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## Validating Responses to a Food Safety Survey with Observations of Food Preparation Behaviors Among Limited Resource Populations

### ABSTRACT

This study was designed to evaluate the criterion validity of the four food safety questions included in the 2018 national evaluation tool utilized by the Expanded Food and Nutrition Education Program (EFNEP) and to identify targets for additional food safety education among EFNEP participants. Study participants were recruited from active EFNEP groups in Florida, Georgia, Michigan, and Tennessee. A total of 76 participants completed the food safety survey questions, and 38 participants completed a food preparation activity within community kitchens, where behaviors were observed to determine agreement with survey responses. Survey questions were validated by 19 of the 22 behaviors that were evaluated when the criterion for validity was set at  $\geq 70\%$  agreement between self-reported behaviors on the questionnaire and observed behaviors during the food preparation activity. However, it is important to note that validation was achieved only when incorrect and correct behaviors were considered "performed." Responses to the survey and observed behaviors indicate that more education is needed to

facilitate behavior change related to proper thawing of raw meats, proper handwashing techniques, reduction of the risk of cross-contamination of kitchen surfaces, and use of a food thermometer to ensure that cooked meats reach a safe internal temperature.

### INTRODUCTION

The most recent data from the United States indicate that foodborne pathogens cause an estimated 9.4 million illnesses each year (7). Although outbreaks from processing and distribution centers receive significant media attention, food safety experts contend that the majority of foodborne illnesses result from improper food handling in home kitchens (4). Thus, educational campaigns that emphasize proper food safety behaviors in the home are needed to reduce the risk of foodborne illness. Additionally, food safety is a critical concept to teach and evaluate in nutrition education programs that include information about how to cook and prepare foods.

The Expanded Food and Nutrition Education Program (EFNEP) is a federally funded program that has provided

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direct education for low-income families throughout the United States since the late 1960s (6). Within the current framework of EFNEP, direct education is delivered in community settings by paraprofessional aides (i.e., peer educators), and EFNEP interventions are delivered as a series of classes that address five content domains: food safety, diet quality, physical activity, food resource management, and food security. Although curricula vary from state to state, the most commonly used curricula include food preparation demonstrations and/or food tastings at each session (19). Nutrition education programs such as EFNEP that teach and demonstrate meal preparation should include reliable food safety information and should reliably measure changes in participant behavior to protect participant health. However, measuring the effectiveness of food safety interventions can be challenging and requires the use of validated methods and evaluation tools (17).

Program impact of EFNEP, which directly reaches over 100,000 low-income adults in rural and urban communities each year (23), is evaluated at the local, state, and national levels by comparing pre- and post-intervention assessments of participants' self-reported behaviors with regard to the five content domains (11). In 1997, a 10-item questionnaire was developed to evaluate behavior changes related to EFNEP's five content domains among program participants. However, in response to changes in program policies and updates to existing nutrition and physical activity guidelines, this questionnaire was updated to a 20-item questionnaire in 2018. Two national evaluation committees were convened to coordinate the creation and evaluation of the new 20-item survey. Domain leaders were established for each of the five content domains (food safety, diet quality, physical activity, food resource management, and food security), and these domain leaders coordinated the content evaluation, face validity testing, and reliability testing for the relevant questions in the revised questionnaire, following previously described methods (18).

This study was conducted by the food safety domain leaders to evaluate the criterion validity of the food safety questions included in the new questionnaire. Criterion validity is defined as the extent to which the results from one instrument are correlated with those of another instrument, ideally the gold standard (13). In this case, investigators set out to determine whether self-reported responses to the food safety survey questions on the new questionnaire were validated by observations of actual food-handling behaviors during a food preparation activity in a community test kitchen. Additionally, this study was designed to inform targets for increased education and skill development, based on study participants' self-reported survey responses and observed food-handling behaviors during the food preparation activity.

## MATERIALS AND METHODS

Study participants consisted of a convenience sample of EFNEP participants in active EFNEP groups in four

states – Florida, Georgia, Michigan, and Tennessee. Each state's EFNEP curriculum included at least one session with a content focus on improving food safety behaviors and/or had food safety information included as part of all lessons. Study participants were recruited during a nutrition education session that followed exposure to the food safety information within each curriculum. The recruitment script and supplemental recruitment materials invited participants to take part in a study evaluating food preparation practices but did not refer specifically to food safety. Eligibility for this study was defined as enrollment in an EFNEP program, completion of the food safety-focused EFNEP educational session, and a "yes" response to each of the following questions: (1) Are you the primary food preparer for your household? (2) Are you willing to prepare meat and poultry? (3) Are you willing to be videotaped while preparing food?

