Consumer Knowledge of Foodborne Microbial Hazards and Food-Handling Practices

SEAN F. ALTEKRUSE,* DEBRA A. STREET, SARA B. FEIN, and ALAN S. LEVY

Division of Market Studies, Office of Scientific Analysis and Support, Center for Food Safety and Applied Nutrition, Food and Drug Administration, Washington, D.C. 20204, USA

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ABSTRACT

A national telephone survey was conducted of 1,620 randomly selected U.S. residents who spoke English, were at least 18 years old, and resided in households with kitchen facilities. Respondents were interviewed about their recognition of foodborne pathogens, foods at risk for transmitting infection, knowledge of safe food handling, and food-handling practices.

One-third of the respondents who prepared meals reported unsafe food hygiene practices: e.g., they did not wash hands or take precautions to prevent cross-contamination from raw meat. Unsafe practices were reported more often by men, adults 18 to 29 years of age, and occasional food preparers than by women, persons 30 years old or older, and frequent food preparers. Respondents who identified a food vehicle for Salmonella spp. were more likely to report washing their hands and cleaning cutting boards after preparing raw meat and poultry.

The results raise concerns about consumer food-handling practices. The influence of food safety training, food-handling experience, and age on food-handling practices should be studied further. Awareness of a food vehicle for Salmonella spp., for example, may indicate knowledge of the etiology of foodborne disease that promotes safe food handling. Understanding the factors associated with safe food handling will assist in development of effective safe-food instruction programs.

Key words: Consumer, food handling, Salmonella, survey

Over 10% of the U.S. population experiences a foodborne illness each year, at an annual cost to the economy that approaches $10 billion (1, 2, 16). Prevention of foodborne infections in the United States is based on pathogen-free food production, hazard control in food processing, surveillance for foodborne illness, and safe food handling by consumers and food-service workers (8). The practices developed by professionals to ensure the safety of food production and processing are based primarily on knowledge of food microbiology. The extent to which consumers' food-handling practices are influenced by these etiologic considerations is uncertain; few published studies have examined factors associated with consumers' self-reported food-handling practices (20, 21).

We analyzed data from a nationwide survey of 1,620 consumers who were asked about their awareness and knowledge of specific microbial pathogens in food, their knowledge of certain food safety principles, and their typical food-handling practices. We hypothesized that knowledge of specific microbial pathogens is associated with greater knowledge of food safety principles and safer reported food-handling practices. The specific food-handling practices we examined were washing hands, preventing cross-contamination, and thorough cooking of meat.

METHODS

Sample

A national telephone survey was designed to estimate the level of consumer understanding of microbiological hazards in foods, knowledge of food safety principles, and the prevalence of safe food-handling practices. Westat, Inc. (Rockville, MD) conducted interviews from 16 December 1992 through 7 February 1993. A probability sample of telephone households was selected according to a modified Waksberg random-digit dialing method, using a multistage cluster design (19). A total of 1,620 persons who were 18 years of age or older, spoke English, and resided in households with cooking and food storage facilities completed the survey, resulting in a response rate of 65%.

Information from all 1,620 participants was included in the analysis concerning knowledge of foodborne pathogens. Of the 1,620 persons surveyed, 1,415 prepared meat or chicken as part of the main meal of the household on at least some occasions. Responses about food-handling knowledge and practices were obtained from these individuals.

Questions on knowledge of foodborne pathogens

A series of questions assessed the respondent's awareness of eight foodborne pathogens. The questions used the most commonly recognized name for the pathogen or associated disease: salmonella for Salmonella spp., campylobacter for Campylobacter jejuni or C. coli, listeria for Listeria monocytogenes, botulism for Clostridium botulinum, staphylococcus for Staphylococcus aureus, cholera or
vibrio for *Vibrio cholerae* and other *Vibrio* spp., trichinosis for *Trichinella spiralis*, and hepatitis virus for hepatitis A virus. Respondents were asked to name foods which were associated with the transmission of each pathogen. For example: Have you heard of salmonella as a problem in food? (The possible response was yes or no.) Do you remember what kinds of foods you heard were related to salmonella problems? (The question was open-ended and interviewers recorded responses on a checklist.)

