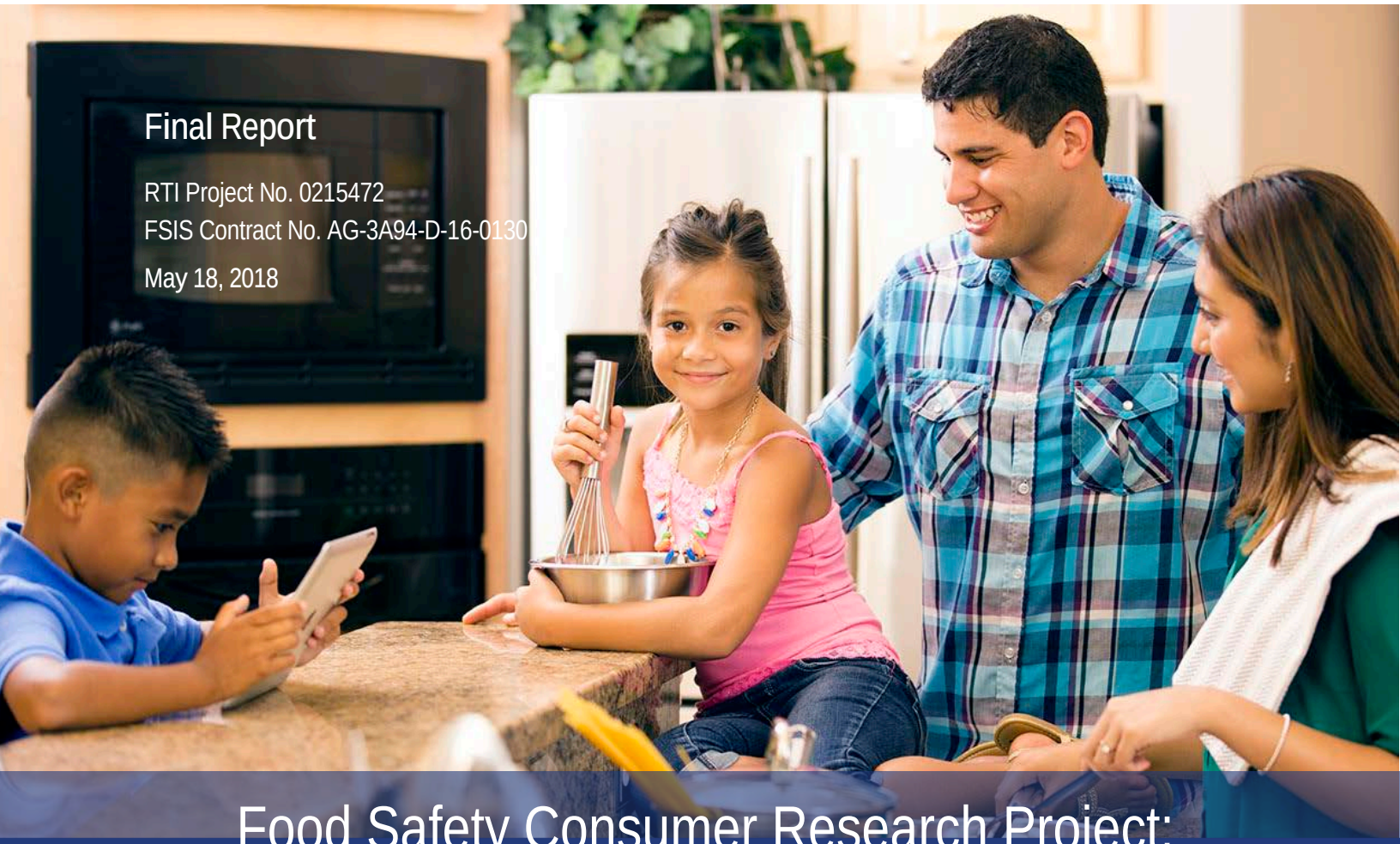

Final Report

RTI Project No. 0215472
FSIS Contract No. AG-3A94-D-16-0130

May 18, 2018

Food Safety Consumer Research Project: Meal Preparation Experiment Related to Thermometer Use

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Executive Summary

The Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture (USDA) contracted with RTI International and its subcontractor North Carolina State University (NCSU) to conduct meal preparation studies to evaluate consumer food handling behaviors in a test kitchen. The research team is conducting five separate iterations of the meal preparation study to address a specific consumer behavior and to determine the effectiveness of a behavior change intervention. The meal preparation studies are part of a larger 5-year annual study that also includes focus groups (two iterations) and web surveys (two iterations). This report describes the results of the first iteration of the meal preparation study that examined consumers' use of food thermometers when cooking ground turkey patties.