At the time of recruitment, eligible participants completed the informed consent process and answered survey questions related to their demographics (gender, race, and ethnicity), frequency of cooking meals at home, and frequency of family dining. Eligible participants also answered the four food safety questions included in the new questionnaire and provided contact information for scheduling direct observations of a food preparation activity in a community test kitchen.

The food safety questions in the new questionnaire were designed to evaluate four of the five behavioral constructs that food safety experts recognize as critical pathogen control factors: keep foods at safe temperatures (i.e., How often do you thaw frozen food on the counter or in the sink?), practice personal hygiene (i.e., How often do you wash your hands with soap and warm running water before preparing food?), avoid cross-contamination (i.e., After cutting raw meat or seafood, how often do you wash all items and surfaces that came in contact with these foods?), and cook food adequately (i.e., How often do you use a meat thermometer to see if meat is cooked to a safe temperature?) (17). Responses to questions were defined on a Likert scale: [Never, Rarely (about 20% of the time); Sometimes (about 40% of the time); Usually (about 60% of the time); Often (about 80% of the time); or Always]. All items were developed on the basis of feedback from food safety subject matter experts, and items and the response scale were refined on the basis of cognitive interviews with EFNEP participants (19).

Within two weeks of study recruitment, each participant was invited to come to a local community test kitchen to complete a food preparation activity that would be observed and video recorded. A trained observer facilitated each food preparation session and completed a kitchen activity checklist to document performance items related to each of the food safety behaviors evaluated by the survey questions. Kitchens were stocked with the supplies listed in *Fig. 1*, and all kitchens were equipped with a functioning stove and

Food Supplies	Cooking Supplies	Cleaning Supplies
Boneless Chicken Breast	Baking Pan	Paper Towels
Apple	Cutting Boards (2)	Dish Cloth and Sponge
Ground Beef	Cooking Spray	Dish Soap
Tomato	Flour	Disinfectant Wipes
	Knife	Hand Soap
	Food Thermometer	
	Pepper	
	Plates (2)	
	Salt	
	Skillet	
	Spatula	
	Utensils	

FIGURE 1. Supplies provided in community test kitchens where study participants completed an observed food preparation activity.

sink. Participants were instructed to prepare two test meals as they would at home, using the supplies provided. One meal consisted of a chicken breast and an apple. The other consisted of two ground beef patties and a tomato.

Instructions for each meal were verbally communicated, and participants were also provided with picture-based, written instructions. Instructions for the chicken meal were verbalized and written as follows: “Prepare chicken as you normally would at home. Cut chicken in half at least once before cooking. Inform instructor when chicken is cooked. Carefully cut apple into large slices.” Instructions for the ground beef meal were verbally communicated and written as follows: “Prepare hamburger as you normally would at home. Cut meat in half before cooking. Inform instructor when hamburger is cooked. Carefully cut tomato into thick slices.” The order of meal preparation was counterbalanced across participants, with half preparing the chicken first and the other half preparing the ground beef first. These methods were modeled after a previous food safety observation study conducted with EFNEP participants (13).

Because observation sessions were limited to one hour, researchers were unable to observe participants’ thawing of frozen meat. Instead, at the beginning of each meal preparation session, the trained observer stated that the meat had been thawed and asked each participant how he/she usually thaws meat at home. The participant’s response was noted on the kitchen activity checklist. When the participant stated that he/she had completed the cooking process, the observer asked the participant how he/she usually determined that meat was fully cooked and noted the participant’s response on the kitchen activity list. The observer also measured the final endpoint cooking

temperature of the chicken and beef, using calibrated food thermometers, and documented the temperatures on the kitchen activity checklist. Participants who completed the food preparation activity were compensated with gift cards ranging from \$25 to \$50, depending on the study site.

The validity of the responses to the four food safety questions on the new questionnaire was tested by comparing each participant’s responses on the questionnaire to the behaviors he/she demonstrated during the food preparation activity. *Table 1* shows the food safety survey questions and the 22 corresponding performance items related to the four pathogen-control factors being evaluated by the survey questions – keep foods at safe temperatures (n = 1), practice personal hygiene (n = 4), avoid cross-contamination (n = 12), and cook food adequately (n = 5). Behaviors (performance items) observed during the food preparation activity were coded as performed correctly, performed incorrectly, or not performed. Criteria for coding the behaviors are shown in *Table 2*. The kitchen activity checklist also included an open-ended comments section where trained observers could note any additional food safety concerns that were not captured by the checklist. All study procedures were approved by the Institutional Review Board at each of the four institutions involved.

