provided their e-mail address, 30 participants were randomly selected to receive an incentive.

Data processing

After the survey was closed, Survey Monkey data were exported to a Microsoft Excel 2007 (v. 12.0, Los Angeles, Calif., U.S.A.) spreadsheet. All confidential information was removed from the spreadsheet and saved as an encrypted document using TrueCrypt software (v. 7.1a, Nevada). Each participant's responses to the 39 food safety knowledge questions were scored based on the scoring procedures defined by Byrd-Bredbenner and others (2007c). One point was awarded for every correct answer, and a "zero" was given to all incorrect answers and skipped questions. Scale scores are the sum of the total points awarded for each of the 5 scales, and the total score is the sum of each scale. Each scale had a different number of questions and possible points; the total number of points possible was 89.

Participants' scores were divided into several groups, based on their responses to demographic questions. Age groups were: 18 to 19, 20 to 21 and 22 to 26 years old. The ranges were selected because they best described age by academic year. The 6 colleges for participants' self-reported major field of study were: Engineering, Liberal Arts & Sciences, Natural Sciences, Forestry and Agriculture, Education and Human Development, Maine Business School, and Other. Any participant who did not identify a major field of study or responded "unknown" was assigned to the "Other" group. Living arrangements were split into 2 groups:

Table 1–General demographic data of respondents to the Univ. of Maine Food Safety Knowledge Questionnaire Survey.

	Percentage (number of participants)
Gender	
Female	68% (71)
Male	32% (33)
Age (years)	
18–19	39% (41)
20–21	32% (33)
22–26	29% (30)
Major college	
Education and Human Development	12% (12)
Engineering	14% (15)
Liberal Arts and Science	27% (28)
Natural Sciences, Forestry and Agriculture	32% (33)
The Maine Business School	9% (9)
Other	6% (6)
Living arrangements	
On campus	52% (54)
Off campus	48% (50)
Total *N*	104

Table 2–Food related behaviors of respondents to the Univ. of Maine Food Safety Knowledge Questionnaire Survey.[a]

Response	Percentage (number of responses)
Self-meal preparation (meals/month)	
0 meals	8% (8)
1–2 meals	18% (19)
3–5 meals	16% (17)
6–10 meals	12% (12)
10 or more meals	46% (48)
Leftover consumption (meals/month)	
0–1 meals	28% (29)
2–5 meals	29% (30)
6–10 meals	25% (26)
10 or more meals	18% (19)
Taken a food safety or food preparation course for college credit	
No	90% (94)
Yes	9% (9)
No response	1% (1)
Exposure to foodborne illness	
No	53% (55)
Yes	26% (27)
Do not know	21% (22)
Importance of food safety[b]	
Important	43% (45)
Not important	48% (50)
No response	9% (9)
Source of food safety information[c]	
Parents	54% (52)
Government agency website (USDA, FDA, etc.)	33% (31)
Internet search	80% (76)
Textbook	14% (13)
Cookbook	51% (48)
I would not know where to look	6% (6)
No response	9% (9)

[a] $N = 104$.
[b] Participants were asked to rank the importance of food safety on a scale of 0 to 10. Responses of 0 to 6 were considered "not important" and 7 to 10 were considered "important."
[c] Participants could select more than one source of information.

on-campus or off-campus. Rank of the importance of food safety on a scale of 0 to 10 was divided into 2 groups: a rank of 0 to 6 was considered unimportant and a rank of 7 to 10 was considered important.

Statistical analyses

Statistical analyses were conducted using Microsoft Excel 2007 and SYSTAT 12 for Windows software (v. 12.00.08, Chicago, Ill., U.S.A.). Descriptive statistics were conducted to determine means and standard deviations. Independent analysis of variance (ANOVA) tests were conducted to determine differences between age, gender, living situation and other demographic criteria, the scores of each of the 5 scales, and the total score of the food safety questionnaire. Chi-square tests were conducted to determine associations between categorical variables. A significance level of $P \leq 0.05$ was used to establish significance.

Results and Discussion

General demographic data

The majority of the participants were between the age of 18 and 21 years (71%) and were female (68%) (Table 1). Almost one-third (32%) of respondents were majors in the College of Natural Sciences, Forestry and Agriculture, which is one of the largest colleges at the Univ. of Maine.

