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Food Safety Knowledge and Practices of College Students

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Abstract

Foodborne illness is a serious issue and accounts to numerous hospitalizations and deaths each year. College students are cooking for themselves for the first time and may lack proper food safety knowledge and practices. **Purpose:** to assess the food safety knowledge and practices of college students and to determine the sanitary conditions of kitchen surfaces in college apartments. **Methods:** Approval from the College of Saint Benedict and Saint John's University's Institution Review Board was obtained. Food safety knowledge and practices were assessed with a survey and kitchen inspections. College students (n=287) completed a food safety knowledge survey (FSKS) containing 16 questions administered through a survey link attached to an email. Informed consent was the first page of survey and participants were required to be at least 18 years and older. Kitchen inspections were conducted in apartments of male and female students (n=20). Consent was obtained at the door of participants. An interview of five questions were asked to assess food safety behavior. Answers were recorded. Refrigerator and freezer temperatures were measured with the AVANTEK infrared thermometer. Five kitchen surfaces (kitchen counter, dish sponge, cutting board, refrigerator handle, and sink drain) were swabbed with 3M™ Quick Swabs from each apartment to assess sanitary conditions. Contents from 3M™ Quick Swabs were poured onto 3M™ Petrifilm™ Aerobic Count Plates and incubated for 24 hours at 36°F. SPSS version 24 was used for statistical data analysis to compare results with independent t-test, frequency, one-way ANOVA, and chi-square. **Results:** Participants scored an average FSKS score of 11.7 points (73%). Female participants scored significantly higher compared to male participants ($p < 0.01$). There is a weak correlation between number of nutrition credits and the FSKS scores ($r = 0.160$). Seniors scored significantly higher on the FSKS compared to first year students ($p = 0.046$). Previous and current food service experience did not appear to correlate with FSKS scores. Freezer temperatures were significantly lower among male student apartments compared to female student apartments ($p = 0.001$). A weak relationship was observed between gender and the sanitary conditions of kitchen surfaces ($\chi^2 = 0.045$). The kitchens of the male students had lower bacterial counts compared to the kitchens of female students. The sink drain was the least sanitary kitchen surface with 75% of sink drains having contamination levels above 250 cfu. Thirty percent of participants admitted to never cleaning their sinks. Of the participants who never cleaned their sinks, 50% had sinks with bacterial contamination considered too numerous to count (TNTC). The most sanitary kitchen surface was the cutting board, with 85% of cutting boards having contamination levels between 25-250 cfu. Only ten percent of participants for the kitchen inspections owned thermometers, all of which were males. **Conclusions:** Kitchen inspection revealed that adequate knowledge was not reflected in behaviors. For example, students cannot apply their knowledge of the proper internal cooking temperature for ground beef without owning a thermometer. As an intervention, a food safety handout was made to distribute to students living in apartments next year. Additionally, residential assistants could take the opportunity to educate college students on proper food safety and cleaning to encourage safe food handling practices

Introduction

Foodborne illness causes one in every six people to get sick, 128,000 hospitalizations, and 3,000 deaths each year¹. The main causes to foodborne illnesses are poor food handling practices such as improperly cooking food, cross-contamination, and unsafe storage of food. The Norovirus, or the Norwalk virus, is responsible for the most foodborne illnesses with an estimate of 5,461,731 individuals affected each year¹. Salmonella is a dangerous pathogen and is responsible for the most hospitalizations and deaths each year with approximately 19,336 hospitalized individuals and 378 deaths¹. The groups at greatest risk for foodborne illnesses include children, pregnant women, older adults, and individuals with vulnerable immune systems².

