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Chicken Preparation in the Home: An Observational Study

ABSTRACT

Poultry has been linked to foodborne illnesses caused by *Salmonella* spp. and *Campylobacter* spp. This study reports on observed handling behavior when 120 volunteers prepared chicken and salad in their homes. A food safety attitudes and knowledge questionnaire was administered to volunteers after meal preparation had been video recorded. In the questionnaire, consumers stated that they were knowledgeable about safe-food handling and had heard of people becoming ill from eating chicken. The video recording, however, revealed that personal hygiene was insufficient, with 65% of meal preparers not washing their hands prior to meal preparation, 40% not washing their hands after handling raw chicken, and 45% washing the chicken prior to preparation. Hand-washing duration was less than 20 seconds, and in one-third of the hand-washing events, soap was not used. Most people judged thoroughness of cooking by appearance. When chicken temperature was taken, 60% of the cooked chickens registered 165°F or above. However, 39% of households stopped cooking even though the internal temperature of the poultry registered below 165°F. These results suggest that educational messages should focus on thorough washing of hands with soap, not washing chicken, and using a calibrated thermometer to determine doneness. To increase consumer protection, the poultry industry should adopt additional approaches to reduce pathogen levels.

INTRODUCTION

Foodborne illness is an important public health problem in the United States. On average, 31 major pathogens cause an estimated 9.4 million cases of foodborne illnesses, 55,900 hospitalizations and 1,351 deaths annually, costing $77.7 billion in health-care costs and lost productivity *(28, 29)*. Among all foods that cause foodborne illness, poultry ranks first because of the significant disease burden caused by both *Salmonella* and *Campylobacter* infections *(2)*. In

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an attribution study of foodborne illnesses between 1998 and 2008, more deaths were attributed to poultry than any other commodity *(25)*. Illnesses traced to chicken continue to occur. A multistate outbreak of *Salmonella* Heidelberg infections linked to chicken occurred in the Pacific Northwest in 2013 *(5)*. Reducing pathogens on poultry and proper personal and kitchen cleaning, using a properly calibrated food thermometer, and cooking poultry to a safe minimum internal temperature have been recommended to reduce incidence of foodborne disease *(20, 34)*.

Targeting specific food-handling errors may be the most effective way to promote safe-handling behavior. To understand the overall status of safe-food handling, Patil and colleagues examined 20 studies on specific food-handling behaviors *(26)*. This meta-analysis revealed that consumption of raw foods, poor hygiene, and cross-contamination varied by demographic categories. Compared to women, men were more likely to undercook foods and to fail to follow practices to prevent cross-contamination. Compared to lower income consumers, higher income consumers were less knowledgeable about hygiene and had poorer cross-contamination practices. The analysis also concluded that consumers may possess food safety knowledge but that knowledge does not necessarily translate into safe food-handling practices *(26)*.

In a study in the United Kingdom, Clayton and colleagues *(6)* found that study participants were knowledgeable about hand-washing techniques, intended to wash their hands, and had positive attitudes toward washing; however, they did not wash their hands on all appropriate occasions. An observational study of food workers found that although workers attempted to wash their hands in 32% of those activities in which washing was appropriate and although they followed recommended practices as to duration of wash, they used soap and properly dried their hands in only 27% of those activities *(14)*. Almost all (96%) of nutrition graduate students videotaped in a model kitchen reported that they washed their hands prior to meal preparation, and 89% actually performed this task *(19)*. Fewer, 84%, stated that they washed their hands after cutting raw chicken and fewer still, 63%, were actually observed to wash their hands. Soap is not always used in washing. Horlzi and colleagues *(17)* found 28% of volunteers washed only with water prior to meal preparation and 50% washed only with water after touching raw chicken. When volunteers prepared burgers in their home, Phang and Bruhn *(27)* recorded that 43% of the volunteers washed their hands prior to meal preparation, only 7% of hand-washing events lasted 20 s or longer, and only 41% of hand-washing events involved the use of soap, as recommended by the Food Code and consumer educational material *(11)*. In another study, the hands of 73% to 100% of consumers who reported washing their hands after touching chicken were found to still be contaminated with *Campylobacter jejuni (7)*. However, proper hand washing can impact food safety. Using the United States Food and Drug Administration's 2010 Food Safety Survey, Ali and colleagues *(1)* determined that self-reported hand washing with soap before food preparation led to a reduction in the probability of reported foodborne illness.

In addition to hand washing, consumers did not always follow handling guidelines to avoid cross-contamination *(10, 13)*. Hoelzi and colleagues *(17)* found 100% of consumers in their observation study washed the cutting board with soap or changed the board after contact with raw chicken. In contrast, 78% of graduate students said they would wash the cutting board under these circumstances, but only 8% actually performed this activity, and some rinsed with water rather than washing with soap *(19)*. An examination of cleaning effectiveness found that pathogens were reduced after washing with soap and mechanical scrubbing, but some remained and were transferred from the cutting board surface to food *(30)*. Use of hypochlorite solution as a disinfecting agent *(30)* or a fresh cutting board reduced cross- contamination *(22)*.