Food related behaviors of participants

Just over half (52%) of participants lived on-campus, but only 8% of participants reported preparing no meals for themselves monthly, suggesting that a majority of participants were engaging in meal preparation (Table 2). A large percentage (72%) of participants was consuming leftovers 2 or more times in a month. It is beyond the scope of this study to determine if the leftovers eaten are the remnants of the self-prepared meals, however this finding does highlight an area of concern since consumption of improperly handled leftovers can be a cause of foodborne illness. Just over half (53%) of participants answered "no" to the question "Have you ever been a victim of food poisoning?" Of the 27 participants who answered that they had been a victim of food poisoning, 80% were unable to identify the bacteria that caused the illness. Figure 1 shows the answers to question 11: "What are the signs and symptoms associated with foodborne illness?" Nearly all participants were able to correctly identify nausea and diarrhea as symptoms of foodborne illness. Symptoms of foodborne illness, such as fever, cramping, and dehydration were correctly identified by at least half of participants in this survey.

Table 2 provides a more detailed explanation of the food-related attitudes and behaviors of participants. Nearly half (46%) of participants reported preparing 10 or more meals for themselves each month, which equates to about 2 to 3 meals each week. Although one limitation to this question is that the term "meal" was never defined in the survey. Therefore, it is possible that some participants considered ready-to-eat meals (that is, microwave dinners) a meal that they prepare themselves. This finding suggests that participants are interested in preparing food, and it is likely that they have some basic food preparation skills. Nearly all (90%) participants had not taken a course on food safety or food preparation for college credit. The 10% of participants who had taken such a course specified the following course titles: FSN 101 Introduction to Food and Nutrition, FSN 103 Science of Food Preparation, FSN 270 World Food Nutrition, FSN 438 Food Microbiology, and FSN 512: Hazard Analysis and Critical Control Points. FSN 103 is a food preparation class, and both FSN 438 and 512 address food safety. Zanjani and others (2006) studied how likely people in different age groups were to change health behaviors (that is, food consumption and food preparation) when diagnosed with a serious health problem. Their findings revealed that young adults (ages 19–42) were more likely to positively change their health behaviors than were older people (Zanjani and others 2006). Just under half of participants (43%) felt that food safety was important to them personally. Based on this research and the Health Belief Model (Rosenstock and others 1988), it is reasonable to infer that