The food safety knowledge and practices of college students are often overlooked because college students are typically not considered a high risk group for foodborne illness. Many college students are cooking for themselves for the first time and may lack proper food safety knowledge. College students are also living on their own and may be unaware of the correct procedures needed to keep cooking environments clean and safe. Only 34.2% of college students scored between 80-100% on one survey and averaged 43% on another survey^{3,4}. Food safety knowledge varies among the genders, with females having better food safety knowledge compared to males^{3,5,6}. Female students score about 7% higher than male students⁵. College students, particularly males, were more likely to engage in risky food behaviors such as the consumption of undercooked hamburgers which could potentially have harmful pathogens like *Escherichia coli*⁷.

There is a lack of research focusing on the sanitary conditions of college student apartments. Research investigating the sanitary conditions of kitchens often is based on appearance rather than the examination of bacteria counts with surface swabs^{8,9}. A surface may appear clean to the naked eye but the amount of bacteria present is unknown which can be dangerous if hazardous pathogens exist on the surface. The most contaminated surfaces are moist surfaces such as dish sponges, dish cloths, and sinks^{10,11}. College students appear to understand and score well on the surveys, but the behaviors and practices demonstrated are different. For example, 85% of college students correctly answered questions pertaining to proper hand washing but only 13.5% reported actually practicing proper hand washing¹². Another shocking example includes 67.3% of participants correctly answering questions regarding the proper separation of raw and cooked food in the refrigerator but only 22.2% reported practicing the method¹³. Approximately 60% of college students do not consider foodborne illness as a personal threat to their health which may explain the food safety behaviors⁸.

Temperature regulation is also an issue for college students^{8,9,12}. Refrigerators should be at or below 40°F and freezers should be at or below 0°F. Mean refrigerator and freezer temperatures among young adults were measured to be 42.9°F and 15.26°F respectively, which are both above the recommended temperature for slowing bacterial growth⁹. About 97% of college students reportedly do not use thermometers to check food readiness⁸, which indicates college students may be using other unreliable methods such as food texture or color to determine food readiness. In addition, approximately only 38.6% of college students practice proper defrosting methods¹².

Understanding food safety knowledge and properly practicing food safety behavior is important in preventing foodborne illness. In addition, another component to food safety is understanding how to clean and keep an environment sanitary which is crucial in controlling cross-contamination. College

students may not be a group at high risk for foodborne illness but are definitely a population lacking food safety knowledge and proper food safety practices. The purpose of the current study was to assess the food safety knowledge and practices of college students and to determine the sanitary conditions of kitchen surfaces in college apartments.

Methods

The College of Saint Benedict and Saint John's University's Institutional Review Board approved the study. The study design consisted of two parts: a food safety knowledge survey (FSKS) and kitchen inspections. The FSKS was sent to the entire study body of the College of Saint Benedict and Saint John's University. The kitchen inspection consisted of 20 kitchens. Refrigerator and freezer temperatures were collected with the AVANTEK infrared thermometer during the kitchen inspection. 3M™ Quick Swabs with 1 ml of sterile broth were used to swab kitchen surfaces and poured onto 3M™ Petrifilm™ Aerobic Count Plates.

The FSKS questions were adapted from a previous published and validated survey and modified after pilot studies¹³. The FSKS was administered using Forms Manager and sent through email with a link. The informed consent was available on the first page of the survey. Participants were required to be 18 years or older to participate. Demographic questions included gender, class rank, major, number of nutrition credits, and previous and current food service experience. The FSKS comprised of 16 questions pertaining to topics such as cross-contamination, temperature control, proper food storage, and sources of foodborne pathogens. The questions were formatted as multiple-choice and true/false. Each question was worth one point with a total of 16 possible points. Participants were able to enter their email address at the end of the survey for a chance to win one of the three \$25 Target gifts cards. Email addresses were not linked with survey scores and remained anonymous. Once the FSKS was closed, a random generator was used to select the three winners with the research advisor.

