

Food Safety Knowledge and Behaviors of Women, Infant, and Children (WIC) Program Participants in the United States

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ABSTRACT

Although the incidence of foodborne illnesses has declined, thousands of cases are still reported in the United States. In conjunction with industry efforts to reduce foodborne pathogens, consumers play an important role in decreasing foodborne illnesses. To assess food safety knowledge and food handling behaviors of low-income, high-risk populations, a study was conducted with participants of the Special Supplemental Food Program for Women, Infants, and Children (WIC). A survey was conducted with 1,598 clients from 87 WIC agencies nationwide. Descriptive statistics, chi-square analyses, *t* tests, and analyses of variance were calculated. A majority of respondents received food safety information from WIC (78.7%), family (63.1%), and television (60.7%). Most respondents recognized the necessity for washing and sanitizing cutting boards and utensils (94.3%), but only 66.1% knew the correct ways to sanitize. Using a thermometer to ensure doneness of meat was least recognized (23.7%) and used by even fewer respondents (7.7%). The majority (77.4%) used color of meat and/or juices when checking the doneness of ground beef items. Over half of the respondents (58.4%) used acceptable thawing methods, but many thawed frozen meats on the counter (21.0%) or in a sink filled with water (20.6%). There were significant differences in thawing methods, overall knowledge scores, and overall behavior scores among different racial and ethnic groups. White respondents had higher knowledge scores than did Hispanics, and blacks had lower behavior scores than did individuals in the other racial and ethnic groups. Results of the study suggested the need for food safety education for low-income consumers and different messages to be delivered to specific demographic groups.

Although the estimated annual incidence of selected foodborne infections has declined since 1996 through 1998, thousands of cases of foodborne illnesses are still reported in the United States (5). In 2006, a 10-state surveillance report revealed 17,252 laboratory-confirmed cases of the 10 most common foodborne infections, and the majority of these cases were caused by *Salmonella*, *Campylobacter*, *Shigella*, and *Cryptosporidium* (5). Because many foodborne illnesses are not reported, especially those acquired from food prepared in homes, the total incidence of foodborne illnesses probably is much higher.

Researchers speculate that the recent overall decline in some foodborne illnesses may be due to efforts by government agencies to reduce pathogens and promote implementation of hazard analysis and critical control point programs in food processing, manufacturing, and service industries (4). However, the role of consumers in preventing foodborne illnesses cannot be overemphasized because consumers are the last line of defense in the farm-to-table continuum.

Several authors have reported that there is room for improvement in consumer food safety knowledge and food handling practices in homes (1, 2, 17, 21, 24, 26, 32). Researchers also found gaps between what people knew and how people handled food, even though increased food safe-

ty knowledge was positively correlated with improved food handling behaviors in general (1, 7, 14, 19, 33). A consumer survey conducted by the U.S. Food and Drug Administration and the U.S. Department of Agriculture (30) revealed that consumers today have greater food safety knowledge than they have had in the past. However, actual safe food handling practices are not consistently followed.

The Centers for Disease Control and Prevention recommends that consumers follow safe food handling practices and avoid consuming unsafe foods such as unpasteurized milk and raw or undercooked oysters, eggs, ground beef, and poultry because these food items are associated with common foodborne pathogens such as *Salmonella*, *Campylobacter*, Shiga toxin-producing *Escherichia coli* (STEC) O157, and *Listeria* (5). Good personal hygiene practices also prevent transmission of foodborne pathogens between and among people (5).

In a study of consumer food safety knowledge and food handling practices, researchers found that only 66% of participants washed their hands after handling raw meat or poultry (1). These researchers also found that female respondents who were ≥ 30 years old and people with > 12 years of education had more food safety knowledge than did the other groups. However, the increased knowledge was not always associated with better food handling practices (1). In another consumer survey related to poultry handling, researchers found that a greater portion of Hispanics, minors, and undereducated respondents were handling poultry in an unsafe manner compared with other

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groups of respondents (14). In general, researchers concluded that personal hygiene such as hand washing practices, proper cooking, preventing cross-contamination, and storing food items such as take-out foods at a proper temperature are some of the most challenging areas where additional food safety education may be needed (1–3, 14, 15, 19, 20, 33).

Extension services provided by universities and government agencies often include food safety education for the general population. Many programs provide Web-based consumer education, including programs aimed at young people (9, 11–13, 23, 29). The information provided by these services is useful, but it is unknown how much access consumers, especially low-income consumers, have to the food safety information provided by these services.