All data were shipped to a central processing location, where two researchers reviewed all video recordings alongside kitchen activity checklists completed by the trained observers so as to ensure uniform accuracy in data coding and data entry. Video recordings were also used to determine the duration of handwashing in seconds at each documented occurrence and to assess additional instances of potential cross-contamination beyond those captured by the kitchen

**TABLE 1. Performance items documented during an observed food preparation activity to evaluate the criterion validity of four food safety survey questions**

Survey Question	Performance Item(s) on Kitchen Activity Checklist
How often do you thaw frozen food on the counter or in the sink?	Reports defrosting meat correctly (meal 1 only)
How often do you wash your hands with soap and warm running water before preparing food?	Washed hands before preparing food (meal 1)
	Washed hands before preparing food (meal 2)
	Washed hands between handling chicken and apple
After cutting raw meat or seafood, how often do you wash all items and surfaces that came in contact with these foods?	Washed hands between handling beef and tomato
	Washed cutting board between cutting chicken and apple
	Washed cutting board between cutting beef and tomato
	Washed cutting board after food preparation (meal 1)
	Washed cutting board after food preparation (meal 2)
	Washed knife between cutting chicken and apple
	Washed knife between cutting beef and tomato
	Washed knife after food preparation (meal 1)
	Washed knife after food preparation (meal 2)
	Used clean plate to serve chicken
	Used clean plate to serve beef
	Washed countertop after food preparation (meal 1)
	Washed countertop after food preparation (meal 2)
How often do you use a meat thermometer to see if meat is cooked to a safe temperature?	Reports using thermometer at home (meal 1 only)
	Used thermometer with chicken
	Used thermometer with beef
	Cooked chicken to $\geq 165^{\circ}\text{F}$
	Cooked beef to $\geq 160^{\circ}\text{F}$

activity checklist. The duration of handwashing was defined as the seconds that elapsed from the time a participant's hands first touched the water until the participant's hands left the water for the last time. To assess additional instances of potential cross-contamination, researchers counted the number of times participants touched kitchen items such as stove knobs and seasonings after touching raw meat and before washing hands. Potential cross-contamination was also assessed by reviewing videos and observer comments to determine if participants washed the raw chicken before preparing it. Handwashing behaviors during the food preparation activity were coded as performed correctly, performed incorrectly, or not performed. For the present study, correct handwashing was defined as washing hands for at least 20 seconds with soap and running water. The 20-second threshold for correct hand-washing was based on the current recommendation of the Centers for Disease Control and Prevention, which is informed by the existing research in this area (10, 12, 22).

Statistical analyses were performed using IBM SPSS 24 (Armonk, NY). Descriptive statistics were generated to summarize demographic characteristics and self-reported behaviors related to frequency of cooking meals at home, frequency of family dining, and responses to the four food safety questions on the revised questionnaire. Fisher's exact tests were used to evaluate differences between completers (participants who completed both the initial survey and the observations) and non-completers (participants who completed the survey only) related to sex, ethnicity, and race. Gamma statistics were used to evaluate differences in survey responses among completers and non-completers regarding frequency of cooking meals at home and frequency of family dining. Descriptive statistics were generated to summarize performance and nonperformance of the food safety behaviors evaluated during the observed food preparation activity. Average handwashing times were calculated at each relevant time point and are reported as the mean ( $\pm$  standard deviation).

**TABLE 2. Definitions used to code food safety behaviors as performed correctly, performed incorrectly, or not performed during an observed food preparation activity**

Observed Behavior	Coding Definitions			
	Performed Correctly	Performed Incorrectly	Not Performed	N/A
Washed hands <sup>a</sup>	Washed hands for at least 20 seconds with soap and running water	Washed hands for less than 20 seconds with soap and running water OR Rinsed hands without using soap OR Washed dishes without explicitly washing hands	Did not make effort to wash hands	Behavior was not captured by the video
Washed cutting board	Washed cutting board with soap and water	Rinsed cutting board with water only OR Wiped cutting board	Did not make effort to clean cutting board	Used a new cutting board
Washed knife	Washed knife with soap and water	Rinsed knife with water only OR Wiped knife	Did not make effort to clean knife	Used a new knife
Used clean plate	Washed plate with soap and water	Rinsed plate with water only OR Wiped plate	Did not make effort to clean plate	Used a new plate
Washed countertop	Used a sanitizing wipe on countertop or washed with soap and water	Wiped the countertop without soap or sanitizer	Did not make effort to clean counter tops	
Cooked meat to a safe temperature	Cooked chicken to a temperature of $\geq 165^{\circ}\text{F}$ OR Cooked beef to a temperature of $\geq 160^{\circ}\text{F}$			Preparation method prevented accurate measurement of final endpoint temperature

<sup>a</sup>Timing for handwashing: Start time — when the participant’s hands touched the water for the first time; End time — when the participant’s hands left the water for the last time.