The second part of the study was the kitchen inspection. Pilot studies were conducted on various kitchen surfaces to determine the final five kitchen surfaces which included knives, refrigerator handles, cutting boards, dish sponges, kitchen counters, dish rags, sink drains, cutting board before and after wash, and various refrigerator compartments. Five kitchen surfaces were ultimately chosen to be swabbed which included kitchen counters, refrigerator handles, dish sponges, sink drains, and cutting boards. Recruitment was done door-to-door in the junior and senior student apartments. Juniors and seniors live in three areas on campus thus recruitment was conducted in all areas for variation (ex. three kitchens from the West apartments, three from the East apartments, and 4 from Centennial Commons). The female student apartments were inspected on the first day while the male student apartments were inspected the following day.

The study was explained to the participants prior to the kitchen inspection and if participants agreed to partake, an interview was conducted. The interview contained a series of five questions to assess food safety habits and behavior. Questions included, "How do you thaw meat?", "How do you clean your sink? How often?", "How do you clean your dish sponge? How often?", "How do you clean your kitchen counter?" How often?", and "Do you own a food thermometer?" Oral responses were recorded. Refrigerator and freezer temperatures were also measured with the AVANTEK infrared thermometer. Each kitchen was assigned a number, which was used to label photos, 3M™ Quick Swabs,

and 3M™ Petrifilm™ Aerobic Count Plates. Labeled 3M™ Quick Swabs were used to swab surfaces and poured onto 3M™ Petrifilm™ Aerobic Count Plates. The 3M™ Petrifilm™ Aerobic Count Plates were incubated for 24 hours at 36°F. Contact information was provided for participants to obtain results of kitchen inspection and general food safety information. Participants were also able to write their name and email address down on a slip of paper for a chance at winning a \$25 Target gift card. The slips of paper were sealed into an envelope and not opened until all kitchens were inspected. The winner of the \$25 Target gift card was determined through a lottery drawing with the research advisor.

The results from the survey and kitchen inspections were analyzed using SPSS version 24. Descriptive statistic was used for demographics and food safety survey scores. Additional tests used to compare food safety knowledge scores with demographics included independent t-test, frequency, and one-way ANOVA while the kitchen inspection used independent t-test, frequency, and chi-square.

Results

Survey

A total of 287 participants completed the FSKS with females (58%) having a higher response rate compared to males (42%) (Table 1). The FSKS consisted of 16 questions with 16 possible points. The average score was 11.7 ± 2.2 (73%). Female students performed significantly better on the FSKS with an average of 76% while male students scored an average of 69% ($p < 0.05$). Only 1.7% of the 287 received perfect scores on the survey.

Table 1. Demographics of survey participants (n=287)

Demographic	Study Population, <i>n</i> (%)
Gender	
Male	121 (42%)
Female	166 (58%)
Majors	
Common Curriculum	0 (0%)
Fine Arts	5 (2%)
Humanities	33 (11%)
Natural Science	152 (53%)
Social Science	89 (27%)
Interdisciplinary and Pre-Professional Programs	8 (3%)
Class cohort	
Freshmen	64 (22%)
Sophomore	66 (23%)
Junior	59 (21%)
Senior	98 (34%)
Previous food service experience	
Yes	189 (66%)
No	98 (34%)

Current food service job	
Yes	48 (17%)
No	239 (83%)

FSKS scores were not significantly different between the class cohorts with the use of one-way ANOVA ($p>0.05$), however, FSKS scores were significantly different between first years and seniors ($p=0.046$) with an independent t-test. Majors and previous/current food experience did not correlate with FSKS scores ($p>0.05$). A weak correlation was observed between the number of nutrition credits and FSKS scores ($r=0.160$) (Fig.1). The question most missed among all participants emphasized the safe handling of leftover foods; only 19% of students were able to correctly answer the question. Students knew more about the food source associated with *Escherichia coli* than *Salmonella* (Fig.2).