RTI and NCSU conducted the study in six test kitchen facilities located in the metro Raleigh-Durham area of North Carolina and Smithfield, North Carolina, a rural location. Before preparing the meal, a randomized treatment group watched the 3-minute USDA food safety video "The Importance of Cooking to a Safe Internal Temperature and How to Use a Food Thermometer." In each test kitchen, six cameras recorded participants' actions at various locations throughout the kitchen and recorded the meal preparation from beginning to end of meal preparation. Participants in the control and treatment groups were observed while cooking turkey burgers (spiked with the harmless tracer bacteriophage MS2) and preparing a chef's salad to determine whether they used a thermometer on the turkey products and whether they adhered to other food safety behaviors throughout the meal preparation. Following meal preparation and cleaning, the study team collected microbiological samples from surfaces and lettuce and analyzed the samples for prevalence and level of MS2. Participants participated in a post-observation interview to collect information on their usual food preparation practices and possible predictors of behavior change. A total of 383 people participated in the study (201 control, 182 treatment).

The key findings from the study are summarized below:

- Viewing the USDA video on thermometer use immediately before food preparation encouraged participants to follow USDA-recommended use of a food thermometer for checking doneness of raw poultry; however, more needs to be done to increase adherence to more nuanced recommended practices.
  - Participants who viewed the video (i.e., treatment group) were twice as likely to use a thermometer to check the doneness of the turkey patties compared with those who were not exposed to the video (i.e., control group) (75 vs. 34%).
  - Participants in the treatment group were twice as likely to place the thermometer in the correct location (i.e., the side of the patty to reach the center and coldest spot) compared with the control group (52 vs. 23% of attempts for thermometer placement).

  - Participants in the treatment group were more likely than participants in the control group to cook the patties to at least 165°F (73 vs. 54%).
  - Use of other indicators of doneness was common among control group participants; most relied on only touch (the firmness or texture of the burger) or color *and* touch.
  - In the post-observation interviews, 66% of participants stated that watching the video influenced their cooking behavior in the kitchen; of these participants, 61% reported using a thermometer as a result of watching the video.
- Proper handwashing, which was not addressed in the video, needs improvement. Of the 2,249 cases across all 383 observations in which a handwashing event was needed to decrease the risk of cross-contamination (e.g., before meal preparation and after handling raw product), participants attempted to wash their hands 31% of the time. Among attempted handwashing events, only 4% included all steps necessary to be considered an adequate handwashing event (defined by the Centers for Disease Control and Prevention's recommended steps).
- Improvements are also needed to reduce the risk of contaminating surfaces and ready-to-eat foods (not addressed in the video). Approximately 50% of participants contaminated spice containers they touched during the preparation of the preformed turkey burgers, and 6% contaminated the lettuce used to prepare the salad, a ready-to-eat food. This relatively low rate of contamination of the salad indicates that cross-contamination was not necessarily frequent but did occur with some regularity.

Based on the study findings and previous work in the literature related to risk communication, we recommend that FSIS consider designing food safety messaging that

- is clear and specific;
- focuses on proper thermometer usage;
- continues to emphasize handwashing and cross-contamination because improvements are needed in these areas;
- tailors messages to audience needs, concerns, and interests;
- stimulates perceptions of risk of illness from not following recommended food safety practices and bolsters self-efficacy for handling food safely; and
- addresses behaviors that lead to the highest incidence of foodborne illness causing the most serious consequences such as cross-contamination, failure to cook to proper lethality temperature, and inadequate handwashing.

There is a great deal more to learn about consumer attitudes and behaviors as they relate to food safety; understanding these factors will help FSIS better create awareness of safe food handling practices and be able to incorporate everyday contexts into food safety communications.

1. Introduction

This report describes the study methods and presents the results from a meal preparation study related to thermometer use, conducted as part of the Food Safety Consumer Research Project. The study, conducted in test kitchens, used an experimental design to measure the rate of thermometer use by consumers and level of adherence in cooking to recommended temperatures to compare behaviors between participants who received an educational intervention on thermometer use and those who did not. The thermometer use study is the first of five iterations of a meal preparation experiment in which consumers are observed while preparing meat and poultry products regulated by the U.S. Department of Agriculture's (USDA's) Food Safety and Inspection Service (FSIS). This report details our study design, data collection procedures, and data analysis approach and presents the results of the study for thermometer use, handwashing compliance, cross-contamination, and self-reported usual behaviors for thawing and storing leftovers. FSIS can use the results of this study to enhance consumer messaging on thermometer use. The rest of this section provides an overview of the Food Safety Consumer Research Project, describes the purpose of the initial meal preparation experiment, and details the organization of the report.

1.1 Background and Project Overview

USDA FSIS's Office of Public Affairs and Consumer Education (OPACE) ensures that all segments of the farm-to-table chain receive valuable food safety information. The consumer education programs developed by OPACE's Food Safety Education Staff inform the public on how to safely handle, prepare, and store meat, poultry, and egg products to minimize incidence of foodborne illness.