Survey responses and observed behaviors were considered “in agreement” if the respondent answered the survey question with never, rarely, or sometimes and the performance item was not performed or, alternatively, if the respondent answered the survey question with often, usually, or always and the performance item was performed (either correctly or incorrectly). A designation of “discordant” was assigned to survey responses and observed behaviors that did not fit this definition of “agreement.” The criterion for validity was established as  $\geq 70\%$  agreement between self-report on the questionnaire and behaviors recorded as performed or not performed during the food preparation kitchen activity, on the basis of previously published work (13).

## RESULTS

A total of 76 individuals enrolled in the study. Of those who enrolled, 38 completed the observed, video recorded food preparation activity (50.0% completion rate). No differences were identified between completers and non-completers on the basis of race ( $P = 0.67$ ), ethnicity ( $P = 0.63$ ), or responses to questions regarding frequency of cooking meals at home ( $P = 0.76$ ) or frequency of family dining ( $P = 0.23$ ). However, a significant effect of sex emerged ( $P = 0.04$ ), with males being significantly less likely than females (14.3% vs 61.7% respectively) to complete the food preparation component of the study.

Descriptive characteristics of participants who completed the observation portion of the study ( $n = 38$ ) are shown in Table 3. Almost all participants were females (97%) and

**TABLE 3. Descriptive characteristics of study participants (n = 38) who completed an observed food preparation activity used to validate responses to four food safety survey questions**

Descriptive Characteristics	Participants (n = 38)	
<b>Gender</b>		
Female	37	97%
Male	1	2.6%
<b>Race</b>		
Black	18	47.4%
White	16	42.1%
Multi-racial	2	5.3%
Not reported	2	5.3%
<b>Ethnicity</b>		
Hispanic/Latino	3	7.9%
Non-Hispanic/Non-Latino	32	84.2%
Not reported	3	7.9%

**TABLE 4. Numbers and percentages of responses to four food safety questions that were evaluated by all participants who enrolled in a food safety survey validation study (n = 76)**

Survey Question	Response Distribution					
	Never	Rarely (about 20% of the time)	Sometimes (about 40% of the time)	Often (about 60% of the time)	Usually (about 80% of the time)	Always
How often do you thaw frozen food on the counter or in the sink?	26.3% (n = 20)	15.8% (n = 12)	13.2% (n = 10)	10.5% (n = 8)	21.1% (n = 16)	13.2% (n = 10)
How often do you wash your hands with soap and warm running water before preparing food?	-	2.6% (n = 2)	-	2.6% (n = 2)	10.5% (n = 8)	84.2% (n = 64)
After cutting raw meat or seafood, how often do you wash all items and surfaces that came in contact with these foods?	2.6% (n = 2)	-	-	-	7.9% (n = 6)	89.5% (n = 68)
How often do you use a meat thermometer to see if meat is cooked to a safe temperature?	50% (n = 38)	26.3% (n = 20)	10.5% (n = 8)	-	7.9% (n = 6)	5.3% (n = 4)

**TABLE 5. Numbers and percentages of study participants who correctly performed, incorrectly performed, or did not perform food safety behaviors that were used to evaluate the criterion validity of four food safety survey questions (n = 38, unless otherwise indicated)**