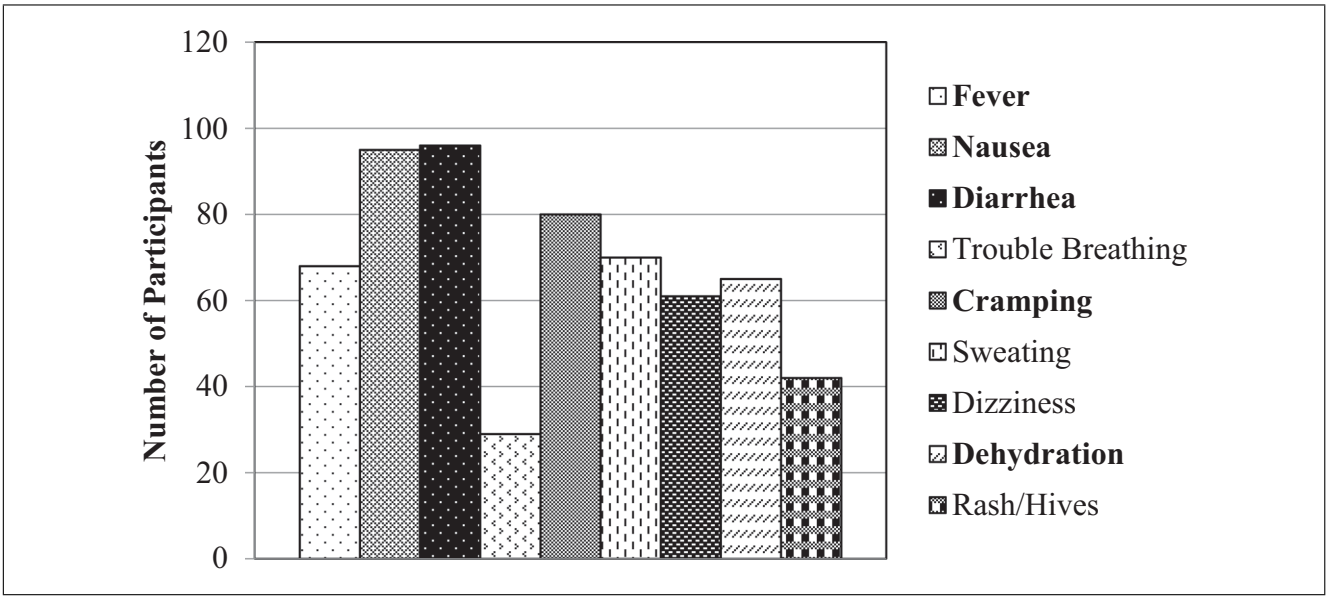

Figure 1–Univ. of Maine undergraduate student responses to the Food Safety Knowledge Questionnaire question "What are the signs and symptoms associated with foodborne illness?"
[a]**Symptoms in boldface indicate correct responses.**

Table 3–Food Safety Knowledge Questionnaire (FSKQ) scores of Univ. of Maine Undergraduate Students.[a]

FSKQ scales[b]	Possible score (points)	Mean score (±SD)	Average % correct responses
Scale 1—cross-contamination prevention/sanitation procedures	0–29	19.9 (±3.2)	67%
Scale 2—safe times/temperatures for cooking/storing food	0–14	7.4 (±3.5)	53%
Scale 3—foods that increase risk of foodborne disease	0–28	15.8 (±4.9)	56%
Scale 4—groups at greatest risk for foodborne disease	0–10	7.3 (±2.1)	73%
Scale 5—common sources of foodborne disease pathogens	0–8	2.5 (±1.6)	31%
Total score	0–89	53 (±11.9)	60%

[a] $N = 104$.
[b] General categories of food safety knowledge (Byrd-Bredbenner and others 2007b).

when participants are interested in a topic, and the topic pertains to them personally, then an intervention program should be well received. Survey responses indicate that 80% of participants would use an "internet search" to find food safety information whereas only 33% would go directly to a government agency website (that is, USDA or FDA). The 2nd most common source (54%) from which participants would obtain food safety information is their own parents. The reliability and accuracy of information obtained from a general internet search and/or a parent may be questionable. This suggests that these participants could use education regarding accurate and reliable sources of food safety information.

Food safety knowledge questionnaire responses

The mean FSKQ total score was 53 points (Table 3), which is a passing score based on the scoring protocol identified by Byrd-Bredbenner and others (2007c). Eighty-six participants answered all 39 FSKQ questions. Eighteen participants skipped at least 1 FSKQ question. Several questions were skipped by participants, and the number of people that skipped any particular question rose toward the end of the survey, which is likely due to the length of the survey and the participant's right to "skip" questions that they may have felt uncomfortable answering. Eleven participants skipped question 28 (Which foods do pregnant women, infants and children need to avoid?), which was the highest number of "skips" of any question in the FSKQ. No one earned a perfect score of 89 points. Eight participants earned scores over 70 points. The highest FSKQ total score earned was 77 points, which was achieved by 2 participants. All 8 of the high-scorers (score >70 points) were females; 6 of them were in the 22–26 age category and lived off-campus. Half of these participants answered "yes" to the question: Have you ever taken a food safety or food preparation course for college credit? Six identified majors within the College of Natural Sciences, Forestry and Agriculture including food science and human nutrition (3), sustainable agriculture (1), biology (1), and marine science (1). Females earned significantly higher FSKQ scores than did males on scale 1 ($P = 0.002$), scale 2 ($P = 0.026$), scale 3 ($P = 0.048$), and total score ($P = 0.007$). There were no significant differences between the scores of males and females on scale 4 and scale 5.

Scale 1—cross-contamination prevention and sanitation procedures

Scale 1 contained questions that required participants to have knowledge of ways to prevent cross-contamination and how to appropriately sanitize food preparation surfaces to prevent foodborne illnesses. Nine of the 11 questions in scale 1 were multiple choice questions and had only 1 correct answer. The responses to the questions in scale 1 indicate that in general, participants were able to identify proper hand washing and dishwashing techniques, knew how to clean a cutting board to prevent cross contamination and were aware of the proper way to bandage a sore when preparing food for others. An observational study of young adults

Table 4–Food Safety Knowledge Questionnaire (FSKQ) scale 1 multiple choice questions and scores of Univ. of Maine FSKQ survey respondents.