OPACE strives to continuously increase consumer awareness of recommended food safety practices with the intent to improve food handling behaviors at home. OPACE shares its messages through the *Food Safe Families* campaign, social media, AskKaren (an online database of frequently asked food safety questions), the FSIS web site, FoodSafety.gov, the Meat and Poultry Hotline; publications, and events. These messages are focused on the four core food safety behaviors: clean, separate, cook, and chill. Additionally, OPACE's public education and outreach initiatives reach vulnerable and underserved populations.

By testing new consumer messaging and tailoring existing messaging, FSIS can help ensure that it is effectively communicating with the public and promoting behavior change with a goal of improving consumer food safety practices. FSIS contracted with RTI International to conduct consumer research over a 5-year period, fiscal year 2017 through fiscal year 2022. RTI is teaming with researchers at North Carolina State University (NCSU) to conduct the project. This behavioral research will include observation studies of food preparation in test kitchens using an experimental design (five iterations), focus group studies (two iterations),

and web surveys (two iterations). Each iteration of each data collection activity will address different research questions and use a different sample of consumers. This research will provide insight into the effect FSIS consumer outreach campaigns have on consumers' food safety behaviors. FSIS will use the results of this research to enhance messaging and accompanying materials to improve food safety behaviors of consumers. Additionally, this research will provide useful information for tracking progress toward the goals outlined in the FSIS fiscal years 2017–2021 Strategic Plan (USDA, FSIS, 2016).

1.2 Objectives of Meal Preparation Experiment Related to Thermometer Use

Previous research suggests that self-reported data collected through surveys on consumers' food safety practices are unreliable because consumers tend to overreport their behavior (e.g., simply rinsing their hands instead of washing with soap and water for 20 seconds as recommended) (Redmond & Griffith, 2003). Because of this limitation, observation is a preferred approach for collecting information on consumers' actual food safety practices. Studies that have used direct observation of consumer food handling have reported that many consumers commit errors during preparation and self-report different actions (Anderson et al., 2004; DeDonder et al., 2009; Jay, Comar, & Govenlock, 1999; Kendall et al., 2004; Redmond, Griffith, Slader, & Humphrey, 2004). The results of the meal preparation experiments will help FSIS assess adherence to the four recommended food safety behaviors of clean, separate, cook, and chill; determine whether food safety messaging focused on those behaviors affects consumers' safe food handling behaviors; and determine whether consumers introduce cross-contamination during food preparation.

Each iteration of the meal preparation experiment addresses a specific consumer behavior; the first iteration examined consumers' use of food thermometers when cooking ground turkey patties. Participants randomized to the control or treatment group (exposed to intervention on thermometer use) were asked to cook turkey burgers and prepare a chef's salad as they would at home. We observed participants throughout this entire process to determine whether they used a thermometer and whether they adhered to other food safety practices such as handwashing. This study also assessed pathogen transfer during meal preparation, measured the temperature of cooked patties using a data logger to determine whether a safe endpoint temperature was achieved, and included the collection of microbiological samples from lettuce (lettuce used as garnish for prepared burgers or lettuce from the prepared salad) and kitchen surfaces. A post-observation interview collected information on consumers' reasons for following or not following recommended food safety practices and self-reported data on practices that could not be observed such as thawing and storing leftovers.

Table 1-1 lists the study's research questions, data sources, and the corresponding section of this report with the results of the analysis conducted to address each research question.

Table 1-1. Research Questions, Data Sources, and Location of Results in Report

Research Question	Data Source	Location in Report
Is the rate of thermometer use higher for the treatment group compared with the control group?	Observations	Section 3.2, Table 3-2
Are participants in the treatment group more likely to use a food thermometer correctly compared with the control group?	Observations	Section 3.2, Figure 3-1, Tables 3-3 and 3-4
Among participants who use a food thermometer, what percentage cook the patties to a safe temperature?	Data logger	Section 3.2, Tables 3-5 and 3-6
What methods are used to determine doneness in lieu of a food thermometer for the control and treatment groups?	Observations, screening questionnaire	Section 3.2, Tables 3-7 and 3-8
What is the rate of successful handwashing attempts for the control and treatment groups? What are the reasons for unsuccessful handwashing attempts?	Observations	Section 3.3, Tables 3-9 and 3-10
What are the prevalence and the levels of contamination of kitchen surfaces and lettuce for the control and treatment groups? When contamination is found, what sequence of events led to the contamination?	Microbiological sampling data	Section 3.4, Tables 3-11 and 3-12
What are the rates of various thawing methods usually followed as reported by participants in the treatment and control groups?	Post-observation interviews	Section 3.5, Table 3-13
What are the rates of various leftover storage practices usually followed as reported by participants in the treatment and control groups?	Post-observation interviews	Section 3.5, Table 3-13
What elements of the intervention video are effective at encouraging participants to follow recommended practices? (treatment group only)	Post-observation interviews	Section 3.6, Table 3-14

1.3 Organization of Report

This report is organized as follows:

- Section 2 describes the research design, data collection procedures, and analysis approach.
- Section 3 presents and discusses the results of the study for thermometer use, handwashing compliance, cross-contamination, and other behaviors.
- Section 4 concludes the report by discussing the implications of the study results for FSIS's consumer food safety education and outreach efforts.