Previous consumer food safety studies have revealed that few consumers with low household incomes have food thermometers (18), store prepared food items in the refrigerator (18), and wash cutting boards after using them for potentially hazardous food items (21). In contrast, low-income consumers are less likely to consume high-risk foods such as raw shellfish and undercooked hamburgers (21). However, the proportion of low-income consumers in previous consumer research projects was small (<20% of participants). Some studies that focused on food safety knowledge and behaviors of low-income consumers were conducted regionally (25, 32). Therefore, more research was needed to assess food safety knowledge and food handling behaviors of this population.

Participants of the Special Supplemental Nutrition Program for Woman, Infants, and Children (WIC) include population groups considered at high risk for foodborne illness. According to the FoodNet surveillance report for 2004, the incidences of *Salmonella* and *Campylobacter* infection in children <1 year old were much greater than those in older children, and children <5 years old had higher incidences of *Salmonella*, *Shigella*, and STEC O157 infections than did older children (4). Women were more likely than men to be infected by *Salmonella* and STEC O157 (4), and pregnant women were 20 times more likely than men to contract listeriosis and have detrimental results for themselves and their fetuses (6). Adequate food safety knowledge and safe food handling practices are important for parents and guardians of infants and children because these adults prepare foods for their high-risk dependents and act as role models for them.

As of April 2004, more than 8.5 million women, infants, and children were enrolled in the WIC program. A majority of these individuals were Hispanic (39.2%), followed by whites (34.6%), and blacks (20%) (27). The demographic characteristics of WIC participants are different from those of the general population; the WIC program includes a higher proportion of minority and lower income consumers. Although the majority of foodborne infections overall occur among the non-Hispanic white population (4), there were as many or significantly more of these infections among minority groups in certain states with high minority populations (4).

Given that the WIC program serves these high-risk

populations, an understanding of the food safety knowledge and food handling behaviors of WIC participants will support future education efforts. Therefore, this study was designed to assess food safety knowledge and food handling behaviors of adult WIC participants (i.e., pregnant and lactating women) and parents and guardians of children younger than 5 years old that were enrolled in the WIC program. Sources of food safety information for these populations also were identified so that future food safety education programs could be designed appropriately.

MATERIALS AND METHODS

Texas Women's University Institutional Review Board reviewed and approved the use of human subjects and the project methodology.

Study sample. A January 2006 report of WIC staffing data collection revealed approximately 2,200 local WIC offices nationwide (28). Of those offices, 200 randomly selected local WIC offices were contacted by mail and telephone to solicit research participation. The number of offices contacted was stratified based on the number of total WIC participants in each state. Directors of these local WIC offices were asked to administer the survey to 20 adult WIC participants (i.e., pregnant or lactating women) or parents or guardians of children enrolled in the WIC program. The maximum sample size was 4,000 adults 18 years or older throughout the United States. Potential participants were informed about the voluntary nature of the survey when they visited WIC offices and were assured that the decision to participate or not participate in this survey would not affect their WIC eligibility or benefits.

Instrument design. A questionnaire that included questions on demographics (i.e., age, education level, and race or ethnicity), food safety knowledge questions, and a variety of food handling behavior questions was developed. Respondents also were asked where they learned food safety information. Food safety knowledge questions were related to cutting board handling, sanitizing, reheating of hot food leftovers, and checking doneness of ground beef patties. Food handling behavior questions were related to cutting board handling, thawing, storing, and reheating of hot food leftovers, checking doneness of ground beef patties, and handling moldy food items. Although hand washing also is considered a priority area for educating this population (3), questions related to hand washing were not included because the authors anticipated a significant halo effect for self-reported hand washing behaviors.

Once developed, the questionnaire was edited to an appropriate reading level (i.e., 6th grade), reviewed by a panel of eight food safety experts for content validity, translated into Spanish, and pilot tested with 20 WIC participants (10 English-speaking and 10 Spanish-speaking participants) in a north Texas area local WIC office. Internal reliability was tested using Cronbach's alpha ($\alpha \geq 0.85$). According to feedback provided by the expert panel and the results of the pilot test, the questionnaire was revised as appropriate.

