Characterization of Food Safety Knowledge, Attitudes, and Behaviors of Adolescents in East Tennessee

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ABSTRACT

Educational interventions can improve food safety knowledge and behaviors when closely aligned with specific needs of target groups. Identifying the needs of adolescents is important because they are under-studied and adolescence is an ideal time to establish life-long behaviors.

The purpose of this study was to estimate food-safety knowledge and behaviors of 7th grade students in East Tennessee and determine relationships between knowledge, behaviors, and specific demographic characteristics. A survey assessing food safety knowledge and behaviors was administered to 232 students in 12 schools through a weighted, stratified, random sample. A hierarchical model was used to obtain least squares means.

Results indicated significant disconnects between knowledge and reported food-handling behaviors. No statistical difference was found in food safety knowledge for any of the demographics except race, in that Asian/Pacific students scored lower (P = 0.0005). Males (P = 0.0134) and Asian/Pacific students (P = 0.0034) reported riskier food-handling behaviors.

Handwashing and use of proper time-temperature conditions, as well as differences in behavior within gender and some ethnic groups, should be focal points in adolescent food safety education. With limited food handling experience and relatively little impact of demographic factors, dissemination of knowledge and development of safe behaviors through adolescent education may prove successful in improving consumer food safety.
INTRODUCTION

It has been estimated that more than 20% of foodborne illnesses may occur because of food-handling errors by consumers (17). Several studies have emphasized the importance of the consumer as the “final line of defense” in the prevention of foodborne illness because they comprise the final step in the food preparation process (9, 20, 30). Concern about the consumer's role in food protection has increased attention to food safety education. As a result, the Healthy People 2010 initiative, which reports that 71% of meals and 78% of snacks are prepared by consumers, has identified increasing the proportion of consumers who follow key food safety practices as one of its seven food safety objectives (8). This emphasis on improving consumer food safety practices has prompted considerable research in food safety education interventions focused on consumer knowledge and behaviors.

Researchers suggest that for effective food safety education and risk communication to encourage safe food-handling practices, behavioral differences between various subpopulations must be understood (15). Several studies have found that food-handling practices differ by gender, ethnicity, age, income, and other demographic characteristics (2, 13, 19). Overall, studies find that safer food practices are reported by women than men (4, 13, 14, 18). While results of differences among ethnic groups between studies have varied greatly, overall, research suggests that race may play some role in determining food safety knowledge and behaviors of consumers (17, 21, 24, 27). Several studies have reported an inverse relationship between safe food-handling behaviors and education, with the most highly educated consumers engaging in the riskiest behaviors, especially with regard to consumption of adequately cooked meats (13, 14, 19, 22, 24). Some researchers have observed the relationship of food safety knowledge, attitudes, and behaviors to socioeconomic status or income levels of consumers. Many studies have found that high-income adults (> $50,000 annual household income) reported greater consumption of unsafe foods, less knowledge of hygiene, and greater likelihood of engaging in cross-contamination practices (13, 14, 19, 29). The effect of geographic location of residence on food-safety knowledge and behaviors has received little attention in research. Patil et al. (19) found that individuals residing in metropolitan areas or cities reported the highest consumption of raw or undercooked ground beef and that use of preventive cross-contamination practices was poorest in the rural mountain area. Other studies report that consumers from urban areas tend to have lower food safety knowledge scores than those from rural areas (1, 24).

The association of frequent food preparation and gender with safe practices suggests that food-handling skills may be acquired through factors related to training, experience preparing food, or maturation (25). Many studies found that unsafe practices were reported more often by adults 18 to 29 years of age, particularly with regard to implementation of preventive cross-contamination practices (2, 14, 19, 22). Interestingly, Altekruse et al. (2) reported that while safe practices did increase with age, knowledge of food hygiene practices did not. The disparity between knowledge and self-reported practices may relate to food-handling experience, which may be lacking in young adults (25).

Throughout food safety knowledge and behavior research, no demographic group consistently outperformed another in every food-handling practice. Overall, food safety behavior differences among gender, race, socioeconomic level, and other demographic characteristics do exist and can be helpful in tailoring education and risk communication efforts to target groups.

Recently, studies have begun to focus on young adults, mostly college or high school students. Many of the same gaps in knowledge and disconnects between behaviors that are found with adult consumers in the areas of good hygiene, adequate cooking, and preventive cross-contamination practices were found among young consumers (5, 10, 26). These studies concluded that some exposure to food safety or experience in food-handling practices may lead to increased safer behaviors. Also, research with college students reveals that some of the differences among demographic groups with adult consumers have already been established by the college years.

Despite a consensus in the public health community that learning safe food-handling habits at an early age benefits health in the short and long term, many adolescents (fifth to eighth grade) have not received adequate education on the topic of food safety (3, 28). Some researchers contend that with increased contamination of food with pathogenic microbes (5) and changes in eating habits of Americans, today's youth are more at risk of experiencing a foodborne illness than previous generations (7). Adolescents are targeted for food safety educational research because many have begun or will soon begin preparing meals or working in food service, and they are currently an understudied population in food safety knowledge and behaviors. Richards et al. (21) suggest that middle school is an ideal time to teach food safety, because adolescents are in the process of establishing life-long behaviors and, therefore, are more likely to synthesize new food safety knowledge in a way that will lead to the development of safer life-long behaviors.