Some consumers do not adequately control food temperature to reduce the risk of foodborne illness. Adequate chilling slows bacterial growth, but consumers do not know the recommended refrigerator temperature, and some home refrigerators were found to be above the recommended 32–41°F *(18, 21, 24, 27)*. Consumers do not routinely use thermometers to cook to the recommended temperature *(12)*. Lando and Chen *(23)* noted that self-reported use of a thermometer when cooking chicken parts increased from 33% in 1998 to 53% in 2010. In contrast, only 16% of nutrition graduate students said that they used a thermometer when cooking chicken *(19)*, while Hoelzi's observational study found that only 3% used a thermometer to check doneness of chicken *(17)*. Most participants determined that chicken was cooked by visually inspecting the surface (78%), checking the interior (28%), or tasting (10%).

The food industry, government regulators, and consumers share responsibility for food safety. The food industry has adopted innovations to reduce pathogens; however, further control may be beneficial to enhance public protection *(3)*. Use of irradiation on poultry and other meats would significantly reduce illness and death from *Salmonella, Campylobacter* and other pathogens *(31)*. At this time, irradiation is not widely used, due in part to lack of public acceptance *(8)*.

In a review of consumer safe handling and consumption trends from 1988 through 2010, Fein and colleagues *(9)* noted that changes in safety practices over the years were consistent with changes in the number of media stories about food safety. These findings suggest that food safety education along with media attention may increase consumer awareness of food safety hazards and increase adherence to safe-handling practices.

The purpose of this study was to observe and record practices related to preparing chicken and salad in their homes that could put consumers at risk of foodborne illness. The study addressed how volunteers handled chicken, with emphasis on personal and kitchen sanitation and potential cross-contamination, and explored attitudes toward use of thermometers to determine when chicken was cooked and interest in selecting irradiated poultry. The findings may help food safety educators identify areas where greater emphasis is needed in consumer education.

MATERIALS AND METHODS

The procedure for recruiting volunteers was developed in consultation between the author, the project sponsor, and a professional consumer research company (WatchLab, Chicago, IL). To capture typical behavior, consumers were asked to prepare a chicken dish that they normally serve their family, rather than follow a specific recipe provided by the author that they might be unfamiliar with. By cooking in their own kitchen, consumers would work in a familiar environment. These specifications would increase the likelihood that observed behaviors were typical practices in the household. To observe practices that could result in cross-contamination, volunteers were asked to prepare either a fresh green or cut fruit salad. A questionnaire addressing consumer food safety attitudes and knowledge, developed by the author, was administered after meal preparation was complete to avoid influencing the volunteer's behavior.

An employee of the consultant company's offices in Los Angeles, CA, San Francisco, CA, Portland, OR, and Seattle, WA (n = 4) met with the author at the University of California at Davis and two undergraduate students to review project goals, the recruitment procedures, the videotaping process in the consumer's home, use of a thermometer to record refrigerator and chicken temperature, and administration of the questionnaire. The consulting company was responsible for recruiting volunteers, obtaining consumer consent, following guidelines of the company, videotaping consumers in their home, recording temperatures, and administering the questionnaire.

Employees from the professional consumer research company interviewed people in shopping centers to determine interest in and eligibility for the study. People were informed that the study would consist of a member of the consulting company completing a 90-minute videotape of the volunteer in the volunteer's home. The eligibility interview included standard questions as to the person's age, gender, ethnicity, employment status, educational attainment, and the number and age of others in the household. If the potential food preparer stated that their cultural heritage was mixed, he or she was categorized in the minority group. For example, someone who described his or her background as Caucasian/Asian mix was classified as Asian. To qualify for the follow-up videotaped interview, the volunteer was required to be 18 years of age or older, purchase all or most of the groceries for the household, prepare all or most of the meals in the household, purchase fresh raw uncooked chicken from a supermarket or warehouse store on a regular basis, not be currently employed by the food production, processing industry or grocery industry, not be employed by a local, state, or national government agricultural or food-related agency, not be a professional chef or cook in a restaurant or catering operation, and not be trained as a physician, veterinarian, nurse, or dietician.

From the list of all who met the eligibility criteria, individuals were contacted so that the sample from each region was similar to the ethnicity/national origin of the region *(35)*. Volunteers were invited to prepare a chicken dish and fresh salad using leafy greens or a cut fresh fruit salad. Volunteers were reminded that the preparation would be videotaped in their home. Volunteers were asked to prepare a chicken dish that they would normally prepare for their household, from start to finish. They were told that a team member from the consultant firm would set up two video cameras and videotape the volunteer preparing the chicken dish that they typically prepare for their family. One camera would be set up to get a wide view of the kitchen and the other camera would be hand-held by the team member. If the chicken was grilled outdoors, the team member would follow the volunteer with the hand-held camera when the volunteer went outside to the grill. Following meal preparation, the team member would ask questions that would take no longer than 10–15 minutes. The volunteers were told that they were responsible for purchasing all food ingredients, fresh chicken must be used, and they would receive $125 compensation. All volunteers signed an informed consent form modeled after those used at the University of California and administered by the consultant company.