Data collection. Of the 200 WIC directors contacted by telephone, 133 gave verbal consent to participate in the study. Twenty-five copies of the survey instrument that included various numbers of both English and Spanish questionnaires, as requested by each director, were sent to each of the WIC directors who agreed to participate. A self-addressed, postage-paid return envelope and 20 coloring books for participants as incentives also were enclosed

TABLE 1. Food safety information sources for WIC participants and parents or guardians of children participating in the WIC program

Source of information	No. of respondents ^a	% of respondents
WIC	1,258	78.7
Family	1,009	63.1
Television	970	60.7
Friends	686	42.9
Newspaper or magazine	651	40.7
School	386	24.2
Work	364	22.8
Radio	339	21.2
Internet	144	9.0
Government programs or hotlines	81	5.1
Other ^b	72	4.5
None	26	1.6

^a Although there were 1,598 participants, the number of total responses exceeds this number because multiple answers were allowed.

^b No specific resources were indicated.

with the questionnaires. Reminder postcards were sent 2 weeks and again 2 months after the initial mailing to WIC directors.

All individual participants were informed that their participation in the survey was completely voluntary and that completion of the survey served as an informed consent to participate in the research, and they were assured that a decision to participate would not affect WIC benefit eligibility in any way. Office staff at each WIC site was asked to distribute and collect questionnaires on a first-come, first-served basis. Completed questionnaires were sent back to the authors for data analyses.

Data analyses. The Statistical Package for Social Sciences software, version 11.5 for Windows (22), was used to perform statistical analyses. Descriptive statistics were calculated to summarize the data. Frequencies and percentages were utilized to describe nominal and ordinal data (8). Means and standard deviations (SDs) were used to describe interval data. Responses to all ordinal level questions were stratified by demographic characteristics (i.e., race or ethnicity, education level, and age of the participants) and assessed for significance at the $P < 0.05$ level using chi-square analyses.

Overall food safety knowledge and behavior scores (both continuous variables) were created by adding discrete values (values 0 or 1) of individual responses. The number of correct (knowledge score) or desirable and/or acceptable (behavior score) responses were added for each participant. Knowledge scores ranged from 0 to 6, and behavior scores ranged from 0 to 8. To identify differences in knowledge scores and behavior scores between and among demographic groups, independent samples t tests and analyses of variance (ANOVAs) with Scheffé's post hoc analyses were conducted.

RESULTS

Of the 133 local WIC offices that agreed to participate, 87 offices located in 31 states returned 15 to 20 completed questionnaires, for a total of 1,598 usable responses. Almost half of the respondents were non-Hispanic white (47.9%), followed by Hispanic (33.2%) and non-Hispanic black Americans (12.1%). The most common age range of

TABLE 2. WIC participant responses to food safety knowledge questions related to cutting boards and food handling (n = 1,598)^a

Question	No. of respondents	% of respondents
The cutting board is a common place for germs to get in foods True ^b	1,322	85.5
Cutting board should always be sanitized after preparing raw meat True ^b	1,461	94.3
A plastic cutting board only needs to be rinsed off False ^b	1,240	80.2
Definition of sanitize Recognized (i.e., apply bleach solution or boiling water)	1,027	66.1
Safest way to keep leftovers that are served hot Cool, cover, and refrigerate within 2 h ^b	818	53.5
Cover and put them into refrigerator right away	516	33.7
It does not matter how long they are kept at room temperature as long as boiled before eating	28	1.8
I don't keep leftovers	168	11.0
Best way to check doneness of ground beef patties Color of meat or juice	823	57.0
Internal temperature ^b	205	23.7
Leave pink inside	355	13.7
Burnt or dry	84	5.6

^a The total number of responses for each item differs because of missing data.

^b Most desirable answer.

respondents was 21 to 25 years (28.8%), followed by 26 to 30 years (22.8%), 18 to 21 years (18.6%), and 31 to 35 years (15.6%). The sample comprised only women, and most participants had completed high school (36.8%), some college (23.7%), or some high school (20.9%). Only 9.5% indicated they had completed a college degree, and 9.1% had an 8th grade level or less education.

The majority of the respondents reported that they obtained food safety information from WIC (78.7%) followed by family (63.1%) and television (60.7%) (Table 1). Government hotlines and the Internet were used by a small number of respondents (5.1 and 9.0%, respectively).

Food safety knowledge. The percentages of participants who responded correctly to statements on food safety knowledge are found in Table 2. Most respondents knew that the cutting board is a common place for germs to contaminate foods, the cutting board should be sanitized after preparing raw meat, and a plastic cutting board was not to be just rinsed off.