Effective educational interventions for adolescents can lead to improved food safety habits, but the success of these interventions depends upon alignment of educational strategies with specific needs of the targeted demographic group. Research suggests that without baseline data, it is difficult to develop and implement effective education efforts (6). Constructing a baseline of food safety knowledge, attitudes, and behaviors for various demographic groups is vital for determining the specific educational strategies that will motivate adolescents to practice safer food-handling.

The objectives of this study were to: (1) develop a rigorous statistical sampling method to allow for the collection of data on the food safety knowledge, attitudes, and behaviors of seventh grade students in East Tennessee; (2) analyze that data to construct a baseline and identify gaps in food-safety knowledge, attitudes, and behaviors; and (3) ascertain the relationship of variables such as geographic location, socioeconomic status (SES), gender, and food-handling experience with food-safety knowledge, attitudes, and behaviors.
MATERIALS AND METHODS

Study design

Participants in the study were seventh grade students attending East Tennessee schools chosen through a proportionally weighted, random sample stratified by US Census Bureau Standard Metropolitan Areas (SMA) classification of the county in which the school is located. The 2006 SMA Data Book describes the general concept of a Metropolitan or Micropolitan statistical area as "a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core" (27). Counties that were not defined by this method were assigned the classification "Other". Within the Metropolitan area classification, counties were further stratified by the principal city (Knoxville, Chattanooga, or Tri-Cities) to ensure a proportionally weighted sample according to percentage of students in that area. The random number generator command in Microsoft Excel was used to randomly select a total of 15 schools (7 Metropolitan, 4 Micropolitan, and 4 schools from the Other SMA) from the possible 193 East Tennessee schools that housed a seventh grade to contact for participation. A minimum of three schools per SMA was required to ensure replication within the sample. The rigor of this methodology allowed the results to be generalized to the entire seventh grade population in East Tennessee (24,701 students).

Questionnaire development

The study instrument, administered as a 40 item questionnaire assessing food-safety knowledge, attitudes and behaviors, was adapted from an instrument developed and validated as part of a larger research project (21). This survey consisted of 20 multiple-choice knowledge questions and 13 true/false and nine Likert-scale (1- Never, 4- Always) questions assessing attitudes and behavior. Assessment items were written to measure specific food-safety learning objectives that were appropriate for adolescent learners. These learning objectives were identified by the Tennessee Food Safety Task Force and a panel of food safety and microbiology experts from the University of Tennessee's Department of Food Science and Technology. The instrument was evaluated by an independent testing expert and field tested for reliability and validity (α = 0.868) prior to its use by a group of similar seventh grade students at a middle school not selected in this study. A five item demographic questionnaire assessing gender, race, and food-handling experience was administered concurrently. (See Appendix 1 for a copy of the assessment.)

Participation and data collection

Access to study participants was gained through the support and cooperation of administrators and teachers of participating schools. Approval from the Institutional Review Board (IRB) for research with human subjects was
APPENDIX I

Directions: Read each of the following statements or questions below and choose the BEST answer from the given. Fill in the matching bubble on your answer sheet.

1) Which of the following is NOT true about bacteria?
   a) They are microscopic.  
   b) They are made up of only one cell.  
   c) They can be found on most surfaces.  
   d) All bacteria make you sick.

2) When bacteria grow they:
   a) Grow in size from an infant to adult.  
   b) Grow in number, not in size.  
   c) Require more and more food to grow larger.  
   d) Eventually get too big and die.

3) How do bacteria get the nutrients they need to survive?
   a) Some make their own energy from the sun.  
   b) Some scavenge from environment around them.  
   c) Some attach to other living things.  
   d) All of these are true.

4) A pathogen is:
   a) A bacterium that helps in digestion.  
   b) A bacterium used to make pepperoni.  
   c) A bacterium that can make you sick.  
   d) A bacterium used to make medicines.

5) All of the following are pathogens EXCEPT:
   a) Salmonella  
   b) Lactobacillus  
   c) E coli O157:H7  
   d) Listeria

6) Which of the following is NOT made using helpful bacteria?
   a) Pickles  
   b) Eggs  
   c) Pepperoni  
   d) Sauerkraut

7) The MOST IMPORTANT thing you can do to keep from getting sick from a pathogen is to:
   a) Refrigerate leftovers.  
   b) Wash your hands.  
   c) Frequently wipe kitchen surfaces.  
   d) Use a hand sanitizer.

8) Which is the BEST example of cross-contamination?
   a) Not reheating food properly.  
   b) Leaving food out at room temperature for too long.  
   c) Using the same knife to cut raw chicken and vegetables.  
   d) None of the above.

9) Leftover foods should be refrigerated within:
   a) 30 minutes  
   b) 1 hour  
   c) 2 hours  
   d) 3 hours

10) Bacteria grow most rapidly in temperatures of:
    a) At zero degrees.  
    b) Below 40 degrees.  
    c) Above 140 degrees.  
    d) Between 40–140 degrees.

11) The safest way to tell if a hamburger is cooked to the proper temperature is to:
    a) Use a food thermometer.  
    b) Check to see if the inside is still pink.  
    c) Burn the outside of the burger.  
    d) None of the above.