Question	% Correct responses (number)	% Incorrect responses (number)
Q14: The best way to keep from getting food poisoning from fresh fruits and vegetables is to wash them with.	52% (54)	48% (50)
Q15: After you have used a cutting board to slice raw meat, chicken, or fish and need to cut other foods, which of these is the best way to prevent food poisoning?	81% (84)	19% (20)
Q16: To prevent food poisoning, the best way to wash dishes is to:	61% (63)	39% (41)
Q17: When should kitchen counters be washed, rinsed, and sanitized?	59% (61)	41% (43)
Q18: Which procedure for cleaning counters is most likely to prevent food poisoning?	35% (36)	65% (68)
Q19: To prevent food poisoning, how often should the kitchen sink drain in your home be sanitized?	33% (34)	67% (70)
Q20: Which is the most hygienic way to wash your hands?	60% (62)	40% (42)
Q21: If you have a sore on the back of your hand, should you prepare food for other people?	63% (66)	37% (38)
Q22: Which should not be done when storing raw meat, fish, or poultry in the refrigerator?	40% (42)	60% (62)

Table 5–Food Safety Knowledge Questionnaire scale 2 multiple choice questions.

Question	% Correct responses (number)	% Incorrect responses (number)
Q25: Which practice is most likely to cause food poisoning?	50% (52)	50% (52)
Q38: When is it safest to place refrigerated foods in your cart when grocery shopping?	65% (68)	35% (36)
Q39: What is the recommended freezer temperature for preventing food poisoning?	20% (21)	80% (83)
Q40: Imagine that your electricity went off and the meat, chicken, and/or seafood in your freezer thawed and felt warm. To prevent food poisoning, what should you do?	64% (67)	36% (37)
Q41: Which of the following is considered the most important ways to prevent food poisoning?	70% (73)	30% (31)
Q42: For ground beef to be safe to eat, it needs to be cooked until its internal temperature reaches:	66% (69)	34% (35)
Q43: What is the maximum temperature refrigerators should be to preserve the safety of foods?	48% (50)	52% (54)
Q44: If a family member is going to be several hours late for a hot meal, how should you store the meal to keep it safe until this person is ready to eat it?	58% (60)	42% (44)
Q45: All foods are considered safe when cooked to an internal temperature of:	54% (56)	46% (48)
Q46: Which method is the most accurate way of determining whether hamburgers are cooked enough to prevent food poisoning?	67% (70)	33% (34)
Q47: Which food does not need to be refrigerated to prevent food poisoning?	79% (82)	21% (22)
Q48: To prevent food poisoning, how long should leftover foods be heated?	35% (36)	65% (68)
Q49: What is the least safe method for thawing a frozen roast?	50% (52)	50% (52)
Q50: What is the safest method for cooling a large pot of hot soup?	17% (18)	83% (86)

found that participants received high scores in the area of kitchen cleanliness (Byrd-Bredbenner and others 2007a). Contrary to the results in that study, this project has identified a knowledge gap in the area of kitchen cleanliness (Table 4). Roughly two-thirds of participants were not able to correctly answer questions 18 and 19 which inquired about proper cleaning and sanitizing kitchen counters and frequency of sanitizing kitchen sinks, respectively. It is likely that these participants are not properly cleaning and sanitizing these areas of the kitchen, which is a risky food behavior as it increases the likelihood of cross-contamination. Another knowledge gap identified within scale 1 involves knowledge of proper cold storage procedures, specifically question 22 "regarding storage of raw meat, fish or poultry in the refrigerator." Sixty percent of participants selected incorrect answers to this question which highlights a need for education surrounding proper storage of potentially hazardous food items. Previous research has also identified improper cold food storage practices within this population (Byrd-Bredbenner and others 2007a). A recent survey of 1504 adults in the United States found that only 17.5% of respondents reported putting raw poultry in a sealed container on the bottom shelf in the refrigerator (Kosa and others 2015).