Procedures were carried out as described to the volunteer. The volunteer purchased fresh whole chicken or chicken parts as needed for their traditional family recipe. One member of the consultant team visited the volunteer's home at a time that was convenient for the volunteer and the consultant. A video camera (Samsung HMX-F90) was positioned in the kitchen to ensure that footage of chicken preparation, hand washing, vegetable/fruit preparation, and cooking was captured. The consultant team member used a second, hand-held video camera (Samsung HMX-F90) and followed the food preparer to observe cooking and preparation not captured by the stationary camera. At the beginning of the visit, the consultant company team member placed a Fisher Brand refrigerator/freezer thermometer (model 15-105-5) in the refrigerator in the location where the chicken was stored. The reading on the thermometer was recorded at the end of the interview to allow ample time for the thermometer to register the refrigerator temperature. When the food preparer believed that the chicken was cooked, the consultant team

member asked the consumer if they wanted to check the final temperature of the chicken. Some volunteers did so, using their own personal thermometer. If they could not find their thermometer and they wanted to check the temperature, they were given a household thermometer (Taylor 5989N Classic Instant Read Pocket Thermometer) by the consultant team member. Next, the consultant company team member took the temperature of the cooked chicken in two places, using a Fisher Scientific instant read thermometer (model 14-648-45). If the internal temperature of the cooked chicken was less than 165°F, the volunteer visually assessed the degree of doneness and continued cooking if the meat did not look fully cooked, based upon their experience and expectation. If the meat was cooked further, the team member recorded the temperature with the Fisher Scientific instant thermometer again. After preparation of the chicken and the salad, the consultant company team member asked participants questions regarding chicken purchase, storage, handling of leftovers, and food safety related knowledge. Finally, the consultant company team member recorded the temperature of the refrigerator/freezer thermometer that had been placed in the volunteer's refrigerator. For participating in the study, the volunteer received a cooking thermometer, and the refrigerator/freezer thermometer used in the study in addition to the financial compensation promised in recruitment.

The completed eligibility questionnaire, consumer knowledge and behavior questionnaire administered after meal preparation, and videotapes from the two cameras were mailed by the consulting company to the University of California for analysis. The video recording was evaluated by two undergraduate students trained by the author. Handling practices deemed to be "critical violations" according to the 2009 Food and Drug Administration Food Code were noted. A "critical violation," defined as more likely than other violations to contribute to food contamination or illness *(11)*, included failure to adequately wash hands (washing for at least 20 seconds with a cleaning compound like soap), inadequate cleaning of food contact surface including utensils, and potential cross-contamination, including touching surfaces after handling raw chicken without attempting to wash hands. Each student independently evaluated five videos, using a score sheet developed by the author in consultation with the students. Then the author and students reviewed the score sheet and video to clarify format. The score sheet was revised as needed to more clearly capture handling practices. The score sheet indicated when hand washing occurred, the length of washing as indicated by the time recorded on the video tape, when water touched the volunteer's hand through when rinsing was completed, whether soap was used, and how the hands were dried. If hands were dried on a cloth towel, the towel was considered "fresh" prior to the first use and "used" if employed for subsequent drying. Washing kitchen counters and utensils, washing raw chicken, and washing fruit or vegetables were also recorded. If the volunteer failed to wash hands after touching raw chicken, the objects touched subsequently were identified and considered contaminated. Other observations noted on the scoring sheet, but not reported in this manuscript, included eating or smoking while cooking, touching hair, face, or other body parts, having a crowded refrigerator, presence of dogs or cats in the kitchen, and presence of flies.

Both students accurately captured all the target behaviors observed in the first five videos, as determined by the author. Thereafter, each student evaluated the videos independently, with each student viewing all videos from two locations and the other student viewing all videos from the other two locations. The author independently viewed all the videos and checked 100% of the score sheet notations for failure to wash hands, hand-washing times, use of soap, washing chicken, and chicken end point temperature. In summary, food preparation in each household was scored by one trained student and all behaviors specified previously were confirmed by the author through a second viewing.

RESULTS

Demographics

An individual in each of 30 households from four Pacific Northwest locations (Los Angeles, San Francisco, Portland, and Seattle (n = 120) were videotaped in their home between July and August, 2013. The majority (58%) of respondents were non-Hispanic Caucasian, with 22% Hispanic and 14% Asian *(Table 1)*. Most volunteers had completed at least some college. The respondents were evenly distributed between the ages of 20 and 50 years, with 9% over 60 years of age. Household characteristics recorded in the eligibility questionnaire indicate that approximately 60% of households included persons at increased risk for foodborne illness (that is, children 13 years or younger or adults who were 60 years of age or older). Although people currently employed in food-related industries were excluded from the study, 48% of participants indicated that they had a food-handler certificate or had previously worked in a restaurant; an additional 10% indicated they had received food-safety training in high school or through a cooking, health, or nutrition class.

Survey

Almost all participants are aware of foodborne illness. Most (95%) had heard of people becoming ill from eating chicken; 94% had heard of *Salmonella* and 48% believed their family had experienced foodborne illness. Few, however, associate foodborne illness with food prepared at home, and only 21% believed their family could become ill from eating chicken prepared in the home. Most (86%) believe that the source of their family's illness was restaurants. A friend's home was believed to be the source of illness by 14% of participants, and 9% identified their home or a picnic as the source of foodborne illness in the past.