12) Which of the following is a possible outcome of not handling food properly?
    a) Getting sick and requiring medical attention.  
    b) Not getting sick at all.  
    c) Getting sick for a few days and then feeling better.  
    d) All of these are possible outcomes.

13) It is okay to eat raw cookie dough:
    a) Anytime. Raw eggs won’t hurt you.  
    b) Only if the cookie dough is store bought.  
    c) Only if it is homemade dough.  
    d) Never. Raw eggs in the dough put you at risk for salmonellosis.
14) The safest way to defrost frozen meat is to:
   a) Set it out on the counter.  
   b) Place it in the refrigerator.  
   c) Cook it while it is frozen.  
   d) None of the above.

15) To make sure that your ground beef is safe to eat, it should be cooked to an internal temperature of
   a) 160°F  
   b) 180°F  
   c) 200°F  
   d) 212°F

16) A foodborne illness is
   a) Any illness humans get from food.  
   b) An illness you are born with.  
   c) Only preventable with a vaccine.  
   d) An illness that cannot be passed from one person to another.

17) Which of the following can cause a foodborne illness?
   a) Bacteria  
   b) Viruses  
   c) Parasites  
   d) None of the above

18) Which of the following is NOT a common symptom of foodborne illnesses?
   a) Chest pains  
   b) Diarrhea  
   c) Vomiting  
   d) Headache

19) You should wash your hands
   a) After using the bathroom.  
   b) Before handling food.  
   c) More frequently when someone around you is sick.  
   d) All of these are true.

20) Which of the following does NOT need to be done in order to avoid foodborne illnesses?
   a) Make sure that all food is thoroughly cooked.  
   b) Throw away all leftovers.  
   c) Refrigerate all leftovers immediately.  
   d) All of these are true.

For the following statements:

Fill in Bubble “A” if the statement is TRUE.

Fill in Bubble “B” if the statement is FALSE.

21) It is possible to wash my hands thoroughly using only water.
   A  B

22) When preparing food, it is okay to use the same surfaces (cutting board, counter top) and utensils for meats and vegetables.
   A  B

23) It is okay to eat pizza that has been sitting out on the counter all night as long as I warm it up first.
   A  B

24) Most people go to the doctor when they get food poisoning.
   A  B

25) More people are hospitalized each year with food poisoning than with the flu.
   A  B

26) Almost all food-poisonings are preventable.
   A  B

27) If I clean a surface with soap and water, it will kill all the bacteria.
   A  B

28) Bacteria cannot grow in food stored in a refrigerator.
   A  B

29) There may be bacteria in my food that can make me sick if my food is not handled correctly.
   A  B

30) All bacteria can make me sick.
   A  B

31) To prevent cross-contamination, it is important to keep raw meat, poultry, and seafood away from other foods in the grocery cart and refrigerator.
   A  B

For the following statements, fill in the bubble of the choice that applies most often.

A – The statement is never true.
B – The statement is rarely true.
C – The statement is sometimes true.
D – The statement is always true.

32) I feel that I know how to correctly handle my food so that I do not become sick.
   A  B  C  D

33) When preparing food, I carefully follow temperature and time directions on the food packaging labels.
   A  B  C  D
34) If necessary, I could properly handle a variety of meats and vegetables to prepare a safe meal for my family.

35) I wash my hands before preparing or eating food.

36) When I see an adult handling food improperly, I point out her or his mistakes.

37) I can identify foods that have a higher risk of making me sick.

38) I use hand sanitizer to clean my hands.

39) I wash my hands after each time I use the restroom.

40) I can recognize the most common symptoms of food poisoning.

41) What is your gender?
   a) Female
   b) Male

42) What is your race?
   a) African American
   b) Asian/Pacific
   c) Caucasian
   d) Hispanic
   e) Native American

43) What types of food do you prepare?
   a) I don’t prepare any type of food
   b) Snacks only
   c) Snacks and meals

44) How many meals or snacks do you prepare in a week?
   a) 0 to 5
   b) 6 to 10
   c) More than 10 meals or snacks

45) How many times does your family eat at a restaurant or fast food during a week?
   a) More than 10 times
   b) 4 to 10
   c) 0 to 3

Thank you for participating in this Survey!

also obtained. Informed consent/assent letters were given to students and their parents or guardians to determine participation. All surveys were prepared by the investigator and shipped to the sites to reduce the likelihood of misadministration. Teachers at the test site collected all consent forms from participating students in their classrooms, administered the 20–25 minute survey, and shipped the completed surveys directly to the investigator. As incentives for participation, students received a pencil and coupon donated by a local food company and, in some cases, extra credit.

Data analyses

Surveys were scored by the University of Tennessee Office of Information and Technology Test Scoring and Scoring department. Individual student assessment scores were considered outliers and removed from the data set under the following conditions: (1) the entire assessment was not finished, or (2) student responses were “offline” on the scantron sheet, giving too few or too many answers on the answer form.

Item analyses by question were completed by aggregating and sorting data in Microsoft Excel to describe the participants’ responses and determine baseline knowledge and attitudes/behaviors for food-safety measures in this survey. All statistical analyses were completed using SAS (version 9.1, Cary, NC). The study participants were characterized by gender, race, socioeconomic status (SES), geographic location of residence, and food-handling experience, using the frequency procedure. Contingency table analysis with the exact test was used to determine significant differences in food-safety knowledge or attitudes/behaviors between genders.