Although the percentage of respondents who answered knowledge questions related to cutting boards correctly was high, only about two-thirds recognized the definition of san-

TABLE 3. WIC participant responses to behavior questions related to handling cutting boards (n = 1,598)^a

Question	No. (%) of respondents				
	Always	Often	Sometimes	Seldom	Never
Do you use a cutting board when preparing food?	572 (36.5)	280 (17.8)	508 (32.4)	89 (5.7)	120 (7.6)
Do you clean the cutting board after using it for raw meat, poultry, and fish?	1,408 (91.5)	51 (3.3)	26 (1.7)	8 (0.5)	46 (3.0)
Do you sanitize the cutting board and knife after preparing raw meat, poultry, and fish?	1,170 (76.1)	146 (9.5)	102 (6.6)	34 (2.2)	86 (5.6)

^a The total number of responses for each item differs because of missing data.

itizing correctly (i.e., apply bleach solution or boiling water on the cutting board) and 64.5% recognized the safest way to handle hot food leftovers. Even fewer (23.7%) knew that the best way to check the doneness of ground beef patties was to check the internal temperature. The “color of meat or juices” was identified by the majority (57.0%) as the best way to check doneness of ground beef patties. Some respondents chose leaving pink inside of the beef patties as the best way (13.7%), and others chose to overcook to ensure doneness (5.6%) (Table 2). The overall knowledge score indicated that respondents were knowledgeable about food safety for two-thirds of items asked (mean \pm SD, 4.09 \pm 1.07 with a maximum possible score of 6.0).

Self-reported food handling behaviors. Food handling behavior questions (Table 3) related to cutting board use were scored on a five-point scale for the following responses: never, seldom, sometimes, often, and always. Only 50.4% of the respondents agreed that they often or always used a cutting board when preparing foods. More than 90% stated they always cleaned the cutting board and/or knife after using it for raw meat, poultry, or fish, but fewer (76.1%) always sanitized the cutting board and/or knife after preparing raw meat, poultry, or fish.

Other food handling behavior questions were related to thawing frozen meat, poultry, and fish items, handling hot food leftovers and moldy food, and cooking ground beef patties. Approximately 60% of respondents reported using the most desirable or an acceptable method of thawing frozen meat, poultry, and fish. However, a significant number of respondents thawed frozen food on the counter (21.0%) or in a sink filled with water (20.6%). For storing hot food leftovers, only 31.5% reported that they cooled quickly, covered, and refrigerated these leftovers. A smaller but significant number of respondents (9.2%) reported that they left leftovers on the stove or countertop without refrigerating until later use.

Twenty-eight percent of respondents stated that they cooked stuffing inside a turkey, although 20.2% removed the stuffing before putting away leftovers. For hot food leftovers, 58.1% of respondents reported that they reheated the leftover until steaming hot, but 24.4% stated that they reheated the food until it was “just warm enough to eat.” Almost all respondents (94.3%) stated that they threw the entire package of cream cheese or cottage cheese away when mold was found (94.3%).

Only about 30% of respondents had food thermometers

in their kitchens, and 38% stated that they had used a food thermometer to check the doneness of a cooked food. In practice, only 7.7% reported that they used a food thermometer to test the doneness of ground beef patties. Over three-fourths of respondents reported they used the color of the meat or juice to determine the doneness. Some stated that they finished cooking the meat with some pink inside (3.2%) or overcooked it until the outside was burnt or dry to ensure doneness (5.6%) (Table 4). The average behavior score was 5.92 \pm 1.07 (maximum possible score of 8.0), indicating that respondents reported following acceptable food handling procedures for three-fourths of the items.

Differences in reported behaviors and knowledge among demographic groups. The majority of respondents relied on family for food safety information (Table 1). Differences in food handling behaviors based on race or ethnicity (Table 5) may be partially due to where respondents received food safety information. There were distinguishable food handling behaviors among different racial or ethnic groups. More white respondents reported using a food thermometer (46.1%) than did members of the other groups (36.2% for black respondents and 25.4% for Hispanic respondents). In addition, nearly half of white respondents thawed frozen meat items in the refrigerator (44.8%), whereas black and Hispanic respondents thawed meat on the counter (26.6 and 22.6%, respectively) or in a sink filled with water (31.9 and 26.7%, respectively). Although the majority of respondents from all racial or ethnic groups used color as a determining factor for checking doneness of meat items, more black respondents reported consuming meat with pink inside (7.5%), and more Hispanic respondents reported that they burnt meat items to ensure doneness (11.3%).