The appendices are organized as follows:

- Appendix A: Screening questionnaire for participation in study
- Appendix B: Observation script and recipes
- Appendix C: Post-observation interview guide
- Appendix D: List of equipment provided in each test kitchen
- Appendix E: Power analysis to determine sample size for study
- Appendix F: Microbiological methods (provides complete description of the selection of the surrogate and the microbiology methodology)
- Appendix G: Observation rubric for coding participant actions in the kitchen

2. Study Methods

This section describes the methodology for the meal preparation experiment; describes the recruitment procedures and the final sample; and details the approach for coding and analyzing the observations, collecting and analyzing the microbiological samples, and analyzing the post-observation interview data. The Office of Management and Budget (OMB control number 0583-0169, expiration date 6/30/2018) and North Carolina State University's Institutional Review Board (IRB) approved the study protocol and materials.

2.1 Meal Preparation Experiment Methodology

2.1.1 Research Design

The first meal preparation experiment focused on the food safety behavior of "cook," specifically whether participants used a food thermometer to check doneness of turkey patties and whether the patties were cooked to the recommended temperature. We randomly assigned participants to a control group (no exposure to food safety messaging) or an intervention (treatment) group.

We calculated the sample size to determine the minimum number of participants needed to provide a level of confidence that the meal preparation experiment was sufficiently powered, meaning that a change of the anticipated size or greater would be interpreted as occurring beyond chance (i.e., statistically significant). Based on the power analysis (see Appendix E), the desired sample size was 400 (200 per group) to provide 80% statistical power and a 95% level of confidence. The sample size calculation took into consideration the anticipated base rate for thermometer use and the anticipated distributional characteristics of a dichotomous outcome and the research design that is feasible given the logistical constraints of conducting test kitchen observations in one location.

2.1.2 Study Procedures

Figure 2-1 summarizes the study procedures. We conducted the study in six test kitchen facilities located in the Raleigh-Durham area of North Carolina (Wake County) and Smithfield, North Carolina, a rural location (Johnston County). In each test kitchen, six cameras recorded participants' actions at various locations throughout the kitchen and recorded the meal preparation from beginning to end. Observers monitored the cameras throughout the process to identify any trigger behaviors for the microbiological sampling. Trigger behaviors are actions that could potentially lead to cross-contamination (see Table 2-1).