Mean knowledge scores were obtained by totaling the 20 knowledge questions as correct, while attitude/behavior mean scores were determined by adding the 11 true/false and nine Likert scale (never, rarely, sometimes, always) behaviors for each subject. The knowledge and true/false questions were scored 1 point for an correct answer and 0 points for an incorrect answer. The Likert scale questions were given 1 point for never, 2 points for rarely, 3 points for sometimes, and 4 points for always. Total knowledge and attitudes and behavior scores were normalized to 100, with a possible range of scores of 0 to 100. A hierarchical model with geographic location (SMA) and SES at the school level and gender and race at the student level was used to obtain least squares means to measure the relationships of these demographic variables with food-safety knowledge or attitudes/behaviors total scores of adolescents in this study. Differences of least squares means by the demographic variables were obtained using Tukey-Kramer’s mean separation adjustment for significance (23).
<table>
<thead>
<tr>
<th>School</th>
<th>District</th>
<th>Geographic area</th>
<th>SES level</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bradley</td>
<td>Metro-Chattanooga</td>
<td>39.3</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Polk</td>
<td>Metro-Chattanooga</td>
<td>66.0</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Washington</td>
<td>Metro-Tri-Cities</td>
<td>57.0</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>Carter</td>
<td>Metro-Tri-Cities</td>
<td>57.6</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Lenoir City</td>
<td>Metro-Knoxville</td>
<td>63.3</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Knox</td>
<td>Metro-Knoxville</td>
<td>25.3</td>
<td>36</td>
</tr>
<tr>
<td>7</td>
<td>Newport</td>
<td>Micropolitan</td>
<td>41.1</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>Greene</td>
<td>Micropolitan</td>
<td>43.8</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>Cocke</td>
<td>Micropolitan</td>
<td>99.3</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>Scott</td>
<td>Other</td>
<td>97.8</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>Morgan</td>
<td>Other</td>
<td>48.6</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>Monroe</td>
<td>Other</td>
<td>69.8</td>
<td>16</td>
</tr>
</tbody>
</table>

*District is designated by the Tennessee Department of Education.*  
*Geographic area is based on US Census Bureau Standard Metropolitan Areas classification.*  
*SES (socioeconomic status) level represents the percentage of students in that school who are economically disadvantaged (i.e., eligible for the free and reduced lunch program).*  
*Sample size refers to the number of students in that school who participated in the food safety survey and submitted consent forms.*

**RESULTS AND DISCUSSION**

Twelve of the 15 randomly selected schools in East Tennessee agreed to participate. The SMA classification (Metropolitan, Micropolitan, and Other) for counties in East Tennessee, as well as the locations of the participating schools, are displayed in Fig. 1. One school from each of the SMA classification areas chose not to participate for one or more of the following reasons: participation required both parental and student consent, administrators and/or teachers did not think that time from the regular curriculum could be spared, or the school or school system did not allow data to be collected from students. The number of participating schools for each SMA was proportionally weighted to the population and included: six schools from the Metropolitan areas; two from each core city; three schools from the Micropolitan areas; and three schools from the Other area classification (Table 1). A total of 232 seventh grade students returned consent forms and completed the survey. The sample sizes for each school ranged from 8 to 38 students (Table 1). The SES level, as determined by the Department of Education free and reduced lunch program, for each school ranged from 25.3 to 99.3 percent, representing the percentage of students in that school that are economically disadvantaged (Table 1). Seven of the 12 participating schools in this survey had SES levels greater than the 50% level that determines federal funding for assistance programs.

In describing the demographic characteristics at the student level, most participants in this study were female (63.2%) and Caucasian (74.5%) (Table 2). Studies surveying food safety knowledge of college students have described similar populations, with females comprising 62 to 65% of respondents (5, 26). Some food-safety surveys with adult consumers report the percentage of respondents who are female to be as high as 80 to 85% (14, 16, 22). In many surveys, both with college students and adults, Caucasians make up the majority (greater than 60%) of respondents.

**Food-handling experience**

The food-handling experience of adolescents in this study and the mean knowledge and attitudes/behaviors scores and differences by response are described in Table 3. The majority (62.61%) of adolescents report preparing both meals and snacks, with a significantly higher proportion (P = 0.0016) of females reporting meals and snacks as the primary types of food they prepare, compared with snacks only or no food preparation. The types of food prepared had an effect on the overall attitudes/behaviors scores, with students who prepared both meals and snacks reporting significantly safer attitudes/behaviors than students who prepared no foods or snacks only; however, knowledge was not significantly different by types of food prepared. Most (40.87%) prepare 0 to 5 meals or snacks...
TABLE 2. Demographic characteristics of participating seventh graders in East Tennessee

<table>
<thead>
<tr>
<th>Characteristic</th>
<th># Students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (n = 231)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>146 (63.2)</td>
</tr>
<tr>
<td>Male</td>
<td>78 (34.8)</td>
</tr>
<tr>
<td>Race (n = 228)</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>15 (6.6)</td>
</tr>
<tr>
<td>Asian/Pacific</td>
<td>6 (2.6)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>170 (74.5)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>15 (6.6)</td>
</tr>
<tr>
<td>Native American</td>
<td>23 (10.1)</td>
</tr>
<tr>
<td>Geographic area* (n = 232)</td>
<td></td>
</tr>
<tr>
<td>Metropolitan</td>
<td>138 (59.5)</td>
</tr>
<tr>
<td>Micropolitan</td>
<td>49 (21.1)</td>
</tr>
<tr>
<td>Other</td>
<td>45 (19.4)</td>
</tr>
</tbody>
</table>

*Geographic area is based on US Census Bureau Standard Metropolitan Areas classification.