Scale 2—safe times and temperatures for cooking and storing food

The 2nd scale of the FSKQ presented participants with questions that tested their knowledge of safe cooking temperatures and proper food storage methods. Table 5 contains the questions and percentage of correct and incorrect responses in scale 2. Because the demographic data collected earlier in this survey proved that participants were preparing their own meals and consuming leftovers, the scores on scale 2 can provide some insight as to how safely these participants were carrying out these practices. Just over half of participants (52%) did not know the proper refrigeration temperature and over 3 quarters (80%) of participants were unable to identify the recommended freezer temperature. The findings regarding proper food storage temperatures are expected, as previous research has shown that 90.9% of people 18 to 29 years old do not own a refrigerator thermometer; similarly, only 68.5% of the refrigerators used by this population were found to be at or below the suggested temperature of 40 °F (Kosa and others 2007). Approximately two-thirds of participants were able to identify the appropriate way to determine doneness of a hamburger (67%), and the correct internal temperature of ground beef (66%). How consumers handle and prepare ground beef, specifically burgers, has been previously researched, and it was discovered that thermometers were only used by 4% of consumers (Phang and Bruhn 2011). Therefore, it is likely that participants in this study have knowledge of when food thermometers should be used, but the actual use may be minimal. Another appropriate use of a food thermometer would be to determine if leftover foods had been reheated to an appropriate temperature, 165 °F (USDA 2011). Questions 48 and 50 inquire about the temperature to which leftovers should be reheated and the proper method for cooling a large amount of hot soup, were answered correctly by 35% and 17% of participants, respectively. Seventy-two percent reported consuming leftovers more than twice each month and based on the survey responses to questions 48 and 50, it is likely that these leftovers are not being properly stored or reheated. Improper handling of leftovers is a risky food behavior that can lead to foodborne illness (USDA 2011).