Figure 2-1. Study Procedures for Meal Preparation Experiment on Thermometer Use

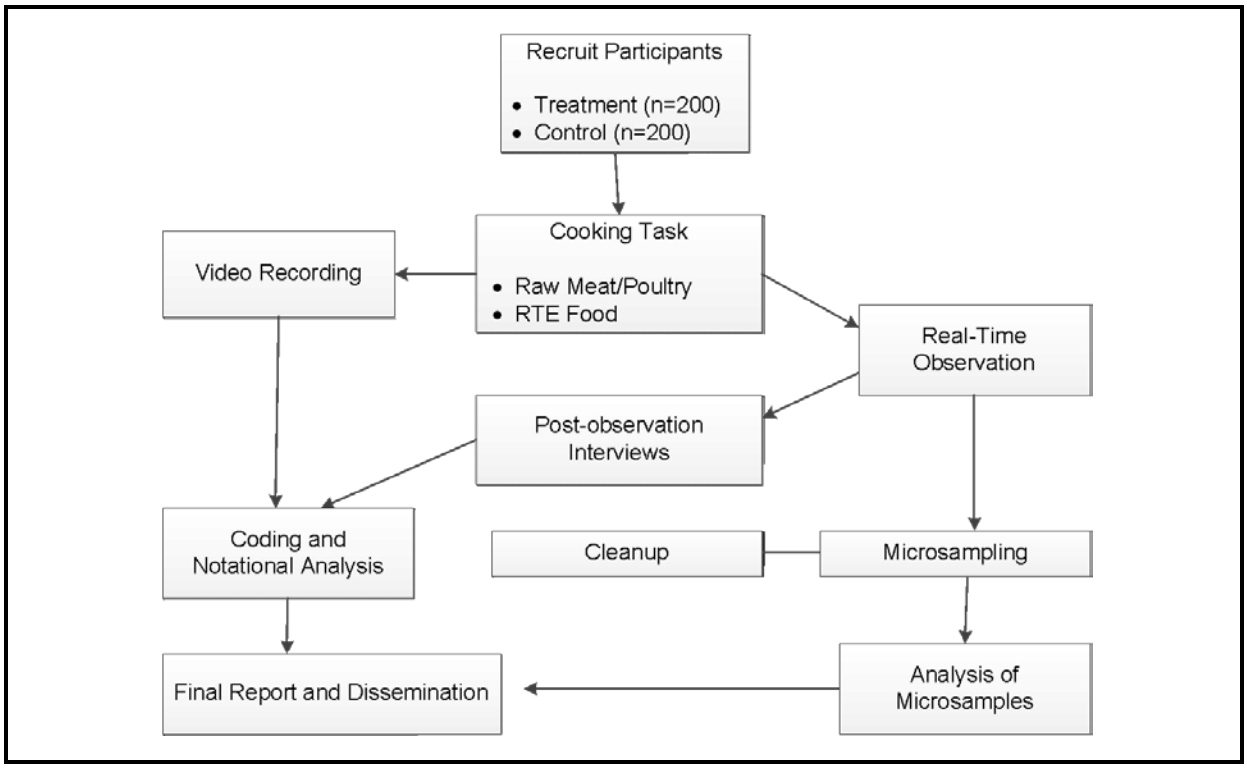


Table 2-1. Trigger Behaviors Used for Microbiological Sampling

Trigger	Options
Handwashing	▪ Washed hands thoroughly ▪ Did not wash hands thoroughly/Did not wash hands
Hand drying	▪ Dried hands after washing using paper towels ▪ Did not use paper towels to dry hands
Packaging	▪ Did not move packaging for ground turkey patty around in food preparation area ▪ Moved packaging for ground turkey patty around in food preparation area
Handwashing	▪ Washed hands after handling raw ground turkey patty ▪ Did not wash hands after handling raw ground turkey patty
Turkey rinsing	▪ Did not wash or blot/dab ground turkey patty ▪ Washed ground or blot/dab turkey patty
Thermometer use	▪ Used thermometer on ground turkey patty ▪ Did not use thermometer on ground turkey patty
Produce washing	▪ Washed produce after handling ground turkey ▪ Did not wash produce
Cutting board use	▪ Did not use the same cutting board and plates for produce and ground turkey patty ▪ Used same cutting board and plates for produce and ground turkey patty

(continued)

Table 2-1. Trigger Behaviors Used for Microbiological Sampling (continued)

Trigger	Options
Knife use	▪ Did not use same knife for produce and ground turkey patty ▪ Used same knife for produce and ground turkey patty
Use of device	▪ Did not touch device (e.g., phone) ▪ Touched device (e.g., phone)
Cutting board wash step	▪ Washed cutting board and utensils with soap and water ▪ Did not wash cutting board and utensils with soap and water
Drying equipment	▪ Dried kitchen equipment (cutting boards, knives) with paper towels ▪ Did not dry kitchen equipment with paper towels

Note: The recommended (safe) practice is listed as the first option.

Six cameras in each test kitchen recorded participant behaviors during meal preparation.

We used convenience sampling to recruit participants using a variety of approaches. Section 2.2 describes the participant screening criteria and recruitment procedures. Participants were told they would receive a $75 gift card and gift (food thermometer) for taking part in the 2-hour study. Participant recruitment began July 5, 2017. We scheduled observation appointments starting August 2, 2017, and ending December 22, 2017.

We randomly assigned participants to the treatment or control group when the appointment was scheduled, with the goal of 200 participants in each group. Before the scheduled appointment for the meal preparation experiment, each participant received a reminder email with a confirmation of location, time, and check-in procedures. The email also included a link to a short YouTube video that explained what participants could expect to take place during the study and the meal they would prepare, along with some visuals on raw product and finished meals (referred to as the expectation video). Additionally, the confirmation email for the treatment group instructed participants to click on a link to the USDA YouTube video "The Importance of Cooking to a Safe Internal Temperature and How to Use a Food Thermometer,"[1] which served as the intervention. Participants were also

[1] https://www.youtube.com/watch?v=-2KkV2yFiN0

shown the video before beginning the study, explained below. This video focuses on the following messages:

- Visual cues are not sufficient to assess safety.
- A proper internal temperature is needed.
- The only way to ensure safety is to use a food thermometer.
- When finished, clean food thermometer with soap and water.

For the hamburger patty portion of the video, flipping is shown, inserting the thermometer from the side is demonstrated, and the message provided is to measure the temperature for each patty.