In one week. There was no significant relationship between the total knowledge or attitudes/behaviors scores of the students or differences between genders for any response to the number of meals or snacks prepared. Students reported eating at a restaurant or fast food with their family 0 to 3 times a week, with no response difference between genders. Students who reported eating out with their family 0 to 3 or 4 to 10 times per week demonstrated significantly greater food-safety knowledge than students who are out more than 10 times a week, but attitudes/behaviors were not significantly different among levels of eating out.

In their study with 178 seventh and eighth grade students, Haapala and Probart (11) also found that the majority of students (52%) prepare meals or snacks, with females and males participating equally in food preparation. Byrd-Bredbenner et al. (5) reported that 84% of college students (mean age 19.9 ± 1.9) prepared at least one meal every week. These results suggest that adolescents are beginning to prepare foods and, while the frequency of food preparation will increase, food-handling experience is limited among young consumers, even at the college level.

Knowledge measures

The adolescents in this study (n = 231) demonstrated only a fair level of food-safety knowledge, answering on average 48% of the knowledge questions correctly. Richards et al. (21) similarly found that seventh grade students (n = 234) from five schools in Tennessee and North Carolina demonstrated only 51% correct food safety knowledge, while Haapala and Probart (11) found that seventh and eighth grade students (n = 178) had a slightly higher total, with 72% correct knowledge. It should be noted that the instrument in this study was a modified version of the survey used by Richards et al. (21); thus knowledge differences reported by Haapala and Probart (11) could be due to differences in the instrument, not in actual student knowledge.

The knowledge of adolescents in the current study on key food safety issues is described in Fig. 2 and Fig. 3. The adolescents demonstrated high levels (63–79%) of knowledge in the importance and frequency of proper hygiene. The majority of participants (83%) overestimated the temperatures needed to safely cook ground beef, but many (67%) incorrectly chose color, over the use of a thermometer, as the best indicator of "doneness" of a hamburger. Awareness of cooling practices for leftover foods was high (88%), but knowledge of proper meat defrosting methods was low with only 26% correctly answering that thawing in the refrigerator is the safest method. The adolescents' understanding of preventive cross-contamination practices, like separating foods and using different or clean utensils between foods, was fair with 57–62% correctly answering. Participants' knowledge of foodborne pathogens was low, with 38% not correctly recognizing E. coli O157:H7 as a pathogen that could cause foodborne illness.

Haapala and Probart (11) reported similar results with adolescents demonstrating high levels of knowledge in proper hygiene (85%) and cooling practices (89%). However, their study reported that 63% of adolescents correctly identified a thermometer reading as the safest indicator of doneness of meat. This finding greatly differs from the current study, which found that 67% of adolescents identified color as the best indicator of doneness. The inconsistency in these findings may be due to the fact that the question regarding safest method for determining meat doneness in the Haapala and Probart study was a true/false item, while the survey question in our study offered multiple choice answers.

Attitude/Behavior measures

Student perceptions of risk of foodborne illness were high, while self-efficacy and personal responsibility toward food safety were fairly low (Fig. 4). Less than half of students felt they could affect their risk of foodborne illness by correctly handling foods, identifying higher risk foods, or recognizing common symptoms. Adolescents in the Haapala and Probart (11) study also exhibited high perceptions toward the risk and severity of foodborne illness and low self-efficacy. College students were found to have higher (82%) self-efficacy scores (5). With adult consum-
TABLE 3. Food-handling experience of participating East Tennessee Seventh graders