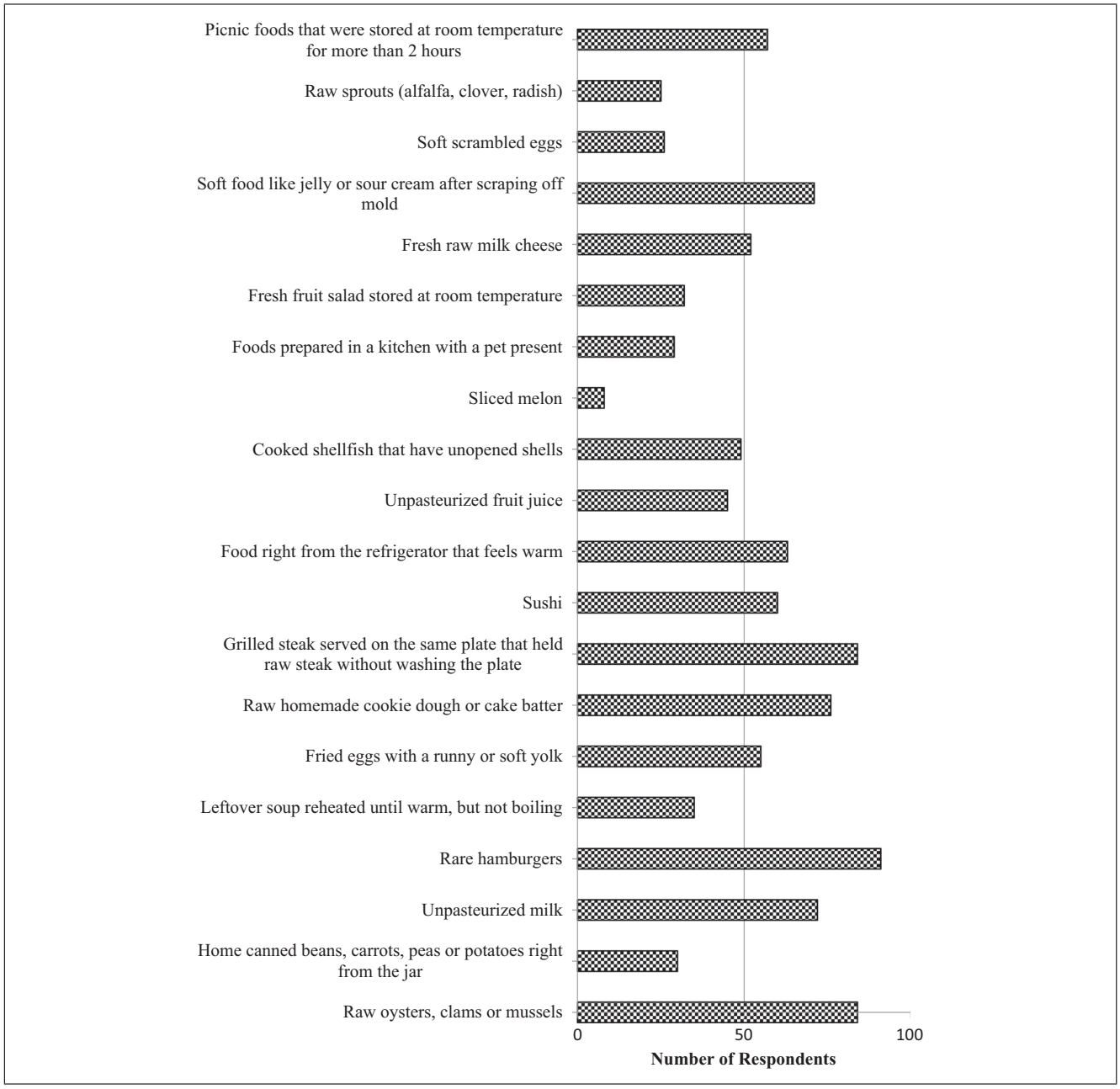

Figure 2–Univ. of Maine undergraduate student responses to the correct answers of Food Safety Knowledge Questionnaire Question 26 regarding risky foods/food behaviors.

Scale 3—foods that increase risk of foodborne disease

Survey question 26 required participants to identify which foods if eaten, would put a person at higher risk for foodborne illness. Figure 2 shows the number of participants responding correctly to the dichotomous answers series. There were no risky foods that were correctly identified by 100% of participants. At least 70% of participants were able to correctly identify foods such as rare hamburgers, raw oysters, mussels or clams, and unpasteurized milk as foods that would increase a person's chance of becoming ill from a foodborne pathogen if one of those food items was consumed. Greater than 70% of participants were also able to correctly identify the behaviors of serving grilled steak on the same plate that held raw steak without washing the plate and consuming soft foods like jelly or sour cream after scraping off mold as behaviors that would increase risk of acquiring foodborne illness. These results indicate that participants are aware of the potential risks associated with consumption of raw animal proteins, unpasteurized dairy products, and behaviors that lead to potential cross-contamination. However, potential risks associated with the consumption of undercooked eggs, improperly processed low-acid, home-canned vegetables, and fresh produce were not as frequently identified by participants. Less than 30% of participants correctly identified consumption of sliced melon, home-canned beans, carrots, peas or potatoes right from the jar, soft scrambled eggs and raw alfalfa, clover or radish sprouts, as high risk foods. Although this survey did not capture data regarding participants' actual consumption of these foods, a previous study of university students indicated that this population does consume foods that

Table 6–Univ. of Maine Undergraduate Student Responses to Food Safety Knowledge Questionnaire Questions in Scale 5: common food sources of foodborne disease pathogens.

Question	% Correct responses (number)	% Incorrect responses (number)	% "Don't Know" responses (number)
Q30: *Salmonella* bacteria can cause food poisoning. How can a food be made safe if it has *Salmonella* in it? ($N = 95$)	67.4% (64)	23.1% (22)	9.5% (9)
Q31: Staph (*Staphylococcus*) bacteria that cause food poisoning are most likely associated with which food? ($N = 96$)	14.6% (14)	49.0% (47)	36.4% (35)
Q32: Botulism is a disease that is most likely associated with which food? ($N = 96$)	30.2% (29)	28.1% (27)	41.7% (40)
Q33: *Listeria* bacteria are most likely associated with which foods? ($N = 96$)	13.5% (13)	29.2% (28)	57.3% (55)
Q34: Harmful *E. coli* bacteria are most likely associated with which food? ($N = 96$)	50.0% (48)	27.1% (26)	22.9% (22)
Q35: Trichinosis is most likely associated with which food? ($N = 95$)	20.0% (19)	21.0% (20)	58.9% (56)
Q36: *Campylobacter* bacteria are most likely associated with which food? ($N = 96$)	10.4% (10)	15.6% (15)	74.0% (71)
Q37: You may contaminate the next food you touch with *Salmonella* bacteria if you do not wash your hands after touching: ($N = 96$)	57.3% (55)	28.1% (27)	14.6% (14)