We recruited participants and scheduled their appointments at one of the test kitchen locations. Upon arrival to the test kitchen, a study team member greeted participants and instructed them to read and sign an informed consent form. A study team member gave participants in the treatment and control groups iPads upon entering the observation waiting area and asked them to view the expectation video. Using a video provided consistency in delivering this information. To ensure exposure to the intervention, treatment group participants viewed the USDA video on thermometer use before beginning to cook. Initially, we told participants the purpose of the study was recipe testing. Consistent with the approach used in other observation studies, we informed participants of the real purpose of the study following the meal preparation and why it was important from a scientific perspective to inform them after the study was complete[2] (Chapman, Eversley, Fillion, MacLaurin, & Powell, 2010; DeDonder et al., 2009).

USDA video on thermometer use served as the intervention

A study team member gave participants a laminated recipe card—one side had a chef's salad recipe and one side had a turkey burger recipe (with a lettuce and tomato garnish)—and instructed them to prepare the foods as they would at home (see Appendix B for a copy of the scripts and recipe). Participants were not told which item to prepare first (burger vs. salad). A study team member pointed out that cabinets containing utensils, dishes, pans,

[2] After being informed of the study's purpose, participants had the option to opt out of the study; if they did opt out, we did not use their data.

and a George Foreman grill were labeled accordingly (see Appendix D for a complete list of equipment provided in each test kitchen and a picture of one of the test kitchens). Recording of a participant's handling and meal preparation began as soon as the participant entered the test kitchen and ended when the participant exited. Study team members also recorded participants' cleaning and sanitizing of the kitchen equipment and surfaces after meal preparation.

We used the tracer bacteriophage MS2 in this study because it (1) is completely harmless to humans because it infects only its bacterial host; (2) has a long history of use as a microbiological indicator; (3) is easy to culture and detect/enumerate by real-time polymerase chain reaction (RT-qPCR); and (4) unlike bacterial surrogates, requires no additional environmental health and safety documentation, such as a biological use authorization approval, for its use in NCSU test kitchens, which was an important consideration given the time constraints for conducting the first iteration of the study.[3] Before the study, we inoculated the turkey patties with the tracer bacteriophage MS2 at a level of 10^{10} per gram of ground turkey meat using a Kitchen Aid mixer. We confirmed homogenous levels of MS2 throughout the ground turkey mixture by testing random samples of the meat-MS2 mixture on turkey patty production days. The purpose of the surrogate was to track any potential cross-contamination from raw turkey patties to various locations around the kitchen and to a ready-to-eat (RTE) salad during meal preparation in the test kitchens. Appendix F provides a complete description of the selection of the surrogate and the microbiology methodology. We gave each participant two turkey patties packaged in a styrofoam tray with clear plastic wrap and with a mock label and the USDA Safe Handling Instructions to resemble patties purchased at a grocery store.

During data collection, trained sample collectors sampled a 10 x 10 cm counter space area (sample "Time 0") to ensure the kitchen space was sterilized effectively (MS2 contamination removed) before each participant entered the kitchen. Following the observation, trained sample collectors collected surface swab samples from kitchen surfaces, utensils, food containers, appliance handles, kitchen towels, and cutting boards (in all observations) for up to 12 samples (see Appendix F, Attachment 1—Sample Collection Form). The RTE salad dish was only sampled if the participant prepared it after preparing the turkey burgers; if the salad was prepared before the burgers, then lettuce from the burger garnish was collected instead. If a participant handled their mobile device during meal preparation, we took a swab sample from the device if the participant gave permission. An NCSU lab processed the swabs to determine the presence and concentration of the MS2. The presence of MS2 indicated that cross-contamination occurred during food preparation. We compared the level of cross-contamination across the sampling sites to determine the highest risk areas. We cleaned and sanitized all accessible kitchen surfaces (e.g., counters, drawer pulls, stove

[3] For the initial study, we did not use a bacteria surrogate because of the lengthy review process that would be required.

top), appliances, and other sites after each participant to ensure that any potentially remaining MS2 contamination was removed before the next participant entered the kitchen. The study protocols detailed consistent methods for conducting the observations and for collecting samples.

Supplementing the observations, we conducted post-observation interviews to provide insight into participants' views, opinions, and experiences during the meal preparation experiment, with questions based on the trigger behaviors that were observed during food preparation. The interviews also collected information on behaviors that we were unable to observe (e.g., storage of leftovers or thawing) and information on antecedents such as concerns about food safety and previous experience with foodborne illness. Interviews lasted approximately 20 minutes (see Appendix C for the post-observation interview guide).

2.1.3 Pilot Testing

Before initiating the full-scale data collection, we conducted two pilot studies to test the study materials, procedures, and the time allotted for data collection. We conducted the first pilot with two food science students as subjects and the second pilot with one subject recruited by convenience sampling. Representatives from FSIS participated in each pilot study. Based on these pilots, we made several modifications to update the recipes and script to provide clearer information to participants, added behaviors to the list of triggers, and updated the list of needed ingredients and kitchen equipment. Before the data collection began, we revised the materials and updated the study's Standard Operating Procedures document.