TABLE 1. Demographic characteristic of food preparers (n = 120)

	San Francisco %(n)	Los Angeles %(n)	Seattle %(n)	Portland %(n)	Total Sample %(n)
Gender					
Female	67(20)	63(19)	63(19)	73(22)	67(80)
Male	33(10)	37(11)	37(11)	27(8)	33(40)
Age group					
18–29	20(6)	43(13)	33(10)	3(1)	25(30)
30–39	37(11)	20(6)	27(8)	13(4)	24(29)
40–49	13(4)	20(6)	13(4)	30(9)	19(23)
50–59	23(7)	13(4)	13(4)	40(12)	23(27)
60 or older	7(2)	3(1)	13(4)	13(4)	9(11)
Ethnicity					
Caucasian	67(20)	23(7)	77(23)	67(20)	58(70)
Asian	17(5)	17(5)	3(1)	17(5)	14(16)
Hispanic	17(5)	53(16)	13(4)	10(3)	22(27)
African American	3(1)	0	0	6(2)	2(3)
Native American	0	0	3(1)	0	<1(1)
Refused	0	7(2)	3(1)	0	2(3)
Formal Education					
Some high school or graduate	0	20(6)	33(10)	27(8)	20(24)
Some college or technical school	13(4)	57(17)	30(9)	47(14)	37(44)
College graduate	50(15)	13(4)	23(7)	13(4)	25(30)
Post graduate	37(11)	10(3)	10(3)	10(3)	17(20)
Refused	0	0	3(1)	3(1)	<1(2)
Total	30	30	30	30	120

Percentages area calculated within each location. n = 30, and for the entire sample, n = 120.

Participants prepared chicken frequently, with 85% serving chicken dishes weekly. Most (84%) volunteers consider themselves completely or very knowledgeable about how to handle and cook chicken to avoid illness *(Table 2)*. However, the subsequent questions revealed that many volunteers lacked critical information and did not follow recommended practices related to temperature control and sanitation. Over half (56%) of the respondents did not know the recommended refrigerator temperature. Of those who thought they knew, responses ranged from -88°F to 70°F. Only 26% correctly responded with temperatures between 32°F and 40°F *(36)*. The thermometer placed on the shelf where volunteers said they placed raw chicken indicates that 64% refrigerators were 40°F or below. However, 12% of the refrigerators were 45°F or warmer, with one refrigerator measured at 60°F *(Fig. 1)*.

TABLE 2. Safe-handling knowledge and practice of volunteers (n = 120)

	Completely	Very	Somewhat	Not very	Not at all
			Knowledgeable %		
How knowledgeable are you about how to handle and cook chicken to avoid illness?	27	57	14	2	0
	Always	Most Times	Sometimes	Seldom	Almost Never
How often do you use a thermometer when:					
cooking whole chicken	67	8	7	11	7
cooking chicken parts like breast or thighs	21	10	16	15	38

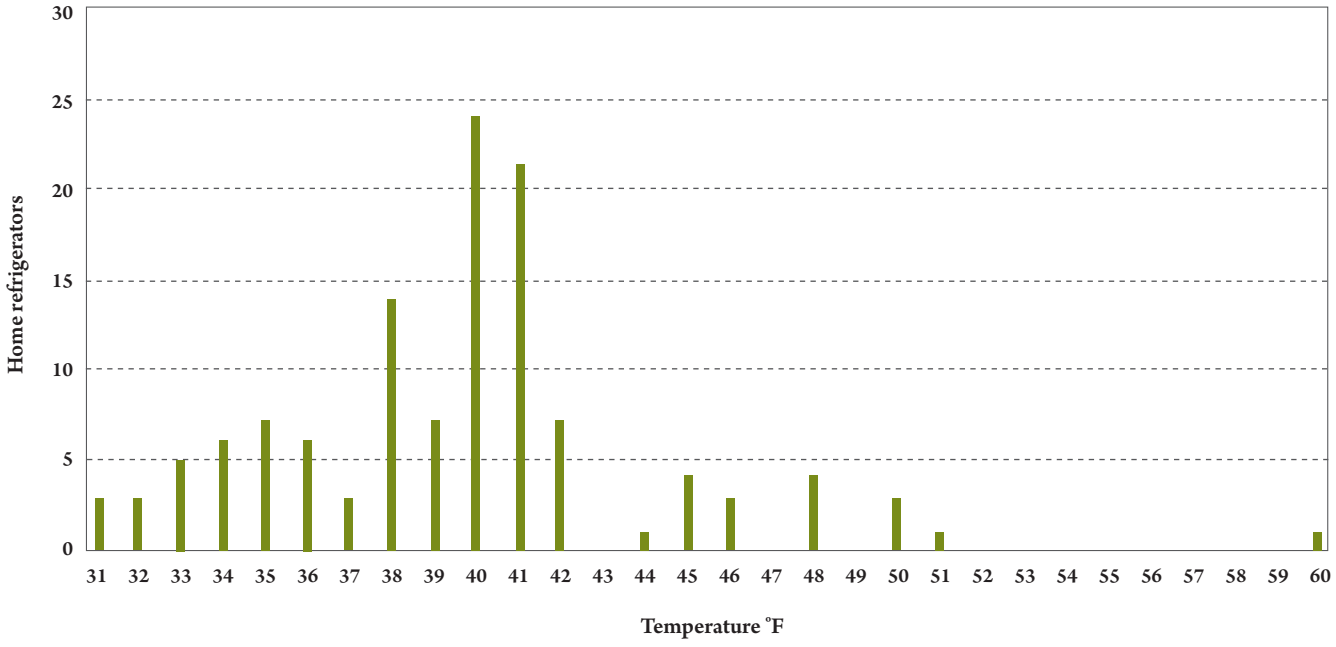


FIGURE 1. Temperature of food preparer's refrigerator

Almost half (48%) of volunteers indicated that they owned a cooking thermometer; 75% said they always or most times used a thermometer to measure when whole chicken was adequately cooked, and 31% said they used it when cooking chicken pieces *(Table 2)*. However, only 53% said they knew the recommended temperature for cooked chicken. Of those who professed to know the temperature, responses ranged from 100–400°F. Only 29% of the sample responded with the USDA recommended temperature of 165°F or higher; 180°F was the previous recommendation and is still listed in some cookbooks and on some thermometers *(37)*. When told they could keep the thermometer used in the cooking project, 81% said they were likely to use it when determining when whole chicken was adequately cooked, with the majority indicating that this tool would make their chicken safer since it was hard to see when the chicken was done. Fewer said they would use the thermometer on chicken pieces.