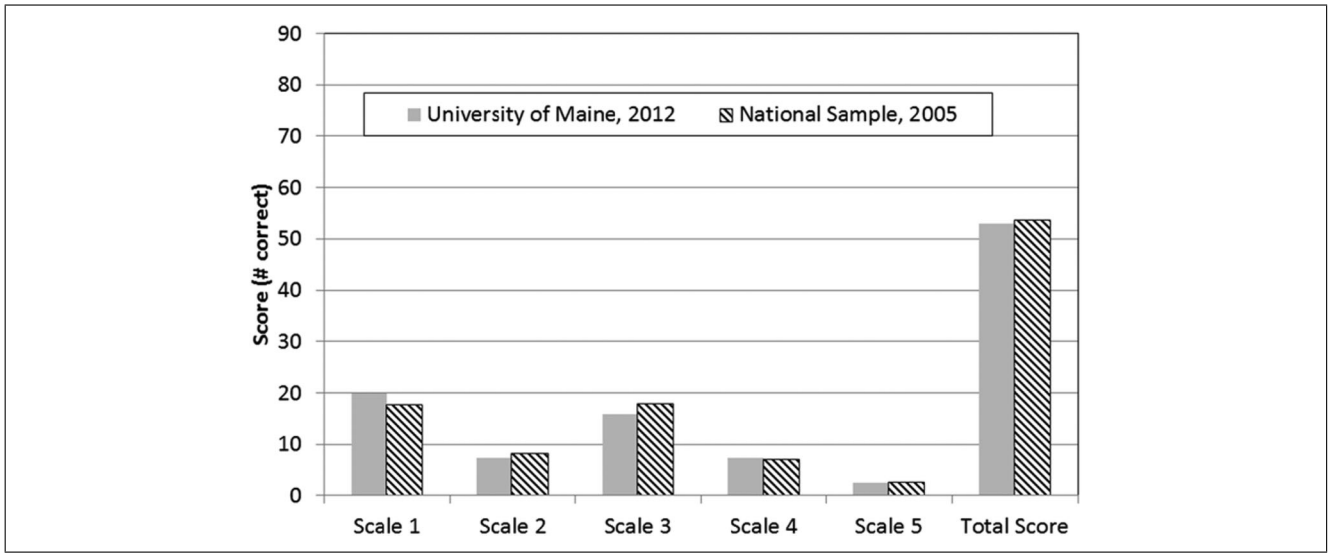

Figure 3–Comparison of Univ. of Maine Food Safety Knowledge Questionnaire results with results from a national survey of college students using the same survey instrument.
[a]Scale 1, cross contamination prevention and sanitation procedures; scale 2, safe times and temperatures for cooking and storing food; scale 3, foods that increase risk of foodborne disease; scale 4, groups at greatest risk for foodborne disease; scale 5, common food sources of foodborne disease pathogens.

increase risk of foodborne illness (Morrone & Rathburn 2003; Byrd-Bredbenner and others 2008).

Scale 4—groups at greatest risk for foodborne disease

Over half of Univ. of Maine survey respondents were able to recognize that someone with diabetes, cancer, or HIV infection should avoid eating raw seafood. Similarly, over 50% of participants were able to identify all of the correct answers to question 29, which inquired about the types of individuals most likely to become ill from foodborne pathogens. Only 39% correctly identified foods that pregnant women, infants, and children did not need to avoid. However, it is also important to note that this question also received the highest occurrence of "skips."

Scale 5—common food sources of foodborne disease pathogens

Scale 5 had the highest mean difficulty index (Byrd-Bredbenner and others 2007c), and in this study, scale 5 had the lowest average percent correct of all 5 scales. Scale 5 contained questions that required participants to have knowledge of the common food sources of foodborne disease pathogens. When the survey was piloted, the answer choice "don't know" accounted for 45% to 72% of participant responses (Byrd-Bredbenner and others 2007b). In this study, the range for "don't know" responses was 9.5% to 74%. Table 6 illustrates the percentage of participants that chose "Don't Know" to the questions in scale 5. Fifty percent of participants were able to identify the association between *Escherichia coli* (*E. coli*) and raw or undercooked beef (question 34). The association between *Salmonella* bacterial species and raw chicken was known by 57.3% of participants (question 37). Food sources of *Clostridium botulinum*, *Listeria monocytogenes*, *Campylobacter jejuni*, *Trichinella* species, and *Staphylococcus aureus* were correctly identified by 30.2%, 13.5%, 10.4%, 18.2%, and 14.6%, respectively. Over 50% of participants indicated they did not know which foods were associated with *Listeria monocytogenes*, *Trichinella* species or *Campylobacter jejuni*; these findings highlight a need for education specifically regarding the food sources of these pathogens. A potential reason for this lack of knowledge may be that foodborne illness education materials rarely discuss specific pathogens.