Overall knowledge and behavior scores also were different among the age groups (Table 6). Respondents older than the age of 25 years had significantly higher knowledge scores (4.17 \pm 1.07) and behavior scores (6.00 \pm 1.07) than did respondents aged 18 through 25 (4.03 \pm 1.05 and 5.84 \pm 1.06, respectively) based on independent sample *t* tests ($P < 0.01$).

Knowledge and behavior scores also differed significantly among participants of different education levels and racial or ethnic groups ($P < 0.001$) based on the ANOVA results (Table 7). Scheffé’s post hoc analysis results indicated that respondents who had some high school or less education had significantly lower knowledge and behavior

scores than did respondents who had high school or beyond high school education. Significant differences among the four ethnic groups on knowledge and behavior scores also were identified ($P < 0.001$). White respondents had significantly higher knowledge scores than did Hispanic respondents, and black respondents had significantly lower behavior scores than did members of the other three racial or ethnic groups ($P < 0.001$).

DISCUSSION

In several studies, consumer food handling practices have been examined (1, 7, 16, 26, 32). However, only a few studies have been focused on food safety knowledge and behaviors of low-income consumers (32). Safe food handling practices are important for all consumers, but they may be more important for those at high risk of foodborne illness (7, 16, 34).

In this study, participants and/or their family members were at high risk for foodborne illness and were low-income consumers whose food safety knowledge and food handling behaviors have not been well studied. Results reinforced previous research indicating a gap between what people know about safe food handling and what they actually do in their own kitchens (1). More specifically, discrepancies between knowledge and reported food handling behaviors existed in cleaning and sanitizing cutting boards, handling hot food leftovers, using food thermometers, and checking doneness of ground beef patties. These food handling practices are particularly important because several of the 10 most common foodborne pathogens monitored by FoodNet are associated with food that has been inadequately cooking and/or contaminated with fecal or environmental pathogens (e.g., *Salmonella*, *Campylobacter*, STEC O157, *Listeria*, and *Yersinia*) (15). These pathogens also are easily transferred by cross-contamination through cutting boards and knives. Therefore, checking the doneness of meat items (e.g., ground beef and chicken) with a food thermometer and sanitizing cutting boards and knives are important practices for ensuring food safety. These behaviors also have been identified as consumer food handling behaviors associated with prevention of common foodborne illnesses (10).

Results of this study can be compared with those of previous studies that focused on food safety knowledge and food handling behaviors of consumers. More respondents from this study identified the safest way to keep hot food leftovers (53.5%) than did those in a previous study, in which only 35% provided the correct answer (32). The difference between these studies may be due to the education level of respondents. In the previous study (32), only 10% of respondents had some college or higher education, whereas about 33% of respondents in the present study had that level of education.

A meta-analysis of previous research revealed that consumers with more education and/or higher incomes consumed more risky foods such as undercooked hamburgers and shellfish (17). Only 3.2% of participants of this study reported consuming hamburgers with pink inside, compared with 19% of consumers with advanced degrees (i.e., beyond

TABLE 4. WIC participant responses to additional food handling behavior questions (n = 1,598)^a

Question	No. of respondents	% of respondents
How do you thaw frozen meat, poultry, and fish?		
In the refrigerator ^b	554	35.5
On the counter	327	21.0
In sink of water	321	20.6
In microwave ^c	203	13.0
Under running water ^c	128	8.9
Cook frozen ^c	16	1.0
What do you do with hot foods not served right after cooking?		
Cool, cover, and refrigerate quickly ^b	483	31.5
Leave on counter to cool, then refrigerate	483	31.5
Cover and refrigerate immediately, no cooling	425	27.7
Leave on counter for later use	141	9.2
What do you do before serving leftovers?		
Reheat until steaming ^b	895	58.1
Reheat until just warm enough to eat	375	24.4
Do not keep leftovers	250	16.2
Do not reheat leftovers	20	1.3
When do you stop cooking ground beef patties?		
Color of meat or juice	1,178	77.4
Correct temperature ^b	117	7.7
Do not cook this item	93	6.1
Burnt or dry	86	5.7
Leave pink inside	48	3.2
If you find mold on cream cheese or cottage cheese, what do you do?		
Throw away the entire package	1,447	94.3
Scoop out little more than the moldy part and eat the rest	58	3.8
Scoop out the moldy part and eat the rest	30	2.0
Do you cook the stuffing inside when roasting a chicken or turkey?		
No	659	43.0
Yes	428	28.0
I don't cook stuffing	444	29.0

^a The total number of responses for each item differs because of missing data.