Respondents who named, in their first response, a probable food vehicle for the transmission of a foodborne pathogen were classified as knowing a food vehicle for that pathogen. Respondents who were unable to name a food vehicle or named an unlikely food vehicle were classified as not knowing a food vehicle for that pathogen. Information in scientific publications (4, 5, 7, 12) was used to determine which foods would be included in a list of probable foods for the transmission of each pathogen. The foods classified as common vehicles for the transmission of *Salmonella* spp. were beef, pork, lamb, poultry, milk, eggs, and mayonnaise. The foods classified as vehicles for the transmission of *Campylobacter jejuni* or *C. coli* were beef, pork, lamb, poultry, milk, and water; *Listeria monocytogenes*, lamb, poultry, milk, cheese, other dairy products, vegetables or fruit salad, and water; *Clostridium botulinum*, fish and canned foods; *Staphylococcus aureus*, egg salad, fish salad, meat salad, reheated leftovers, stews, homemade soups, milk, and improperly handled foods; *Vibrio cholerae* or other *Vibrio* spp., shellfish, raw or undercooked fish, and water; *Trichinella spiralis*, pork and raw meat; and hepatitis A virus, shellfish, shellfish eaten raw, improperly handled food, and water.

**Questions on food handling**

Three food-handling principles were examined. Two principles were related to food hygiene (washing hands and preventing cross-contamination of foods). The third principle related to thorough cooking of meat and poultry. Respondents were asked two questions on each of the food safety principles. One question was designed to evaluate knowledge of how the practice affects the risk of food poisoning. The second question was designed to evaluate self-reported at-home practices.

The two questions for hand-washing were as follows: “Do you think washing your hands with soap before you prepare food makes food poisoning more likely to occur, less likely to occur, or makes no difference?” (The knowledgeable answer was “less likely to occur.”) “After handling raw meat or chicken, do you usually continue cooking, or do you first rinse your hands with water, or wipe them, or wash them with soap?” (The response denoting safe practice was “wash them with soap.”)

The two questions about preventing cross-contamination of foods were as follows: “Do you think serving steak on the same plate that held raw steak without washing the plate makes food poisoning more likely to occur, less likely to occur, or makes no difference?” (The knowledgeable answer was “more likely to occur.”) “After you have used a cutting board or other surface for cutting raw meat or chicken, do you use it ‘as is’ for other food to be eaten raw for the same meal, or do you first rinse it, or wipe it, or wash it with soap?” (Responses in addition to those listed in the question were accepted. The following practices were considered safe: wash cutting board with soap or bleach; use another cutting board.)

The two questions about adequate cooking of meat were as follows: “Do you think cooking meat until it is medium well or well done makes food poisoning more likely to occur, less likely to occur, or makes no difference?” (The knowledgeable answer was “less likely to occur.”) “In your home, are hamburgers usually served rare, medium, or well done?” If the response was “medium,” another question was asked, “Do you mean they are brown all the way through or still have some pink in the middle?” (The responses denoting safe practice were “medium” (brown all the way through) and “well done.”)

**Statistical analysis**

We examined the distribution of participants according to demographic characteristics and frequency of food preparation. The percentage of participants who were aware of specific foodborne pathogens and the percentage of participants who knew a common food for the transmission of *Salmonella* spp. were also calculated. Chi-square tests were performed to determine whether demographic characteristics and frequency of food preparation were related to knowledge of safe food-handling principles and safety of reported food-handling practices.

Odds ratios were used to estimate the strength of the association between knowledge of food vehicles for transmission of *Salmonella* spp. and knowledge and practice of safe food handling. This pathogen was chosen because of its widespread recognition as a foodborne pathogen. The 95% confidence interval for each odds ratio was approximated by using Woolf’s method (13). Logistic regression analysis was conducted to obtain adjusted odds ratios, i.e., to evaluate the strength of the association after controlling for age, gender, education, and frequency of food preparation.

The data for the above analyses were weighted for certain household and respondent factors. Weights were calculated to account for differential selection probabilities due to different numbers of households in a cluster, phones per household, and persons 18 or more years of age in a household. The data from the sample were also weighted by respondents’ education level, race, and marital status according to 1990 U.S. census distributions. SUDAAN (11), a statistical package used to account for weights derived from the complex sample survey, was run with a SAS program (14) to obtain adjusted variance estimates that were used in the chi-square and logistic regression analyses.