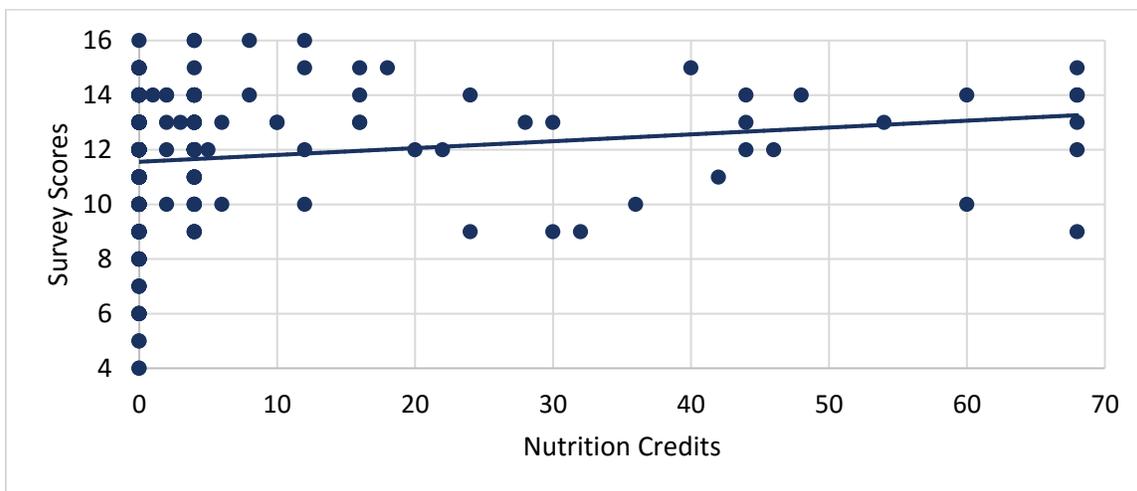


Figure 1. Correlation of nutrition credits and FSKS scores ($n=287$, $r=0.160$, $p=0.007$).

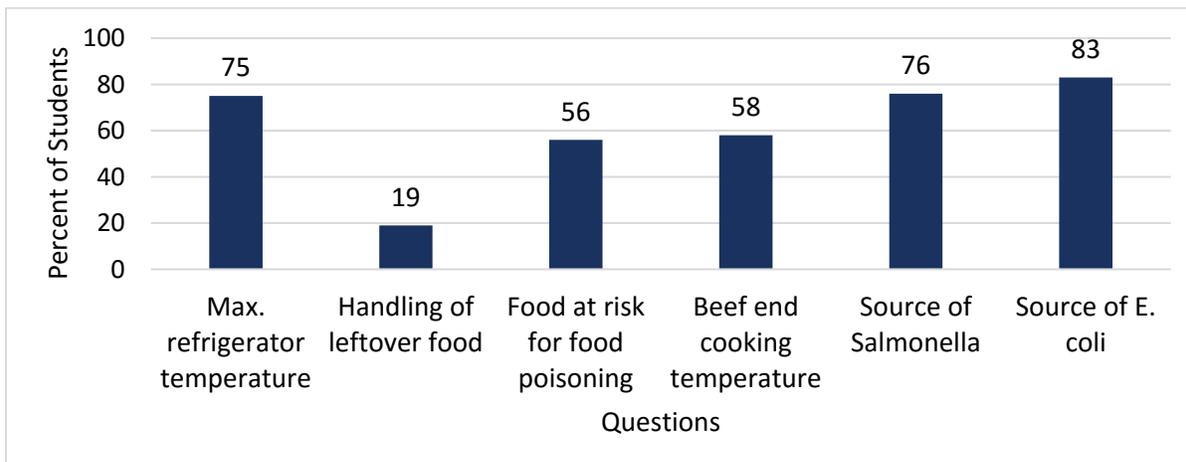


Figure 2. Percentage of students correctly answering FSKS questions

Kitchen Inspection

Refrigerator temperatures were not significantly different between male and female student apartments, but freezer temperatures were significantly lower in male student apartments ($p=0.001$) (Fig.3). Only two out of the 20 apartments inspected had food thermometers, both of which were male student apartments. When asked how students thaw meat, 35% thaw meat in the fridge and 20% thaw meat on the counter (Fig.4)