Most consumers responded that they refrigerated leftovers within 1–2 h; however, 43% of the respondents indicated that they stored leftovers in a container more than 4 inches tall, rather than a shallow container, as recommended *(36)* *(Table 3)*. Respondents also indicated that chicken was eaten within 1–2 days of preparation; however, 9% said they kept the leftover chicken for 5 days or more.

One-third of the preparers were aware that irradiation could be used to reduce harmful bacteria and thereby reduce the risk of foodborne illness. When the following description of irradiation was read, "Irradiation, sometimes called cold pasteurization, destroys 99.9% of harmful bacteria like *Salmonella* and *E. coli* O157:H7. Like heat, pasteurization of milk, irradiated foods must still be refrigerated and handled safety," almost half, 48%, said they would be interested in buying irradiated chicken, 29% were not sure and 23% said they were not interested. Those reluctant to buy irradiated chicken said they wanted information as to the effect of irradiation on taste, nutritional value, and safety before deciding.

When asked who was primarily responsible for the safety of chicken, 36% cited the chicken company and another 36% said the consumer. The government was deemed primarily responsible for the safety of poultry products by 17% of the respondents, while 11% of the respondents indicated that supermarkets were responsible.

TABLE 3. Handling of leftover chicken

If there are leftovers, how do you handle them? n = 124	**%**
Refrigerate within 1–2 hours	84
Freeze for later use	5
Refrigerate before the end of the day	4
Never have or save leftovers	6
Leave outside of refrigerator until eaten	1
Size of container used to hold leftovers * n = 129	
Large container over 4 inches tall	43
Small container, 2–3 inches tall	57
How soon leftovers are usually eaten* n = 116	
Within 1–2 days	76
After 3–4 days	15
After 5–6 days	7
After a week or more	2

Multiple answers accepted
*Only those with leftovers responded

Chicken preparation

Based on the video footage collected, a total of 367 hand-washing events were recorded. Hand washing was noted when the meal preparer used water only or water and soap. Sixty-four percent of meal preparers did not wash their hands before starting meal preparation and 38% did not wash their hands after touching raw chicken. Other activities in which preparers failed to wash their hands include after placing items in the trash (36%), after touching body parts (28%), and after touching other surfaces, such as door handles, spices, or a cell phone (67%). About one-third of hand-washing events utilized water only. Only 10% of the hand-washing events lasted 20 s or longer *(Fig. 2)*. Thirty-six percent of the hand-washing events lasted 5 s or less. Hands were dried most frequently with disposable paper towels (41%); used kitchen towels were employed 26% of the time; fresh towels were used 10% of the time; preparers shook their hands dry 9% of the time; and 12% of the preparers made no effort to dry their hands. Eight volunteers had marinated their chicken before the team member arrived to commence filming. Of the volunteers who began their chicken preparation on videotape, 47% washed their chicken. This practice was observed among 40% of Caucasians, 71% of Hispanics, and 73% of Asians. There was no correlation between having a food handler's certificate and washing hands before beginning meal preparation, washing after handling chicken or washing the chicken.

Participants chose the manner of chicken preparation. Three volunteers prepared whole chicken, two as an oven roast and one boiled on top of the stove. All other volunteers used chicken parts. The most common method was frying/stir frying (39%), followed by grilling and oven baking (27% each), simmering in a pot (6%) and pressure cooking (1%). The most common method of determining when chicken was done was appearance. In the questionnaire administered after meal preparation, volunteers said they looked for white colored meat, absence of blood or pink spots, and firm meat. Some consumers volunteered that they disliked dry chicken. During meal preparation, fewer than 5% of preparers voluntarily used a thermometer to record chicken temperature. When asked by the researcher if they wanted to check the cooked chicken's temperature, 34% of the preparers used their own household cooking thermometer or the thermometer provided by the project to note the temperature. In all but 4 cases, the researcher used the Fisher Scientific thermometer to record the temperature. Both the food preparer and the researcher placed the tip of the thermometer in the thickest part of the chicken and waited until a stable temperature was reached. In three cases, the household thermometer and Fisher Scientific registered the same temperature, and in an additional 8 cases, the temperatures recorded by the two instruments were within 5°F of each other. In other cases the temperature deviation ranged from 6°F to over 50°F *(Fig. 3)*. The food preparer did not mention calibrating their home thermometer. When the researcher advised the food preparer to follow directions on the web to calibrate their thermometer, some food preparers expressed surprise that calibration was possible and advisable.