^b Most desirable response.

^c Acceptable responses.

a bachelor's degree) who consumed undercooked hamburgers (18). Because less than 10% of respondents in the present study held at least a bachelor's degree, results of this study seem to be consistent with those of other research projects. Other studies also revealed that older consumers had safer food handling practices (24, 32). In the present study, higher mean food safety knowledge and behavior scores were recorded for participants >25 years old than for those who were 18 through 25 years old.

The public has been counseled not to use visual signs

TABLE 5. Significant differences in food handling behaviors based on race or ethnicity of WIC participants (n = 1,598)^a

Questions	No. (%) of respondents				P ^c
	Non-Hispanic white	Non-Hispanic black	Hispanic	Other ^b	
Have used a thermometer					<0.001
Yes	344 (46.1)	67 (36.2)	128 (25.4)	47 (44.3)	
No	402 (53.9)	118 (63.8)	374 (74.6)	59 (55.7)	
Total	746 (100.0)	185 (100.0)	502 (100.0)	106 (100.0)	
Thawing method					<0.001
On counter	139 (18.7)	50 (26.6)	115 (22.6)	20 (18.7)	
In sink full of water	102 (13.7)	60 (31.9)	136 (26.7)	22 (20.5)	
In microwave	124 (16.7)	5 (2.7)	56 (11.0)	18 (16.8)	
Under running water	35 (4.7)	18 (9.6)	79 (15.5)	5 (4.6)	
In refrigerator	333 (44.8)	55 (29.3)	119 (23.4)	42 (39.2)	
Cook frozen	11 (1.5)	0 (0.0)	4 (0.8)	0 (0.0)	
Total	744 (100.0)	188 (100.0)	509 (100.0)	107 (100.0)	
Checking doneness of meat					<0.001
Color	592 (83.2)	154 (85.9)	332 (77.0)	85 (86.0)	
Pink inside	32 (4.5)	13 (7.5)	9 (2.0)	1 (1.0)	
Temperature	62 (8.7)	7 (3.9)	41 (9.5)	6 (6.0)	
Burnt or dry	25 (3.5)	5 (2.7)	49 (11.3)	7 (7.0)	
Total	711 (100.0)	179 (100.0)	431 (100.0)	99 (100.0)	

^a The total number of responses for each item differs because of missing data.

^b Native American, Asian or Pacific Islander, other, or those who declined to answer.

^c Based on chi-square analyses.

such as color of the meat or juices to determine doneness of meat. Experts caution that such visual signs should be reserved for situations in which the food has already reached a safe internal temperature (31). The natural browning of meat during storage from oxidation may mislead the consumer when using only the color of the meat to determine doneness. However, the majority of consumers in this study used color to check doneness of the meat rather than using a food thermometer. Previous studies showed that consumers with more education and higher incomes had food thermometers in their homes (>40%) (18), whereas only 29.7% of respondents in the present study reported having a food thermometer.

Cross-tabulation of age, race or ethnicity, and education levels with food safety knowledge and food handling practice revealed some associations between knowledge and behaviors and demographic characteristics. Hispanic or black respondents and those who did not graduate from high school were less likely to have used a food thermometer. White respondents with a high school education thawed frozen meat, poultry, and fish items more safely than did Hispanic and black respondents and those without

a high school diploma. Some of these results were consistent with previous reports of lower food handling practice scores for less educated and lower income consumers (24).

Knowledge and behavior differences among different ethnic groups may be explained by the source of education about food safety. In addition to WIC, the family was identified as the most prevalent source for food safety information in this study. If respondents learned certain food handling behaviors from their families, this may account for differences in food handling practices related to ethnicity. In a study of low-income consumers in Florida, family was the most important influence on food handling behaviors (25).