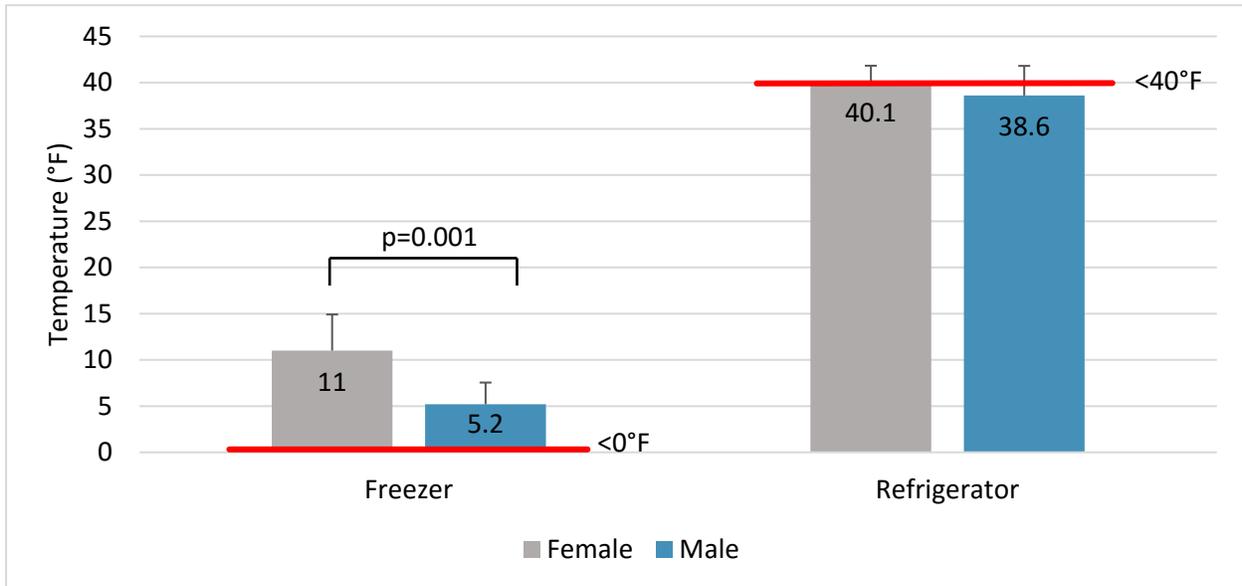


Figure 3. Comparison of freezer and refrigerator temperatures between male and female student apartments. Red lines indicate recommended temperatures for freezers and refrigerators.