2.2 Recruitment Procedures and Description of Final Sample

The study team used convenience sampling with quotas to help ensure that study participants reflected the demographic characteristics of the U.S. population based on the most recent Census data. We recruited participants using social media outlets (e.g., Facebook, Craigslist), by sending emails to Expanded Food and Nutrition Education Program (EFNEP) participants to reach low-income consumers, and by posting and distributing flyers about the study in approximately 150 locations within driving distance of the test kitchens located in Raleigh, North Carolina, and Smithfield, North Carolina. Flyers were posted/distributed in locations where low-income and older adults may congregate such as churches, community centers, libraries, and food pantries. The study team faced challenges recruiting people with a high school education or less, adults 55 years or older, and Hispanic people; thus, we requested and received OMB approval the last month of data collection to use outbound recruiting to recruit participants and to conduct the study in Spanish. We worked with a local market research firm to contact individuals in their database with the desired demographic characteristics (i.e., high school, age 55 years or older, and/or Hispanic) and to screen the individuals for eligibility. Additionally, we translated the recruitment materials into Spanish and posted the recruiting materials in Spanish on

Craigslist and in the Que Pasa Raleigh newspaper, as well as conducted outreach at locations in which Hispanic people may congregate such as Hispanic grocery stores, churches, and community organizations including The Hispanic Family Center.

Participants had to meet specific inclusion and exclusion criteria. The inclusion criteria were as follows:

- age 18 or older
- speak English or Spanish
- do all or most of the grocery shopping in the household
- prepare meals at home at least 4 times a week
- cooked raw meat or poultry at home in the past 3 months

The exclusion criteria were as follows:

- have ever received any type of food safety training, such as ServSafe
- have ever been employed as a food worker or manager in a food preparation setting
- are vegetarian or vegan

Recruitment materials directed prospective participants to call or email the study team to be screened for eligibility or to a web link that hosted the screening questionnaire (see Appendix A). For participants screened by phone, we invited eligible participants to participate in the study and scheduled an appointment during the screening call. For participants who completed the web-based screener, we contacted eligible participants by phone, invited them to participate in the study, and scheduled an appointment. We told participants that study participation involves preparing several recipes and participating in a short interview. Appointments were scheduled during work hours, evenings, and weekends to allow for a broader participant pool. After an appointment was scheduled, we sent a confirmation email or letter and made a reminder call 1 or 2 days before the scheduled appointment.

Table 2-2 provides the target number of participants by demographic characteristic based on 2014 Census data and the actual number of participants in the sample. A total of 383 people participated in the study; thus, we fell slightly short of the target of 400 participants. The demographic characteristics of the participants differed from Census data targets primarily in terms of education level and family (i.e., children in the household) versus nonfamily household (i.e., no children) status. The percentage of participants with less than high school or high school diploma/GED was 24% compared with the Census target of 42%. This difference was a result of the local population's higher educational attainment, initial classification of technical/vocational training in the "some college" category, and higher screen-out rates due to food safety training and food industry experience for the less than

Table 2-2. Comparison of Demographic Characteristics for the U.S. Population (2014) with the Study Sample

Characteristic	Percentage from Census Data[a]	Target Number of Participants based on Census Data (*n* = 400)	Actual Number (Percentage) of Participants in Study Sample (*n* = 383)
Race			
White	74%	296	253 (66%)
Non-White[b]	26%	104	130 (33%)
Ethnicity			
Not Hispanic or Latino	83%	332	330 (86%)
Hispanic or Latino	17%	68	53 (14%)
Age			
18–34[c]	28%	112	134 (35%)
35–54	36%	144	154 (40%)
55+	36%	144	95 (25%)
Education			
Less than high school or high school diploma/GED[d]	42%	168	93 (24%)
Some college	29%	116	99 (26%)
Bachelor's degree	18%	72	119 (31%)
Graduate or professional degree	11%	44	72 (19%)
Household status[e]			
Family household (children)	66%	264	176 (46%)
Nonfamily household (no children)	34%	136	207 (54%)

[a] Source: U.S. Census Bureau. (n.d.). 2010-2014 American Community Survey 5-year data profiles. Retrieved from https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2014/

[b] Non-White includes Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, other races, or 2 or more races.

[c] For the Census data, the first age category was 20–34 years, instead of 18–34 years.

[d] During the last month of data collection, we changed this category to include participants who may have completed one or more classes as part of a technical or vocational training program (e.g., welding, refrigeration, cosmetology).