According to a meta-analysis, there are distinctive differences in food handling knowledge and behaviors for specific ethnic groups (17). More risky food behaviors related to raw or undercooked ground beef consumption were reported by white respondents, whereas black respondents consumed fewer raw or undercooked food items than did members of other racial or ethnic groups (17). However, in this study, which had only a small proportion of black respondents (12.1% of total respondents), more blacks (7.5%)

TABLE 6. Comparisons of mean scores of knowledge and behavior of WIC participants in different age groups (n = 1,598)^a

Group	Knowledge				Behavior			
	Mean	SD	t	P	Mean	SD	t	P
Age (yr)			-2.60	0.009			-3.03	0.002
18-25	4.03	1.05			5.84	1.06		
>25	4.17	1.07			6.00	1.07		

^a Comparison was based on independent t test. Maximum scores were 6.0 for the knowledge test and 8.0 for the behavior test.

TABLE 7. Comparisons of mean scores of knowledge and behavior of WIC participants in different education groups and different ethnic groups^a

Group	n	Knowledge				Behavior			
		Mean	SD	F	P	Mean	SD	F	P
Education	1,576			38.08	<0.001			16.48	<0.001
Some high school or less	473	3.77 x	1.14			5.69 x	1.08		
High school diploma	580	4.13 y	1.01			5.99 y	1.07		
Beyond high school	523	4.35 y	1.07			6.06 y	1.03		
Ethnicity	1,548			11.63	<0.001			18.72	<0.001
Non-Hispanic white	757	4.26 x	0.98			6.03 x	1.08		
Non-Hispanic black	192	3.98 xy	1.10			5.39 y	1.13		
Hispanic	525	3.92 y	1.13			5.94 x	0.96		
Other ^b	74	3.99 xy	1.16			5.96 x	1.11		

^a Scores were based on an ANOVA. Maximum scores were 6.0 for the knowledge test and 8.0 for the behavior test. Within a column, means followed by different letters are significantly different (Scheffé's multiple range comparison test, $P < 0.05$).

^b Native American, Asian or Pacific Islander, other, or those who declined to answer.

consumed undercooked ground beef patties than did whites (4.5%) or Hispanics (2%).

That meta-analysis also revealed that white and Hispanic populations were less likely to follow safe food handling procedures for preventing cross-contamination, including washing and sanitizing cutting boards and other utensils (17). However, those researchers did not determine food handling behaviors related to proper cooking and thawing methods across all racial or ethnic groups (17) as was done in the present study. Identification of unsafe food handling practices specific to certain racial or ethnic groups may help focus education efforts to target specific racial or ethnic groups.

This study was focused on food safety knowledge and food handling behaviors of low-income consumers with family members who are at high risk for foodborne illnesses. Findings from this study were consistent with those of previous research studies that revealed disparities between food safety knowledge and behaviors and areas where additional consumer food safety education may be needed. Despite many available online resources, the majority of low-income consumers did not utilize such information. Although food safety is not the main education focus of the WIC program, this program was identified as a food safety information source by the majority of respondents of this study. Thus, there is an opportunity to approach this population through WIC and other food assistance programs available to low-income consumers. Many respondents identified their family as the next most available source for food safety information, and results showed distinctive differences in food handling behaviors based on racial or ethnic groups. Therefore, further education efforts may need to target specific racial or ethnic groups with relevant and culturally sensitive education materials.

The content of future food safety education for low-income consumers should be consistent with the Fight BAC! themes: clean, separate, cook, and chill. This study revealed a lack of knowledge and the prevalence of undesirable behaviors of low-income consumers in some of these four areas. One of the least desirable practices dem-

onstrating poor food safety knowledge was lack of thermometer use to check doneness of meat items. Consumers must be educated that the only reliable way to ensure doneness of meat, poultry, and fish is to check internal temperatures. Distribution of inexpensive food thermometers and instructions on how to use them correctly could accompany the food safety education programs targeting this population.

Study respondents were from 31 states, and the researchers did not find any association between results and geographical location. However, because survey respondents were only females enrolled in WIC and the majority were relatively young (≤ 35 years old), the results may not be generalized to low-income males, older populations, and those not eligible for the WIC program. The types of questions related to food safety knowledge and behaviors used in this study did not represent all aspects of recommended consumer food safety education content (e.g., Fight BAC!). Future studies should explore all aspects of food safety knowledge and food handling behaviors to identify areas in which effective food safety education is needed. Other low-income consumer groups who were not represented in this study should be identified and approached with food safety messages. Once education needs and ways to approach diverse groups are identified, culturally sensitive food safety education programs can be developed and provided for different populations to improve their knowledge and eventually their food handling practices.

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