**RESULTS**

After the sample was weighted to 1990 U.S. census distributions for educational status, race, and marital status, a somewhat higher proportion of respondents were women (55.0%). Persons aged 65 years and older comprised the smallest age group in the weighted study sample (13.3%). Almost 36% of participants had completed 12 years of education, and nearly 44% had completed more than 12 years of education. A large proportion of persons surveyed, about 90%, prepared the household’s main meal either all or some of the time.

**Knowledge of pathogens**

Tables 1 and 2 present the results of weighted analyses for awareness of eight major foodborne microbial hazards, knowledge of common food vehicles for transmission of those pathogens, and selected characteristics of persons who knew a common food vehicle for *Salmonella* spp. A large proportion of the total sample claimed to have heard of *Salmonella* spp. (80.2%) and *Clostridium botulinum* (74.8%). *Campylobacter jejuni* or *C. coli* (4.7%) was the least recognized of the eight pathogens. When respondents were asked what food(s) they associated with the transmission of
TABLE 1. Percentage of total respondents who were aware of each foodborne pathogen and a common food vehicle for the transmission of the pathogen

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Aware of pathogen (%)</th>
<th>Knew food vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella spp.</td>
<td>80.2</td>
<td>53.7</td>
</tr>
<tr>
<td>Clostridium botulinum</td>
<td>74.8</td>
<td>23.1</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
<td>40.8</td>
<td>26.1</td>
</tr>
<tr>
<td>Hepatitis A virus</td>
<td>39.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>25.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Vibrio spp., V. cholerae</td>
<td>25.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>9.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Campylobacter jejuni/coli</td>
<td>4.7</td>
<td>0.4</td>
</tr>
</tbody>
</table>

*Percentages are derived from weighted analysis; n = 1,620 before weighted adjustment.

Table 1 shows that each pathogen, the proportion of total participants who knew a likely food vehicle was highest for Salmonella spp. (53.7%), followed by Trichinella spiralis (26.1%) and Clostridium botulinum (23.1%). Fewer than 15% knew a common food vehicle for hepatitis A virus, Staphylococcus aureus, Vibrio cholerae or other Vibrio spp., Listeria monocytogenes, or Campylobacter jejuni or C. coli.

The proportions of those who were able to name a food vehicle which transmitted Salmonella spp. were higher for women, people with more than 12 years of education, and individuals who usually prepare the main meal than for men, individuals with 12 or fewer years of education, or occasional preparers of the main meal. The proportion of those who were able to identify a food vehicle for Salmonella spp. was lower for persons aged 18 to 29 years than for persons in higher age categories.

### Food handling

Figure 1 and Table 3 show the results of the food-handling analysis. Of the 1,415 persons who prepared meals containing meat or chicken at least some of the time, approximately two-thirds or more reported safe practices for washing hands, preventing cross-contamination, and adequate cooking of meat (Fig. 1). The proportion of food preparers who responded knowledgeably about safe hygiene principles was greater than the proportion who reported using safe practices. Eighty-six percent of the food preparers knew that hand washing reduces the risk of food poisoning, but only 66% washed their hands after handling raw meat or poultry. Eighty percent of the food preparers knew that serving steak on a plate that had held the raw steak increased the risk of food poisoning, but only 67% cleaned a cutting board after contact with raw meat or poultry. Some groups had conspicuous differences between levels of knowledge and practices: males, people younger than 30 years of age, those with more than 12 years of education, and infrequent food preparers (Fig. 1).

The disparity between prevalence of knowledge and self-reported safe practice observed for hygienic principles (washing hands and preventing cross-contamination) was not observed for adequate cooking of meat and poultry. Sixty-seven percent of the food preparers knew that cooking meat until well done reduces the risk of food poisoning; 71% served adequately cooked hamburgers at home (Fig. 1). Gender, age, and frequency of cooking were related to food-handling practices for washing hands and cleaning cutting boards. Women, people aged 30 years or older, and frequent food preparers reported safer practices than did men, people younger than 30 years, and occasional food preparers. Knowledge of food hygiene principles did not increase with age, but safe practices did. Conversely, knowledge of the effect of hand washing increased with education, but hand-washing practices did not differ by educational status (Fig. 1). Similarly, knowledge of the principle of thorough cooking of meat increased with education, but the practice of serving adequately cooked hamburgers decreased with years of education.

### Multivariate analysis

The 1,415 consumers who prepared meals at home at least some of the time were included in a logistic regression analysis to assess the strength of the association between knowledge of a vehicle for transmission of Salmonella spp. and food-handling practices. After controlling for gender, age, education, and frequency of meal preparation, the odds of knowing and reporting safe practices for the hygienic principles of washing hands and preventing cross-contamination were 1.5 to 2.3 times greater for persons who could specify a vehicle for Salmonella spp. than for those who could not specify a vehicle (Table 3).