<table>
<thead>
<tr>
<th>Types of food prepared* (n = 230)</th>
<th>Total number (%)</th>
<th>Female number (%)</th>
<th>Male number (%)</th>
<th>Total Knowledgeb mean ± SEa</th>
<th>Total Attitudes/Behaviorsb mean ± SEa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare no foods</td>
<td>30 (13.04)</td>
<td>14 (6.09)</td>
<td>16 (6.96)</td>
<td>42.1 ± 3.0a</td>
<td>59.6 ± 2.4a</td>
</tr>
<tr>
<td>Snacks only</td>
<td>54 (23.48)</td>
<td>27 (11.74)</td>
<td>27 (11.74)</td>
<td>50.0 ± 2.3a</td>
<td>69.0 ± 1.9a</td>
</tr>
<tr>
<td>Meals and snacks†</td>
<td>144 (62.61)</td>
<td>105 (45.65)</td>
<td>39 (16.96)</td>
<td>49.9 ± 1.6a</td>
<td>73.4 ± 1.4a</td>
</tr>
<tr>
<td>No answer</td>
<td>2 (0.87)</td>
<td>1 (0.44)</td>
<td>1 (0.44)</td>
<td>38.0 ± 3.8a</td>
<td>60.9 ± 6.0a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of meals or snacks prepared* (n = 230)</th>
<th>Total number (%)</th>
<th>Female number (%)</th>
<th>Male number (%)</th>
<th>Total Knowledgeb mean ± SEa</th>
<th>Total Attitudes/Behaviorsb mean ± SEa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 5</td>
<td>94 (40.87)</td>
<td>59 (25.65)</td>
<td>36 (15.65)</td>
<td>48.4 ± 1.8a</td>
<td>69.2 ± 1.4a</td>
</tr>
<tr>
<td>6 to 10*</td>
<td>83 (36.09)</td>
<td>56 (24.35)</td>
<td>27 (11.74)</td>
<td>49.0 ± 4.1a</td>
<td>72.3 ± 1.5a</td>
</tr>
<tr>
<td>More than 10</td>
<td>50 (21.74)</td>
<td>32 (13.91)</td>
<td>18 (7.83)</td>
<td>50.8 ± 3.2a</td>
<td>70.6 ± 6.5a</td>
</tr>
<tr>
<td>No answer</td>
<td>3 (1.30)</td>
<td>1 (0.44)</td>
<td>2 (0.87)</td>
<td>25.6 ± 7.8a</td>
<td>57.7 ± 2.0a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of eating out† (n = 230)</th>
<th>Total number (%)</th>
<th>Female number (%)</th>
<th>Male number (%)</th>
<th>Total Knowledgeb mean ± SEa</th>
<th>Total Attitudes/Behaviorsb mean ± SEa</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 10 times</td>
<td>10 (4.35)</td>
<td>5 (2.17)</td>
<td>5 (2.17)</td>
<td>34.8 ± 5.1a</td>
<td>61.8 ± 4.2a</td>
</tr>
<tr>
<td>4 to 10</td>
<td>65 (28.26)</td>
<td>43 (18.70)</td>
<td>22 (9.57)</td>
<td>48.2 ± 2.1a</td>
<td>70.2 ± 1.6a</td>
</tr>
<tr>
<td>0 to 3</td>
<td>150 (65.24)</td>
<td>97 (42.17)</td>
<td>53 (23.04)</td>
<td>50.6 ± 1.5a</td>
<td>71.8 ± 1.1a</td>
</tr>
<tr>
<td>No answer</td>
<td>5 (2.17)</td>
<td>2 (0.87)</td>
<td>3 (1.30)</td>
<td>35.2 ± 5.8a</td>
<td>56.9 ± 4.8a</td>
</tr>
</tbody>
</table>

*Mean separation based on Tukey-Kramer (P < 0.05) adjustment method. Means within responses to food-handling experience questions followed by the same letter are not significantly different.

bKnowledge and Attitudes/Behaviors scores normalized to 100, with possible range of scores 0 to 100.

cSignificant difference between female and male response (P = 0.0016).

dLarge deviation and cell Chi-square values indicate specific response differs by gender.

†Number of meals or snacks prepared by the student in one week (P = 0.6130).

‡Frequency the student and their family eats out (i.e., at a restaurant or fast food) in one week (P = 0.6058).

ers, Redmond and Griffith (22) reported that while perceived threat or risk of foodborne illness was low, self-efficacy was high, with 66% of consumers thinking they had full or nearly full control of their food safety and 84% perceiving their personal responsibility for food safety to be high. Overall, these results suggest that a high level of confidence in ability to handle food safely increases with age and food-handling experience.

Reported safe food-handling behaviors by adolescents in this study were high (i.e., greater than 50%) for several behavior measures (Fig. 4); however, disconnects between knowledge and the reported behaviors in hygiene and temperature practices were observed. In this study, results showed that 63% knew the importance of hand-washing, but only 51% reported ‘always’ washing their hands before eating or preparing food; 79% demonstrated knowledge of the importance of washing their hands after using the restroom, but only 59% reported ‘always’ doing so; 50% reported ‘always’ following temperature directions, but 85% did not know how to determine if a hamburger was cooked properly, and 74% did not know how to safely thaw meat. These results support the findings of other research with adolescents (11), college students (5, 10), and even adults (2, 19, 20), in which their reported behaviors disagreed with their actual knowledge.

Knowledge and attitudes/behaviors by gender

Responses to some knowledge questions differed significantly by gender (Table 4). However, no overall significant difference (P = 0.0805) was found between genders in total food safety knowledge, with mean scores ranging from 38 to 42% correct (Table 5). Only the differences in responses to questions regarding hygiene were highly
significant ($P = 0.0006$), with 55% of females and only 23% of males responding correctly. There was a significant difference ($P = 0.0134$) between genders in overall scores for attitudes/behaviors toward food safety (Table 4). Significant differences in responses to questions relating to self efficacy and proper hygiene between genders was observed (Table 3). Again, the difference between genders was highly significant for hygiene practices, with females reporting higher frequency of washing hands after using the restroom (41%) and using hand sanitizer (35%) as compared to male reported behaviors, 18 and 14%, respectively.