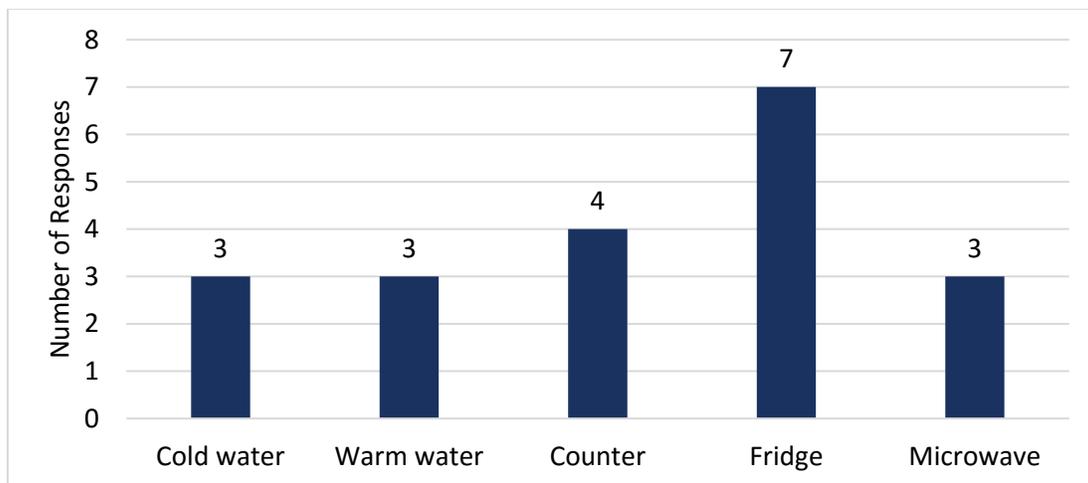


Figure 4. Methods of thawing meat.

There is a weak relationship between gender and sanitary conditions of kitchen surfaces. Male student apartments had less contaminated kitchens compared to female student apartments. Approximately 58% of female student kitchen surfaces and 38% of males' had contamination levels above 250 cfu (the max. acceptable level).

The sink drain was the most contaminated kitchen surface with 75% having contamination levels above 250 cfu (Fig.5). About 30% of students admitted to never cleaning their sinks (Fig.6) and of those, half of the sinks were contaminated with levels considered too numerous to count (TNTC). Only 20% reported using disinfectant to clean their sinks. The cutting board was the least contaminated kitchen surface with 85% of cutting boards having contamination levels between 25-250 cfu (the acceptable level).



Figure 5. Kitchen sinks

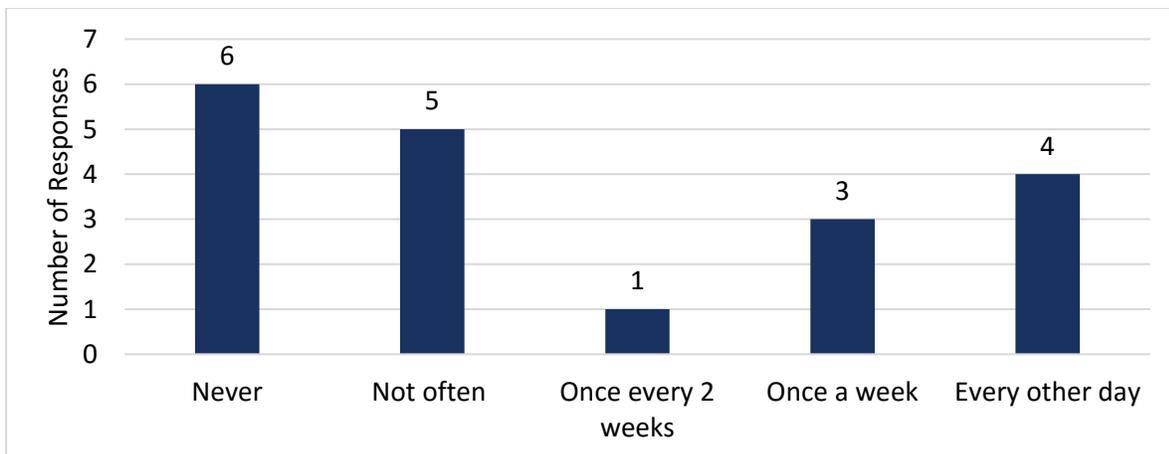


Figure 6. Frequency of cleaning for sink.

The kitchen counters were cleaned more often compared to the sinks (Fig.7), however 55% of kitchen counters were above 250 cfu. The majority of students cleaned their kitchen counters with disinfectant (Table 2). About 35% of student never clean their sponges. Some students responded to replacing their dish sponge once it “gets nasty” or “gets flat and starts to disintegrate”.