Performance Item	Correctly Performed		Incorrectly Performed		Not Performed	
	n	%	n	%	n	%
Used clean plate to serve meat, beef (n = 37)	35	94.59%	-	-	2	5.41%
Washed knife after meal preparation, beef (n = 31)	28	90.32%	2	6.45%	1	3.23%
Washed cutting board after meal preparation, beef (n = 30)	27	90.00%	2	6.67%	1	3.33%
Used clean plate to serve meat, chicken (n = 36)	32	88.89%	-	-	4	11.11%
Washed cutting board between meat and produce, chicken (n = 28)	22	78.57%	5	17.86%	1	3.57%
Washed cutting board between meat and produce, beef (n = 28)	22	78.57%	4	14.29%	2	7.14%
Washed knife between meat and produce, beef (n = 22)	17	77.27%	4	18.18%	1	4.55%
Washed knife between meat and produce, chicken (n = 34)	26	76.47%	8	23.53%	-	-
Washed knife after meal preparation, chicken (n = 36)	27	75.00%	6	16.67%	3	8.33%
Washed cutting board after meal preparation, chicken (n = 35)	26	74.29%	5	14.29%	4	11.43%
Cooked meat to appropriate temp, beef (n = 31)	20	64.52%	-	-	11	35.48%
Washed countertop after meal preparation, meal 2	24	63.16%	4	10.53%	10	26.32%
Cooked meat to appropriate temp, chicken (n = 31)	18	58.06%	-	-	13	41.94%
Defrosts meat correctly (1st meal only)	18	47.36%	-	-	20	52.63%
Washed countertop after meal preparation, meal 1	13	34.21%	5	13.16%	20	52.63%
Washed hands between meat and produce handling, chicken	4	10.53%	31	81.58%	3	7.89%
Washed hands between meat and produce handling, beef	6	15.79%	29	76.32%	3	7.89%
Washed hands before preparing food, beef (n = 32)	2	6.25%	24	75.00%	6	18.75%
Washed hands before preparing food, chicken (n = 34)	5	14.71%	27	79.41%	2	5.88%
Used thermometer with meat, beef	7	18.42%	5	13.16%	26	68.42%
Used thermometer with meat, chicken (n = 37)	5	13.51%	7	18.92%	25	67.57%
Reports using thermometer at home, 1st meal only	3	7.90%	-	-	35	92.10%

almost half identified as black (47.4%). The majority of these participants reported that on three or more days per week, they cooked at home (84.2%) and ate meals as a family (78.9%).

Survey responses for participants who enrolled in the study are presented in *Table 4*. Most respondents reported high levels of desirable food safety behaviors related to practicing personal hygiene and avoiding cross-contamination, with 84.2% reporting that they always wash hands before preparing food and 89.5% reporting that they always wash items that come into contact with raw meat or seafood. Fewer respondents reported desirable food safety behaviors related to keeping foods at safe temperatures, with just 26.3% reporting that they never thaw frozen food at

room temperature. Additionally, only 5.3% of respondents reported desirable food safety behaviors related to cooking food adequately, indicating that they always use a food thermometer to see if meat is cooked to a safe temperature.

*Table 5* summarizes the behaviors observed during the food preparation activity in descending order, based on the percentage of participants who correctly performed each behavior, as evaluated by video alongside the kitchen activity checklist. Behaviors that were most consistently performed correctly were food safety behaviors to prevent cross-contamination, including using clean plates to serve cooked food (88.9% to 94.6%) and washing knives (75.0% to 90.3%) and cutting boards (74.3% to 90.0%) after contact with raw meat. A smaller majority (63.2%) prevented cross-contam-

**TABLE 6. Numbers and percentages of study participants who washed hands incorrectly during an observational study to validate a food safety survey. Reported percentages are based on the total number of valid observations at each time point, which include all valid observations (i.e., all observed behaviors that were correctly performed, incorrectly performed, and not performed)**

Performance Item (total number of valid observations)	Incorrect Handwashing Behavior <sup>a</sup>									
	Inadequate Duration <sup>b</sup>						Rinsed Hands without Using Soap		Washed Dishes without Explicit Handwashing	
	< 20 sec		< 15 sec		< 10 sec					
Washed hands before preparing food, chicken (n = 34)	15	44.1%	13	38.2%	6	17.6%	2	5.9%	10	29.4%
Washed hands before preparing food, beef (n = 32)	13	40.6%	9	28.1%	6	18.8%	3	9.4%	8	25.0%
Washed hands between meat and produce handling, chicken (n = 38)	14	36.8%	8	21.1%	5	13.2%	4	10.5%	13	34.2%
Washed hands between meat and produce handling, beef (n = 38)	15	39.5%	13	34.2%	7	18.4%	2	5.3%	12	31.6%

<sup>a</sup>Incorrect handwashing behavior stratified by the three definitions of incorrect practices.