Many studies of college students and adults have reported that females demonstrate higher food-safety
<table>
<thead>
<tr>
<th>Questions</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>To prevent cross-contamination, it is important to keep raw meat away from other foods in the grocery cart and refrigerator.</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>All bacteria can make me sick.</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>It is possible to wash my hands thoroughly using only water.</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>When preparing food, it is okay to use the same surfaces and utensils for meats and vegetables.</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>It is okay to eat pizza that has been sitting out on the counter all night as long as I warm it up first.</td>
<td>74%</td>
<td>26%</td>
</tr>
<tr>
<td>Most people go to the doctor when they get food poisoning.</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>More people are hospitalized each year with food poisoning than with the flu.</td>
<td>44%</td>
<td>56%</td>
</tr>
<tr>
<td>Almost all food poisonings are preventable.</td>
<td>37%</td>
<td>63%</td>
</tr>
<tr>
<td>If I clean a surface with soap and water, it will kill all the bacteria.</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>Bacteria cannot grow in food stored in a refrigerator.</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>There may be bacteria in my food that can make me sick if my food is not handled correctly.</td>
<td>17%</td>
<td>83%</td>
</tr>
</tbody>
</table>

Percent of students (n=231) reporting the specified answer
TABLE 4. Significant differences* in East Tennessee adolescent knowledge and attitudes/behaviors of food safety by gender

<table>
<thead>
<tr>
<th>Food safety issue</th>
<th>% Answering knowledge question correctly or responding to attitudes/behavior statements ‘always’ or ‘sometimes’</th>
<th>Female</th>
<th>Male</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. When should hands be washed?</td>
<td></td>
<td>55.41</td>
<td>23.81</td>
<td>0.0006</td>
</tr>
<tr>
<td>A. after using the bathroom, before handling food, and more frequently when someone is sick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. What is the safest way to defrost meat?</td>
<td></td>
<td>14.29</td>
<td>12.55</td>
<td>0.0446</td>
</tr>
<tr>
<td>A. in the refrigerator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. A pathogen is:</td>
<td></td>
<td>42.42</td>
<td>18.18</td>
<td>0.0247</td>
</tr>
<tr>
<td>A. a bacterium that can make you sick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. It is okay to eat pizza that has been sitting out on the counter all night?</td>
<td></td>
<td>51.08</td>
<td>23.81</td>
<td>0.0274</td>
</tr>
<tr>
<td>A. False</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. Bacteria cannot grow in food stored in the refrigerator</td>
<td></td>
<td>50.65</td>
<td>22.51</td>
<td>0.0086</td>
</tr>
<tr>
<td>A. False</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attitudes/Behaviors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. I feel that I know how to correctly handle my food so that I do not become sick</td>
<td></td>
<td>35.93</td>
<td>13.42</td>
<td>0.0397</td>
</tr>
<tr>
<td>A. Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. I could properly handle food to prepare a safe meal for my family</td>
<td></td>
<td>26.84</td>
<td>9.09</td>
<td>0.0417</td>
</tr>
<tr>
<td>A. Always</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. I use hand sanitizer to clean my hands</td>
<td></td>
<td>34.63</td>
<td>13.85</td>
<td>0.0276</td>
</tr>
<tr>
<td>A. Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q. I wash my hands after each time I used the restroom</td>
<td></td>
<td>41.13</td>
<td>18.18</td>
<td>0.0288</td>
</tr>
<tr>
<td>A. Always</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant differences obtained from the exact test in contingency table analysis (n = 231).

knowledge and reported behaviors than males (2, 5, 19, 22). However, Haapala and Probart (11) also found, as in the current study, no overall significant difference in food safety knowledge between genders in adolescents. Their study suggested that with increasing age, females tend to get more practice in food-handling and therefore score higher than males in studies of adults. Others have also suggested that food-safety knowledge may increase with age and experience (2, 14, 19, 25). The findings that reported attitudes and behaviors differ between genders in the current study may be explained by the higher proportion of females preparing both meals and snacks, and thus receiving more experience in handling a variety of foods. However, the frequency of food preparation or handling experience for adolescents in this study was low, with no difference between genders. The overall lack of experience with food-
TABLE 5. Least squares means for knowledge and attitudes/behaviors of adolescents by gender, race, and geographic area

<table>
<thead>
<tr>
<th>Effect</th>
<th>Knowledge(^b) estimate ± SE(^a)</th>
<th>Attitudes/Behaviors(^b) estimate ± SE(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender(^c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>42.0 ± 2.1(^e)</td>
<td>66.2 ± 18.7(^a)</td>
</tr>
<tr>
<td>Male</td>
<td>38.4 ± 2.2(^e)</td>
<td>63.3 ± 1.8(^a)</td>
</tr>
<tr>
<td>Race(^d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>43.2 ± 3.8(^a)</td>
<td>63.8 ± 3.1(^a)</td>
</tr>
<tr>
<td>Asian/Pacific</td>
<td>26.8 ± 6.0(^a)</td>
<td>54.5 ± 5.1(^a)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>49.5 ± 1.3(^a)</td>
<td>70.2 ± 1.1(^a)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>41.5 ± 4.1(^a)</td>
<td>67.9 ± 3.2(^a)</td>
</tr>
<tr>
<td>Native American</td>
<td>40.0 ± 3.2(^a)</td>
<td>65.1 ± 2.4(^a)</td>
</tr>
<tr>
<td>Geographic area(^e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan</td>
<td>43.3 ± 1.9(^a)</td>
<td>68.4 ± 1.6(^a)</td>
</tr>
<tr>
<td>Micropolitan</td>
<td>36.6 ± 2.7(^a)</td>
<td>62.4 ± 2.3(^a)</td>
</tr>
<tr>
<td>Other</td>
<td>40.7 ± 2.8(^a)</td>
<td>62.3 ± 2.2(^a)</td>
</tr>
</tbody>
</table>

\(^a\)Mean separation based on Tukey-Kramer (P < 0.05) adjustment method. Means within gender, race, or geographic area followed by the same letter are not significantly different.