TABLE 2. Percentage of respondents who specified a food vehicle for transmission of Salmonella spp., within demographic categories

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Knew food vehicle for Salmonella spp. (%)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>49.2</td>
</tr>
<tr>
<td>Female</td>
<td>57.4</td>
</tr>
<tr>
<td></td>
<td>$\chi^2 = 7.67, P = 0.01$</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>18–29 yr</td>
<td>42.5</td>
</tr>
<tr>
<td>30–39 yr</td>
<td>57.1</td>
</tr>
<tr>
<td>40–49 yr</td>
<td>58.2</td>
</tr>
<tr>
<td>50–64 yr</td>
<td>60.4</td>
</tr>
<tr>
<td>65 yr</td>
<td>52.9</td>
</tr>
<tr>
<td></td>
<td>$\chi^2 = 18.82, P &lt; 0.009$</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>&lt;12 yr</td>
<td>35.1</td>
</tr>
<tr>
<td>12 yr</td>
<td>51.6</td>
</tr>
<tr>
<td>&gt;12 yr</td>
<td>64.3</td>
</tr>
<tr>
<td></td>
<td>$\chi^2 = 41.49, P &lt; 0.009$</td>
</tr>
<tr>
<td>Prepare main meal</td>
<td></td>
</tr>
<tr>
<td>All/nearly all the time</td>
<td>59.0</td>
</tr>
<tr>
<td>Only some of the time</td>
<td>50.9</td>
</tr>
<tr>
<td>Never</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>$\chi^2 = 16.91, P &lt; 0.009$</td>
</tr>
</tbody>
</table>

a Percentages are derived from weighted analysis; n = 1,620 total respondents before weighted adjustment.
Hand-Washing

Percentage who think that washing hands before preparing food decreases risk of food poisoning.

Percentage who wash their hands after handling raw meat or poultry.

Overall

Gender

Age

Education

Cook meals

FIGURE 1. Percentage of respondents who gave knowledgeable or safe responses to questions on safe food handling (washing hands, preventing cross-contamination, and adequate cooking of meat) by demographic characteristic and frequency of food preparation; \( n = 1,415 \) before weighted adjustment. *\( P \leq 0.05 \) for chi-square tests.
Preventing Cross-Contamination

Percentage who think that putting steak on a plate that held raw meat increases risk of food poisoning.

Percentage who wash or change cutting boards after cutting up raw meat or poultry.

Overall

Gender

Male
Female

Age

18-29
30-64
65+

Education

< 12 y
= 12 y
> 12 y

Cook meals

Usually
Sometimes

FIGURE 1. (Continued)
Adequate Cooking

Percentage who think cooking meat "well done" decreases the risk of food poisoning.

Percentage who serve hamburgers medium or well done.

FIGURE 1. (Continued)
TABLE 3. Crude and adjusted odds ratios and 95% confidence intervals (CI) for the association between knowledge of a food vehicle for Salmonella spp. and safe food-handling knowledge and practice among respondents who prepared food

<table>
<thead>
<tr>
<th>Question</th>
<th>Crude odds ratioa (95% CI)</th>
<th>Adjusted odds ratiob (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinks washing hands reduces risk of food poisoning</td>
<td>2.97 (1.97–4.49)</td>
<td>2.27 (1.53–3.36)</td>
</tr>
<tr>
<td>Washes hands after handling raw meat</td>
<td>1.54 (1.19–1.98)</td>
<td>1.45 (1.10–1.90)</td>
</tr>
<tr>
<td>Thinks serving steak on a plate that held raw steak increases risk of food poisoning</td>
<td>1.99 (1.49–2.67)</td>
<td>1.93 (1.44–2.60)</td>
</tr>
<tr>
<td>Washes or changes cutting board after cutting raw meat or poultry</td>
<td>1.86 (1.41–2.45)</td>
<td>1.80 (1.37–2.37)</td>
</tr>
<tr>
<td>Thinks cooking meat “well done” decreases food poisoning</td>
<td>1.70 (1.27–2.78)</td>
<td>1.48 (1.10–1.98)</td>
</tr>
<tr>
<td>Serves hamburgers medium or well done</td>
<td>0.72 (0.55–0.95)</td>
<td>0.83 (0.62–1.12)</td>
</tr>
</tbody>
</table>

a Odds ratios and confidence intervals are derived from weighted analysis; n = 1415 before weighted adjustment.

b Odds ratios adjusted for gender, age, education, and frequency of food preparation (usual versus sometimes).