<sup>b</sup>Duration of handwashing substratified by three cutpoints for inadequate duration (i.e., < 20 seconds, < 15 seconds, < 10 seconds).

ination by correctly washing the counter top after preparing the second meal. However, only 34.2% of participants correctly washed the counter top after preparing the first meal. Additional risks of cross-contamination were noted by observers, including that 31.6% of participants washed raw chicken prior to cooking it and 60.5% of participants touched other ingredients and kitchen surfaces after contact with raw meat and before washing hands. Less than half of participants (47.4%) reported that they defrost meat so as to keep it at safe temperatures. Regarding personal hygiene practices, only 6.3% to 15.8% of participants correctly performed handwashing (e.g., using soap and water for a minimum of 20 seconds) at each appropriate time point, with most participants incorrectly washing hands at each opportunity before preparing food or between handling meat and produce (75.0% to 81.6%).

Table 6 summarizes the numbers and percentages of participants who washed hands incorrectly at each timepoint – stratified by the three definitions of incorrect handwashing and substratified by varying cutpoints for inadequate hand-

washing duration (i.e., <20 seconds, <15 seconds, <10 seconds). Inadequate duration of handwashing was the primary reason handwashing was coded as incorrectly performed, with participants washing hands for 13.2 (± 5.4) seconds before preparing food and 13.7 (± 6.4) seconds after contact with meat.

Less than 20% of participants used a food thermometer to measure the endpoint cooking temperature for beef (18.4%) or chicken (13.5%), with most (81.8%) indicating that they used color or appearance of meat to determine whether meat was cooked to the proper temperature. Despite low frequency of using a meat thermometer, more than half of the participants cooked food adequately, with 64.5% cooking beef to a temperature ≥160°F and 58.1% cooking chicken to a temperature of ≥165°F.

Table 7 shows the number and percentage of survey responses and observed behaviors during the food preparation activity that were “in agreement” and “discordant.” Survey questions were validated by 19 of the 22 observed behaviors when incorrect and correct behaviors were



**TABLE 7. Numbers and percentages of survey responses and observed behaviors during a food preparation activity that were “in agreement” and “discordant” in a food safety survey validation study. Validity was established as  $\geq 70\%$  agreement between self-report on the survey and behaviors recorded during the food preparation activity**

Survey Question	Performance Item	Discordant		In Agreement		Total	Valid
		Count	Percentage	Count	Percentage		
How often do you thaw frozen food on the counter or in the sink?	Defrosts meat correctly (meal 1 only)	11	28.95%	27	71.05%	38	Yes
	Washed hands before preparing food (chicken)	3	8.82%	31	91.18%	34	Yes
How often do you wash your hands with soap and warm running water before preparing food?	Washed hands before preparing food (beef)	5	15.63%	27	84.38%	32	Yes
	Washed hands between meat and produce handling (chicken)	4	10.53%	34	89.47%	38	Yes
	Washed hands between meat and produce handling (beef)	2	5.26%	36	94.74%	38	Yes
	Washed cutting board between meat and produce (chicken)	2	7.14%	26	92.86%	28	Yes
After cutting raw meat or seafood, how often do you wash all items and surfaces that came in contact with these foods?	Washed cutting board between meat and produce (beef)	1	3.57%	27	96.43%	28	Yes
	Washed knife between meat and produce (chicken)	1	2.94%	33	97.06%	34	Yes
	Washed knife between meat and produce (beef)	1	4.55%	21	95.45%	22	Yes
	Used clean plate to serve meat (chicken)	5	13.89%	31	86.11%	36	Yes
	Used clean plate to serve meat (beef)	3	8.11%	34	91.89%	37	Yes
	Washed cutting board after food preparation (chicken)	3	8.57%	32	91.43%	35	Yes
	Washed cutting board after food preparation (beef)	2	6.67%	28	93.33%	30	Yes
	Washed knife after food preparation (chicken)	2	5.56%	34	94.44%	36	Yes
	Washed knife after food preparation (beef)	2	6.45%	29	93.55%	31	Yes
	Washed countertop after food preparation (meal 1)	21	55.26%	17	44.74%	38	No
	Washed countertop after food preparation (meal 2)	9	23.68%	29	76.32%	38	Yes
	How often do you use a meat thermometer to see if meat is cooked to a safe temperature?	Reports using thermometer at home (meal 1 only)	6	15.79%	32	84.21%	38
Used thermometer with meat (chicken)		11	29.73%	26	70.27%	37	Yes
Used thermometer with meat (beef)		11	28.95%	27	71.05%	38	Yes
Cooked meat to appropriate temp (chicken)		15	48.39%	16	51.61%	31	No
Cooked meat to appropriate temp (beef)		20	64.52%	11	35.48%	31	No

considered “performed” and the validity was defined as  $\geq 70\%$  agreement. Responses to the questions about thawing frozen foods and washing hands were in agreement with observations of these behaviors. Responses to the question about preventing cross-contamination were in agreement with 11 of 12 cross-contamination behaviors observed during the food preparation activity, with washing the countertop after preparation of the first meal being the discordant behavior. Responses to the question about using a food thermometer were in agreement with three of the five behaviors related to cooking food adequately, but reported thermometer use was discordant with cooking both chicken and beef to the appropriate temperature.