When the researcher recorded chicken temperature using the Fisher Scientific thermometer or for 4 cases in which the

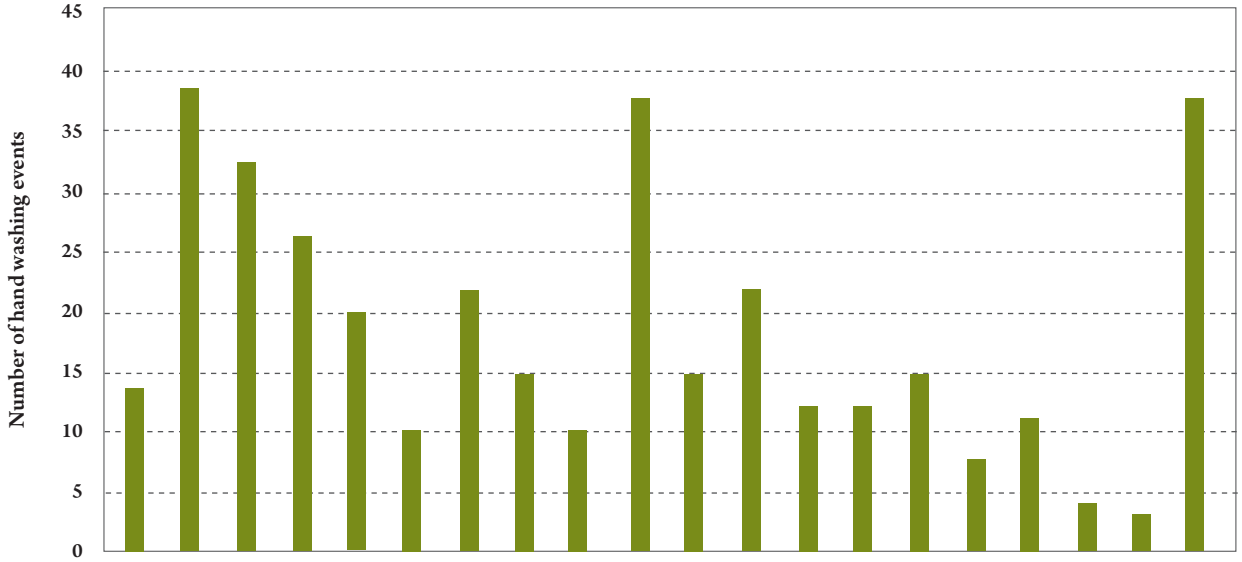
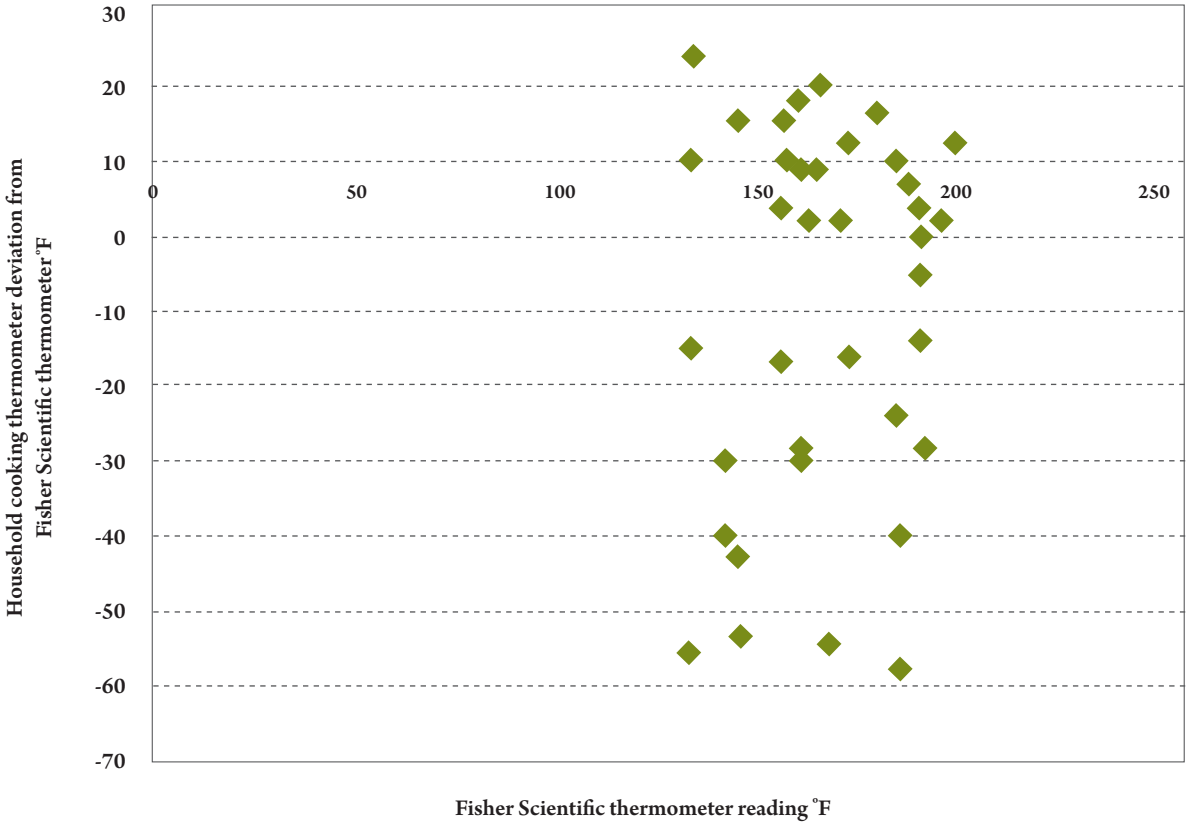


FIGURE 2. Duration of hand washing in seconds



If the household thermometer registers higher than the Fisher Scientific thermometer, the data point is above the zero line. If the household cooking thermometer registers a lower temperature than the Fisher Scientific thermometer, the data point is below the zero line.