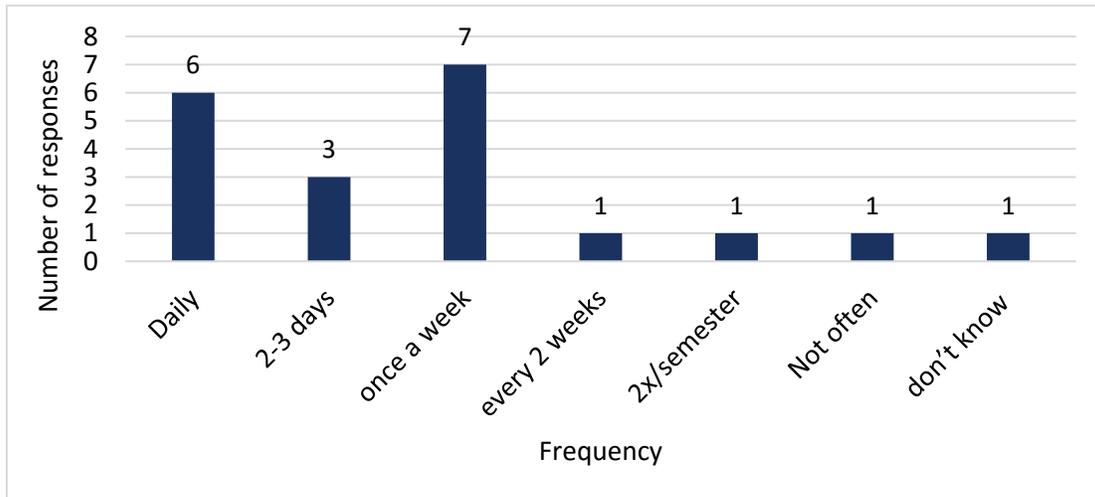


Figure 7. Frequency of cleaning for kitchen counters

Table 2. Methods and response rates in cleaning kitchen counters

Method of cleaning kitchen counter	Frequency
Disinfectant	10 (50%)
Dish rag with soap	4 (20%)
Dish rag with water	1 (5%)
Dish rag	2 (10%)
Sponge	1 (5%)
Water	1 (5%)
Just wipe it	1 (5%)

Discussion

The average score from the current study was 73%, which is higher compared to scores from other published research^{4,5}. Multiple choice format was used for the FSKS questions in the current study in an attempt to increase the response rate of students. However, students could use the process of elimination to perhaps guess the correct answers. Natural science majors were expected to perform

better on the FSKS because food safety is taught in science courses (mainly nutrition and microbiology), but academic majors did not statistically correlate with FSKS scores. The research is mixed regarding whether students in certain academic majors performed better on food safety surveys^{4,12,14}. The College of Saint Benedict and Saint John's University requires each student take a natural science course. Approximately 38% of students in introductory nutrition courses are non-nutrition majors which may explain where the non-nutrition majors learned food safety. Surprisingly, 53% of the students with zero nutrition credits scored above average on the FSKS. Previous and current food service experience also did not correlate with FSKS scores. Students' performance on the FSKS could be a reflection of their training at work. Students may have only been trained on specific job tasks rather than receiving proper food safety training.

Questions pertaining to food sources of various pathogens were hypothesized to be the most difficult questions for college student to answer⁴. However, students in the current study were able to correctly identify food sources of *Escherichia coli* (83%) and *Salmonella* (76%). The question most missed by students was how to handle leftover foods which included "all of the above" as an answer option. Many students may have not read all the answers thoroughly and opted for the "all of the above" choice, which was the most selected response.

Students (74.6%) correctly answered questions regarding the appropriate temperatures for refrigerators and freezers. The average refrigerator and freezer temperatures were 39.3°F and 8.1°F which are slightly better compared to the data from a population of young adults with temperatures of 42.9°F and 15.3°F⁹. Temperatures overall were lower for the freezers and refrigerators from the male apartments compared to the females'; however, only the freezer temperatures were statistically different. Better temperatures for the male refrigerators appear to be due to less grocery shopping, less food in the refrigerator improving air flow around food, and reduced cold air loss due to less use [door opening]. Although males had lower freezer temperatures than females, both exceeded the recommendation (0°F). Refrigerator temperatures met the recommendation of 40°F or less in both male and female kitchens. Students commented that upon arrival to moving in, refrigerators and freezers were set and never changed. Not one apartment owned a refrigerator or freezer thermometer; consequently students are not aware of the temperatures of their refrigerators and freezers. Food stored in refrigerators and freezers above the recommended temperatures could potentially allow for the growth of dangerous pathogens.