## DISCUSSION

This study was designed primarily to assess the criterion validity of the four food safety survey questions included in the 2018 EFNEP evaluation questionnaire by comparing survey responses to observed food safety behaviors during a food preparation activity in a community test kitchen. Results showed that the survey responses were in agreement with 19 of the 22 behaviors that were assessed during the food preparation observation. However, it is important to note that validation was achieved only when incorrect and correct behaviors were considered “performed.” Additionally, this study was designed to inform targets for increased education and skill development. Survey results and observations of behaviors during the food preparation activity indicated that food safety behaviors were either incorrectly performed or not performed by many of the study participants, highlighting a need for more targeted education to address proper food safety behaviors related to each of the four critical pathogen control factors evaluated in this study.

Responses to the question “How often do you thaw frozen food on the counter or in the sink?” were validated by participants’ responses during the food preparation activity regarding their usual method for thawing meat at home. However, almost half (44.8%) of survey respondents reported that they often, usually, or always thaw meat at room temperature, and more than half (52.6%) reported improper thawing techniques during the food preparation activity. While thawing has seemingly received less attention in the literature relative to other food safety topics, existing evidence suggests that because the majority of microbes that cause foodborne illness are found on the surface of meats, higher thawing temperatures may result in greater microbial growth, as surface areas are first to rise in temperature (1). Thus, the existing evidence and the present results indicate that nutrition education messages within EFNEP curricula should be evaluated and potentially revised to better address safe defrosting methods for consumers.

Responses to the question “How often do you wash your hands with soap and warm running water before preparing food?” were validated by all four observations of participants’

handwashing behaviors during the food preparation activity, when both incorrect and correct behaviors were considered “performed.” For the present study, correct handwashing was defined as washing hands for at least 20 seconds with soap and running water. Incorrect handwashing was defined as washing hands with soap and running water for less than 20 seconds, rinsing hands without using soap, or washing dishes without explicitly washing hands. In response to the survey question, almost all (97.4%) respondents reported that they usually, often, or always wash their hands with soap and warm running water before preparing food. However, observations of handwashing behaviors showed that only 6.3% to 15.8% of study participants correctly washed hands at each of the four time points that were assessed. A majority of participants washed hands incorrectly at all four time points, with inadequate duration of handwashing being the most common reason why the behavior was evaluated as being incorrectly performed. While some previous studies have defined correct handwashing as “using soap and running water at any temperature for any length of time” (13), behaviors in this study were evaluated within the context of the current recommendations of the Centers for Disease Control and Prevention, which base the 20-second recommendation on several studies that have shown that washing hands for 15 to 30 seconds reduces surface microbes to a greater degree than washing for shorter durations (10, 12, 22). Nonetheless, both incorrect and correct handwashing behaviors were used to validate survey responses within the study, so the designation of the 20-second cutpoint for correctly performed handwashing did not affect results of the validation component of the study.

Survey responses to the question “After cutting raw meat or seafood, how often do you wash all items and surfaces that came in contact with these foods?” were validated by 11 of the 12 cross-contamination behaviors that were observed during the food preparation activity. The one cross-contamination activity that was discordant with survey responses to this question was washing countertops after preparing the first meal. Almost all (97.4%) survey respondents indicated that they often, usually, or always wash all items and surfaces that come in contact with raw meat and seafood, and during the food preparation activity, a large majority (74.3% to 94.66%) of participants correctly performed behaviors to reduce cross-contamination by washing knives and cutting boards that came into contact with raw meat and serving cooked meat on clean plates. These observed behaviors suggest that participants were cognizant of food safety measures to prevent cross-contamination with surfaces that came into direct contact with raw meats. However, participants seemed less aware of food safety measures to prevent indirect cross-contamination of kitchen surfaces, as evidenced by the observation that only one-third of participants (34.2%) washed kitchen countertops after preparing the first meal.

Additionally, observers noted that over half (60.5%) of participants introduced one or more opportunities for cross-contamination by touching other ingredients and kitchen surfaces after contact with raw meat and before washing hands, and nearly one third (31.6%) of participants introduced the potential for cross-contaminating kitchen surfaces by washing raw chicken prior to cooking it.