Persons specifying a food vehicle for Salmonella spp. were more likely to know that “cooking meat until well done reduces the risk of food poisoning” than people who did not specify a food vehicle (odds ratio [OR] = 1.48, 95% confidence interval [CI] = 1.1 to 1.98). However, those people specifying a food vehicle for Salmonella spp. had reduced, though not statistically significant, odds of serving adequately cooked hamburgers when compared with those who did not specify a food vehicle (OR = 0.83, 95% CI = 0.62 to 1.12) (Table 3).

DISCUSSION

Outbreak investigations indicate that consumers do not always take precautions to reduce risks of foodborne infections (3). This finding suggests that they do not fully understand the hazards of foodborne contamination. In this survey, approximately two-thirds of the respondents reported safe practices for three food-handling principles (washing hands, preventing cross-contamination, and adequate cooking of meat), leaving one-third who reported unsafe food-handling practices. Health education efforts should identify subgroups of consumers with poor food-handling practices and find strategies that will motivate them to develop safe practices (9).

Persons who were able to specify a food vehicle for the transmission of Salmonella spp. were more likely to report washing their hands and cutting boards after contact with raw meat or poultry than were those who were unable to specify a food vehicle. A basic knowledge of microbiology may motivate consumers to use safe food-handling practices. To the extent this interpretation is valid, our findings may support recommendations to provide consumers with information about the risks for contamination of foods with foodborne pathogens, similar to the etiological strategy used by the food industry to control hazards during food processing (6).

The association of frequent food preparation, gender, and age with safe hygienic practices suggests that food-handling skills may be acquired through factors related to training, experience with handling food, or maturation (15). Those who handle food frequently, for example, have been found to be receptive to information on food safety (21). Alternatively, the association may reflect a trend toward eating away from home, which has resulted in fewer opportunities for in-home food safety instruction. This has occurred at a time when many schools have placed decreased emphasis on home economics and food safety education.

Knowledge of specific food-handling principles was more prevalent than the corresponding safe hygiene practices. A noticeable difference existed between the level of knowledge of principles and safe food-handling practices among certain groups. The level of knowledge of food safety principles for some groups (males, young adults, occasional food preparers, and those with more than 12 years of education) was similar to the overall level in the sample, but these groups had lower rates of self-reported safe practices. The disparity between knowledge and self-reported practice may relate to food-handling experience, which may be lacking in these groups (15) or it may be due to risk-taking behavior (10, 18). In either case, interventions probably need to be based on strategies beyond simply stating basic food-handling principles.

The results suggest that adequate cooking of meat or poultry is a different type of behavior from washing hands and preventing cross-contamination. Frequent food preparation, gender, and age, variables that may indicate food preparation experience, were not associated with adequate cooking of meat. Individuals who could specify a food vehicle for Salmonella spp. or who had more than 12 years of education were more likely to serve inadequately cooked hamburgers than those with no knowledge of 12 or fewer years of education. These findings are difficult to reconcile. Failure to cook hamburgers adequately may be seen as a food preference rather than a food safety issue. Alternatively, serving inadequately cooked hamburgers may be a risk-taking behavior (10).

The strengths of the present study included the large sample size and the national survey design. A limitation of the present study was its cross-sectional design, which precluded determination of the causal relationships among factors associated with safe food-handling practices.

The U.S. Health and Human Services Healthy People 2000 objectives for the reduction of foodborne pathogens state that lack of effective consumer education is the primary cause for concern about microbial contamination of raw foods (18). Regulations requiring labeling of raw meat and poultry products with food safety information were recently implemented by the U.S. Department of Agriculture (17).
This effort should encourage all food preparers to use safe food-handling practices. Other interventions might include instruction about risk factors such as time-and-temperature mishandling that contribute to the risk of foodborne illness (20), cultural rituals in food preparation (9), and instructions about safe practices such as hand-washing and prevention of cross-contamination (21). Studies should evaluate the effectiveness of proposed food safety interventions, with the goal of identifying strategies that motivate target groups to practice safe food handling.

REFERENCES