\(^b\)Knowledge and Attitudes/Behaviors scores normalized to 100, with possible range of scores 0 to 100. SE = standard error (n = 231).

\(^c\)Gender fixed effect test: knowledge P = 0.0805; attitudes/behaviors P = 0.134.

\(^d\)Race fixed effect test: knowledge P = 0.0002; attitudes/behaviors P = 0.0034.

\(^e\)Geographic area fixed effect test: knowledge P = 0.866; attitudes/behaviors P = 0.0280.

Safety issues among adolescents may explain the lack of difference between genders in food-safety knowledge.

**Association with demographic variables**

The socioeconomic status variable was found to be confounded with other variables, and thus was not included in the model. Geographic area (i.e., location of residence) was not significant (P > 0.05) in determining food-safety knowledge or attitude/behavior of adolescents (Table 4). The association between geographic location of residence and food-safety knowledge and behaviors has received little attention in research. Patil et al. (19) found that use of preventive cross-contamination practices was poorest in the rural mountain area. Other studies report that consumers from urban areas tend to have lower food safety knowledge scores than those from rural areas (1, 27). The results from the current study suggest that any association between geographic location of residence and food-safety knowledge or behaviors are yet to be established in adolescents.

Significant differences were found with race for both knowledge (P = 0.0002) and attitudes/behaviors (P = 0.0034) (Table 2). Differences of least squares means were highly significant for both knowledge (P = 0.0021) and attitudes/behaviors (P = 0.0189) between Asian/Pacific and Caucasian students, with Caucasian students scoring higher. There was also a significant difference between the knowledge scores of Caucasian and Native American students (P = 0.0363), again with Caucasian students scoring higher. No significant differences were found between other ethnic groups.

Few studies with adolescents or college students have investigated and reported the relationship of race on food safety knowledge or attitudes and behaviors. Meer and Misner (16) found that Caucasian adults scored significantly higher (P < 0.001) in food-safety knowledge than Hispanics, but no significant differences were found among other ethnic groups. Likewise, a FoodNet survey from 1996 to 1997 of 7,493 consumers found that Hispanics were more likely than other ethnic groups to engage in fewer safe food-handling behaviors, such as washing hands and cutting boards after handling raw meat (24).
FIGURE 4.

I feel that I know how to correctly handle my food so I do not become sick.

When preparing food, I carefully follow temperature and time directions on food packaging labels.

If necessary, I could properly handle a variety of meats and vegetables to prepare a safe meal.

I wash my hands before preparing or eating food.

Questions

When I see an adult handling food improperly I point out his or her mistakes.

I can recognize most common symptoms of food poisoning.

I wash my hands after each time I use the restroom.

I use hand sanitizer to clean my hands.

I can identify foods that have a higher risk of making me sick.

Percent of students (n=231) reporting the specified answer

However, Patil et al. (19) found that the difference in good hygiene between Caucasians and Hispanics was not significant, but that African Americans and Asians reported significantly higher use of good hygiene than Caucasians or Hispanics (19). The results from the current study indicated that Caucasian students score significantly higher in food safety knowledge measures and report safer behaviors than Asian/Pacific students. However, it should be noted that the Asian/Pacific student population was very small (less than 10 students) and 2 students of this
ethnicity were removed from the sample as outliers because their questionnaires were not completed. It is possible that a significant language barrier existed for some Asian/Pacific students, thus skewing results. However, the finding from this study that Caucasian students score higher in food-safety knowledge and report safer attitudes and behaviors supports the findings of several studies with adults (16, 19, 24).

CONCLUSIONS

While there have been many studies on the topics of food-safety knowledge, attitudes, and behaviors, very few have focused on adolescents. This study aids in constructing a baseline of food-safety knowledge, attitudes, and behaviors for various demographic groups that is vital for determining the specific educational strategies that will motivate adolescents to practice safer food-handling. Overall, the adolescents in this study have less than optimal levels of food-safety knowledge and safe food-handling behaviors. Students' reported behaviors often disagreed with their valid knowledge, especially their knowledge of personal hygiene and cooking practices. Many studies have reported that knowledge may not definitively determine behaviors, so emphasis must be placed on not only increasing knowledge, but encouraging and empowering adolescents to change their behaviors. Engaging students in age-specific and hands-on activities that have real-world applications of food safety in the school setting will reinforce the importance of these concepts in students' daily lives.

The findings of this study support the need for food-safety education efforts geared toward adolescents, with focal points in hand-washing and use of proper cooking temperatures, as well as differences in behavior within gender and some ethnic groups. The results of this study suggest that some differences in knowledge and behaviors between demographic groups are less pronounced in adolescents than those found in similar studies with adults. With limited food-handling experience and weaker relationships with demographic factors, dissemination of knowledge and development of safe behaviors through adolescent education may prove successful in improving consumer food safety. The information from this study will allow researchers and educators to more effectively develop and implement food safety education materials for this age group, as well as target specific populations in need of educational interventions.

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REFERENCES


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