These findings related to cross-contamination are in line with findings of other studies that have used tracer organisms to assess cross-contamination of kitchen surfaces during food preparation activities among study subjects with and without exposure to food safety information (5, 21). Further, although the proportion of study participants who introduced the opportunity for cross-contamination by washing raw chicken is concerning, a recent nationally representative survey found that nearly 70% of respondents reported engaging in this unsafe food preparation practice (15). Given that participants in the present study had received nutrition and food safety education, it is plausible that the lower occurrence of this behavior among this study group may be attributable to the intervention. However, without a baseline assessment or a control group, it is not possible to draw this conclusion. Additionally, earlier evaluations of home food preparation behaviors have shown that individuals of lower socioeconomic status (SES) are less likely than those of higher SES groups to engage in unsafe food safety practices (8, 14). While the reason for this observation is not fully understood, this may also explain the difference between the results of this study, conducted with limited resource populations, and those of the nationally representative survey.

Finally, while survey responses to the question “How often do you use a meat thermometer to see if meat is cooked to a safe temperature?” were validated by participants’ reported and actual use of food thermometers during the food preparation activity, responses to this survey item were not a valid indicator of whether or not participants cooked either chicken or beef to the appropriate temperature. Only 13.2% of survey respondents reported that they often, usually, or always use food thermometers to see if meat is cooked to a safe temperature. During the food preparation activity, only 7.9% of participants reported that they use a food thermometer at home, while 13.5% of participants correctly used the thermometer to check the chicken and 18.4% correctly used the thermometer to check the beef. While the majority of participants cooked the chicken (58.1%) and beef (64.5%) to safe temperatures, most participants reported that they determined the doneness of meats by the color of the cooked meat and its juices or by cooking time. These findings are comparable to those of a national study of the Special Supplemental Food Program for Women, Infants, and Children (WIC), in which the majority of respondents (77.4%) used the color of meat as an indicator of its being cooked to correct temperature and only 7.7% used a food

thermometer (16). Further, findings from the U.S. Food and Drug Administration Food Safety Survey have also shown that food thermometer use has not increased significantly over the past decade, with the 2016 results showing just 19% of American consumers use a food thermometer to determine whether chicken is adequately cooked and 10% use a food thermometer to determine whether hamburgers are adequately cooked (9). Nonetheless, educational messages should emphasize that measurement of the internal temperature with a calibrated food thermometer is the most reliable method to determine whether meat has been adequately cooked (9), and reliance on color or cooking time to determine when meat has reached a safe internal temperature can result in both undercooking and overcooking (3, 20).

This study makes a contribution to the literature by reporting food safety survey data and performing direct observations of food safety behaviors among limited-resource populations. The study also evaluated the criterion validity of food safety questions included in the evaluation tool that is used nationally to evaluate impact of the Expanded Food and Nutrition Education Program. However, it is not without limitations.

Because of the small sample size, the researchers were unable to distinguish between varying answers on the Likert scale, and because of the convenience sampling methodology, results may not be generalizable to populations in other geographic areas. Nonetheless, results are in line with previous findings regarding food safety behaviors in home kitchens suggesting that the study sample was representative of the target population (13, 16). Additionally, while the sample size was less robust than desired, the data provide important insight into the food safety practices within a population that is often excluded from research efforts because of barriers such as limited access to transportation and childcare (2).

It is also important to note that there is no statistical test of validity. However, researchers based their threshold for criterion validity on previous work that has been instrumental in the design and conduct of food safety evaluations (13). A final point of discussion is that the present study was performed in community test kitchens, and equipment and the supplies provided may not be present in the participants’ homes. Having access to certain kitchen equipment and/or the act of being observed during the food preparation may have caused study participants to alter their usual behaviors. However, conducting the observations within community kitchens permitted greater standardization across test sites and served as a less intrusive method for working with the target population.

In summary, although responses to the food safety survey questions included in the 2018 EFNEP evaluation tool were largely validated by observing behaviors during the food preparation activity, the percentage of behaviors

that were incorrectly performed highlight a limitation of survey data. The percentages of behaviors that were both incorrectly performed and not performed highlight a need for more targeted education on the proper food safety behaviors. Leaders within EFNEP and other nutrition education programs may explore strategies to better promote effective behavior change as it relates to improving food safety behaviors within critical control pathways, and more robust evaluations of self-reported and observed food safety behaviors should be considered moving forward.

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