Identification of needs

The results from this study have similar findings to other food safety surveys administered to university populations (Byrd-Bredbenner and others 2008; Abbot and others 2009). Figure 3 compares results from a national survey (Byrd-Bredbenner and others 2007b) with the results from this survey. The scores

remained relatively similar over a 7-year period, which suggests a similar national trend and possible areas to improve education to college students on proper food handling procedures and food safety. The participants with the highest scores were generally females, between the ages of 22 to 26, living off campus, had taken a food safety or food preparation course for college credit, and had identified a major within the College of Natural Sciences, Forestry and Agriculture. These findings are consistent with previous research; females appeared to be more knowledgeable about food safety, than were males (Redmond & Griffith, 2003), and older students and people who are interested in food safety had higher scores (Yarrow and others 2009).

Even though the majority of participants in this survey stated that using a thermometer is the best way to test for doneness of foods, future research should determine how many Univ. of Maine students own a food thermometer and whether thermometers are used correctly and often. Very few participants were able to identify sliced melon as a risky food, but fresh produce including melon were implicated in foodborne illness outbreaks between 2004 and 2012 in the United States and in Europe (Callejón and others 2015). Furthermore, just as the consumption of fresh fruits and vegetables is encouraged by health professionals, it is important to educate consumers about safe handling of these foods.

An important limitation of this study was that survey respondents chose to participate; students not interested in food safety may have been under-represented in the survey. The relatively small sample size used in this research ($n = 104$) was a subsample of the Univ. of Maine student body as a whole, which is another limitation of this study. The enrollment statistics published by the Univ. of Maine office of institutional Studies at the time of the survey was 11168 students, which includes full-time and part-time undergraduate, graduate, and nondegree seeking students. The sample was adequate and diverse enough to be used as investigative data of food safety knowledge and food-related behaviors among this demographic group. The observations made through this research highlight the food safety knowledge gaps that exist among Univ. of Maine students. Because of the role that these students may play as their own food preparer, their children's or future children's food preparer, and possibly as caregivers for their elderly parents (Morrone and Rathbun 2003), it is important to provide these students with an opportunity to gain this missing knowledge.

Abbot and others (2012) reported that a multimedia food education campaign reached about 90% of students at one northeastern university. A social media site, Facebook, was effective in providing food safety information to undergraduates, but students who attended a lecture in person and participated on Facebook scored higher than did students who used only one form of training (Mayer and Harrison 2012). Future food safety education efforts at the Univ. of Maine will include researchers from the Dept. of Communication and Journalism to develop videos aimed at college students. Targeted recruitment of male students is needed to ascertain food safety knowledge in that student group. Students in their 2nd year of studies may be the most practical group of Univ. of Maine students to educate about food safety because they are required to live on campus, or with parents/guardians. The Univ. of Maine encourages students to live off-campus in the 3rd and subsequent years of study. One approach to increasing food safety knowledge among students would be to develop web-based, interactive games about food safety based on educational videos, and award prizes within sophomore dormitory clusters for high-scores. Incentives would be needed for completion of pre- and posttest FSKQ to evaluate the success of the program. The Univ. of Delaware and Univ. of Maryland, Eastern Shore, are collaborating on an interactive web-based gaming product to increase knowledge of food safety, and assess attitudes about agriculture and the food system (http://canr.udel.edu/anfs/food-investigation/). Another option is the recruitment of local apartment complex managers to hold safe food preparation demonstrations and to provide free food thermometers to all rental units.

Conclusions

Students at the Univ. of Maine demonstrated food safety knowledge comparable to that of a large national survey published several years earlier. The Univ. of Maine students that participated in this study had a good understanding of some aspects of food safety such as identifying groups that are at the greatest risk for foodborne illness, cross-contamination prevention procedures, and foods that increase the risk of contracting a foodborne disease. This population, however, does not appear to have much knowledge regarding the common food sources of foodborne pathogens because scores on scale 5 were low. There seems to be a knowledge gap about the risks associated with fresh produce items. The 1st 2 years on-campus may be an opportune time to educate young adults about safe food handling practices to prepare them for independent living in the latter 2 years of college. Effective food safety education may reduce the risk of foodborne illness in the future.

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