FIGURE 3. Comparison of temperature differences when cooked chicken is measured by a household cooking thermometer and a Fisher Scientific thermometer

consumer reading was recorded, 40% of the chicken registered an internal temperature less than 165°F *(Fig. 4)*. Oven cooking resulted in the lowest percentage of undercooked chicken *(Table 4)*.

Cross-contamination through improper use of a cutting board was not observed. Food preparers either used a separate cutting board (47%), did not cut chicken (37%), washed the cutting board with soap after cutting raw chicken (11%), prepared items eaten raw before cutting chicken, or did not use a cutting board to prepare fruit or vegetables eaten raw. Similarly, people either used a different knife to cut chicken and raw produce or washed the knife with soap between uses.

When the refrigerator thermometer was placed in the home refrigerator, volunteers indicated the location in the refrigerator when the chicken was stored. Almost half (44%) placed the chicken on the top shelf, 27% on the bottom shelf, 21% on the middle shelf, 7% in the drawer, and 1% in the door of the refrigerator.

DISCUSSION

The volunteers in this study considered themselves knowledgeable about safe food preparation. In reality, results indicated that volunteers failed to follow recommended practices. Even though volunteers were aware that people could become ill from eating chicken, had heard of *Salmonella*, and in some cases believed members of their family had actually experienced foodborne illness, fewer than 10% believed that it was likely that illness could be caused by inappropriate handling of poultry in their home. Results also indicated that hand washing was inadequate, with 68% not washing their hands before beginning meal preparation and 38% of preparers not washing their hands after handling raw chicken. Even when washing occurred, duration of the hand wash was much shorter than the recommended 20 s, and about one-third of the washing occasions used water only, rather than soap and water. Although consumers reported that they washed their hands, failure to wash as frequently as necessary, scrub

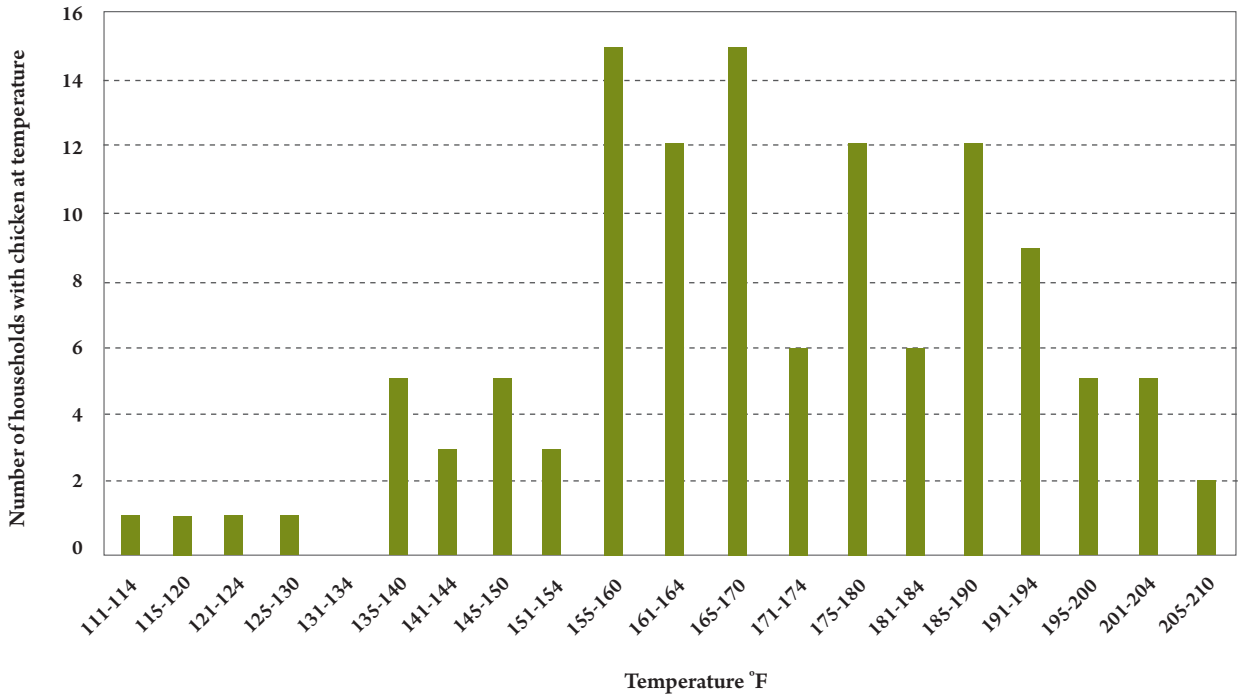


FIGURE 4. Final temperature of chicken when food preparer considered chicken cooked

TABLE 4. Cooking method for chicken considered done when end point temperature was below 165°F (n = 120)

Cooking method	Grilling	Fry	Oven roast	Boiled top of stove	Pressure cooker
Number cooked by this methods	33	46	33	7	1
Number below 165°F	17	19	9	2	0
Range of temperatures below 165°F	118–162	130–164	149–163	123–159	na
Average deviation below 165°F	18.1	13.9	6.9	24	na

as long as suggested, and use soap as well as water have been reported in other observation studies *(17, 19, 27)*.