Approximately 58% of students could identify the proper end cooking temperature for ground beef but only 10%, all of whom were male, owned a food thermometer. Similarly, only 7% of all participants had food thermometers (mostly females) in another similar college population⁹. Even when thermometers were available, 97% of college students do not use the thermometers to measure end cooking temperature⁸. College students may own thermometers, but owning does not guarantee use. The only reliable way to determine food readiness is by confirming end cooking temperature with the use of a thermometer which means college students are determining food readiness by either color or texture. Students were asked what methods were used to thaw meat during the kitchen inspection. The majority of students responded to thawing meat in the fridge (75%) which is a correct method. However, 20% of students responded to thawing meat on the kitchen counter which is incorrect. This is not surprising, given only 38.6% of college students defrosted their frozen food using correct techniques in a previous study¹².

Female participants scored higher on kitchen cleanliness compared to males⁹, however in the current study, the surfaces in the male student apartments were less contaminated than the females'. Conversations with the male students during the kitchen inspection revealed many did not cook often and therefore are less likely to contaminate surfaces.

The sink drains and dish sponges were the most contaminated surfaces perhaps due to the moist nature which allows for bacteria to grow rapidly. The results from this research is similar to another study which demonstrated the kitchen drain and the sponge as the two surfaces with the highest median count of bacteria¹¹. High contamination levels of the sink drains were due to 30% of students never cleaning their sinks. Only 25% of students who claim to clean their sinks regularly, had acceptable levels of counts. In addition, approximately 20% of students reported using disinfectant to clean their sinks but only half had acceptable levels. Although students claim to clean their sinks regularly, the results indicate the need for improvement. The high contamination levels of the sink drain may be due to when student last cleaned their sinks or prepared and cooked a meal prior to the kitchen inspection.

Roughly 35% of students do not clean their sponges regularly and 25% do not replace them until after 3 to 4 weeks which may cause cross contamination. Previous research indicated 62% of the dish sponges in the kitchens of young adults were clean based on appearance¹². Thirty percent of kitchen counters are cleaned daily however 55% of the surfaces were above the acceptable level. Students may be using incorrect methods to clean the kitchen counters such as simply wiping with contaminated dish towels and dish sponges.

A limitation of this study was using multiple choice questions in the FSKS. The use of open ended questions may have been more beneficial in revealing true knowledge. Additionally, questions regarding the last time students cooked or cleaned their kitchens prior to the kitchen inspections may have explained the results. Lastly, 3M™ Petrifilm™ Aerobic Count Plates were used to only assess the number of aerobic bacteria rather than the type of bacteria. Not knowing the type bacteria present on what surface prevents us from determining how threatening the contamination is to students. Only a few bacteria are required to cause foodborne illness. Although male students have lower counts on kitchen surfaces, the bacteria present could be extremely pathogenic. Future research should include using 3M™ Petrifilm™ Staph Express Count Plates and 3M™ Petrifilm™ Salmonella Express Plates to assess bacteria such as *Salmonella* and *Staphylococcus aureus*.

The average score on the FSKS was satisfactory but the kitchen inspections revealed that knowledge was not reflected in behaviors. Without thermometers for checking end cooking temperatures and refrigerator/freezer temperatures, students cannot apply their knowledge. Residential assistants could educate college students on proper food safety and cleaning to encourage safe food handling practices as well as periodically checking refrigerators and freezers temperatures. Additionally, a food safety handout was created after the study for students living on campus next year. A residential area coordinator as well as the health promotion assistant director and programmer were contacted to distribute the food safety handouts.

Acknowledgements

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