While people did not wash their hands, they did wash their chicken, a practice that is not recommended as it leads to contamination in the kitchen *(33, 34)*. Henley and colleagues reported that African-American, Asian-American and Hispanic consumers washed chicken prior to cooking *(16)*. This project found that Caucasian consumers were also likely to wash their chicken. This finding indicates that food safety educators should remind consumers not to wash poultry. An animated video illustrating cross-contamination can help consumers visualize how cross-contamination occurs *(12)*. This sample of food preparers followed recommended practices regarding use of the cutting board between cutting raw chicken and ready-to-eat items. Use of a sanitizing solution in addition to a soap and water scrub or use of a separate board should be stressed, since use of just soap is relatively ineffective in removing bacteria *(30)*.

While most consumers said they refrigerated leftovers within the recommended 1–2 hours, almost half (48%) said they stored leftovers in containers 4 inches or taller. Since food in large containers takes considerable time to reach 40°F or below, the safety of leftovers may be compromised. Rapid chilling facilitated by use of shallow containers should receive greater emphasis in food safety messages.

Consumers continue to be uninformed regarding the recommended temperature for refrigerator storage. A study in Ireland found 41% of refrigerators operated above the recommended temperature of 5°C *(21)*, while 19% of refrigerators in a California study registered 6°C or higher *(27)*. In this project, 12% of refrigerators registered 7°C (45°F or higher). Food-safety educators should stress the benefits of adequate refrigeration, highlight where raw and ready-to-eat items should be stored, urge consumers to use a refrigerator thermometer, and lobby manufacturers to make refrigerators with thermometers built into the units.

Consumers are advised to avoid cross-contamination by placing raw food below ready-to-eat items *(38)*. Placing chicken on the bottom shelf or in a drawer was consistent with this recommendation. The 66% who stored raw chicken on the top or middle shelf or placed the chicken in the refrigerator door created an environment that could lead to cross-contamination, should juice from raw poultry drip onto other foods.

In this study, consumer use of thermometers to determine when whole chicken is cooked was similar to that reported by others *(21)*. In this study, reported use of thermometers for determining doneness was likely higher than actual use, since less than 5% used a thermometer voluntarily and only 29% knew the recommended end point temperature for cooked chicken. Based upon observed behavior, consumers knew where to insert the thermometer. One food preparer, however, tried to take the temperature of the cooked chicken while the case was still on the thermometer.

Food preparers were unaware that household cooking thermometers needed to be calibrated. This observation is understandable, since other thermometers they may encounter, such as outdoor or medical thermometers, do not need calibration. This project was not designed to measure the accuracy of household thermometers. Other factors, including the variation of internal temperature between one chicken piece and another, could account for some of the temperature variation observed. Nevertheless, the temperature spread between the Fisher Scientific and household thermometers indicates that advising consumers to use a thermometer to determine thoroughness of cooking will not necessarily result in chicken being cooked to the recommended temperature. Food-safety educators should stress the importance of calibrating home thermometers. Further, older food preparers had to put on their glasses to read the thermometer. Thermometer manufacturers could help overcome this barrier to use by offering thermometers with larger print.

Generally, consumers did not think a thermometer was necessary, because they determined doneness by the appearance of the meat *(16)*. This sample of food preparers differed from those of Kendall and colleagues *(19)*, who reported that consumers who did not use a thermometer adequately cooked their food. In contrast, 40% of the chicken considered cooked by food preparers in this study registered a temperature below 165°F. USDA advises consumers that cooked poultry can be white, pink or tan and that it is safe to eat when the temperature reaches at least 165°F *(32)*. Although consumer education stresses that the color of ground beef does not always reflect the meat's internal temperature *(32)*, this author is not aware if a similar message has been developed for poultry. Research should be conducted on chicken similar to that completed on burger patties to determine if appearance, i.e., white, firm flesh, is an adequate indicator of the destruction of *Salmonella (15)*. If chicken meat appearance does not correlate with the destruction of *Salmonella* and other pathogens, consumers should receive this message.

Since almost 60% of participants either had a food-safety certificate or had received training in food safety, this sample likely captured behaviors of those most informed about safe handling. Those individuals with less exposure to safe-handling information may unknowingly commit more food-handling errors.

Based on the findings from this study, the handling practices observed would not provide adequate protection from foodborne illness. Consumers will make errors, and even people with food safety training do not always follow recommended practices *(9, 26, 27)*. Consumers should recognize that they have responsibility for safe handling, but many ascribe primary responsibility to the chicken company (36%), supermarket (11%), and the government (17%). Food-safety educators should focus messages on areas where consumers are currently not performing. Additionally, the poultry industry and government should explore all options to decrease the level of contamination on raw poultry during processing, including use of technologies like irradiation. Answers to consumer questions as to safety, nutritional value, and flavor of irradiated poultry is available *(4)*. A coalition of industry, health educators, and government agencies should deliver these messages, and irradiated poultry should be available to consumers in the supermarket.

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