[e] For the Census data, family household includes households with children 18 years or younger; married-couple families; male householder, no wife; and female householder, no husband. Nonfamily household includes people living alone and people 65 years or older. For the current study, we classified a participant as a family household if the participant had a child less than 18 years of age living at home.

high school/high school/GED population.[4,5] The percentage of participants from a nonfamily household was 54%, yet the Census data target for this category was 34%. The difference in our study population was likely due to a higher percentage of participants (35%) in the 18 to 34 years age category. More highly educated respondents were recruited and scheduled first, which made it more difficult to recruit people from other target demographic groups (e.g., high school, Hispanic, and 55 years or older), resulting in the need for outbound recruiting. Although the Census targets were not met, the study sample is still diverse regarding the demographic characteristics of interest.

The eligibility rate (percentage of cases that completed the web-based or phone screening and met the eligibility criteria) was 36%. For prospective participants completing the web-based survey, we screened out approximately 12% because they did not do all or most of the grocery shopping for the household. Of the potential participant pool at this point, we then screened out approximately 16% because of prior food safety training (e.g., ServSafe) and then 12% of this potential population because of work experience in the food industry. Among the 383 study participants, we recruited 58% using social media, 18% via outbound recruiting efforts, and 8% via posters and flyers; thus, social media was much more effective than using posters and flyers to recruit participants. The expected response rate (show rate) for the kitchen preparation study was 80%; the actual show rate averaged 85%.

2.3 Coding of Observation Data and Analysis

We used notational analysis to assess recorded actions and their frequencies. Notational analysis is a generic tool used to collect observed events and place them in an ordered sequence (Hughes & Franks, 1997); it has been used to track food safety behaviors, because it enables the recording of specific details about events in the order in which they occur by associating a time stamp with actions (Clayton & Griffith, 2004). Using a time-stamp is especially useful when looking at sanitation steps limiting cross-contamination or the use of common food contact surfaces and equipment. Notational analysis has been used in both nonparticipant and participant consumer food safety behavior observation studies, as well as participant foodservice observation (Chapman et al., 2010; Clayton & Griffith, 2004; Green et al., 2006; Redmond et al., 2004).

We developed separate coding rubrics to characterize the following behaviors:

- handwashing
- thermometer use

[4] The average screen-out rate for food safety training and food industry experience for the high school/GED population was 48% compared with 30% in the “some college” demographic, 26% in the “college degree” demographic, and 21% for the “postgraduate degree” demographic.
[5] The educational attainment levels in Wake County are higher relative to the U.S. population: 50% of adults in Wake County have a bachelor’s degree compared with 18% for the U.S. population (U.S. Census Bureau, 2016).

- direct cross-contamination
- indirect cross-contamination

Observers followed the rubric to indicate level of adherence to recommended behaviors while observing participants. The rubric also included a list of trigger behaviors that prompted additional questions during the post-observation interview and items to be sampled. Coders were trained by reviewing the coding rubric and using practice food safety handling scenarios to compare inter- and intracoding reliability. Incorrect and inconsistent coding situations were discussed with coders to ensure that proper and consistent training occurred. Appendix G provides the coding rubrics.

2.4 Microbiological Data and Analysis

We determined the concentration of MS2 on swab samples by comparing RT-qPCR results with a standard curve. We determined a swab sample was significantly contaminated if it contained 5 $\log^{10}$ MS2 RT-qPCR genome equivalent copies (GECs) or higher. We would not expect contamination levels of pathogens in USDA regulated food products to exceed 5 $\log^{10}$, in step with data-supported assumptions found in 9 CFR Parts 301, 317, 318, 320, and 381. To confirm effective decontamination of the kitchen between participants, one cleaning validation surface swab was taken before a participant began their meal preparation. A total of up to 12 surface samples and one lettuce sample were taken for each observation, resulting in up to 14 total samples per observation. The results provided in this draft report describe the prevalence and level of contamination of the RTE salad, mobile device (if used), refrigerator handle, faucet handle and spice containers. Further analysis is being conducted on remaining samples, and data will be provided in a supplement to this report in July 2018. Appendix F provides additional information on the microbiological analysis procedures.

2.5 Thermometer Data and Analysis

A trained observer viewed each video to assess thermometer usage frequency, correct placement, and specific temperatures. We created a heat map to show not only the approximate placement of the thermometer when placed into each the patty, but also the angle of insertion (whether from the top, directly from overhead, or from the side) as observed during the study. We also constructed a unique instrument for this project: a data logger placed inside the housing of a thermometer constructed to look like a commercially available thermometer for consumer use. When participants used the thermometer/data logger, it recorded the temperature of the probe tip every second. In addition to the placement and temperature, observers also recorded whether the thermometer was used on one or two patties (because often the temperature varies between patties). Supplemental to the thermometer use, observers also recorded the number of flips per patty, because flipping can lead to more even heating of the product.

2.6 Post-observation Interviews and Analysis

The post-observation interviews collected information on participants' decisions while cooking the meal and information about their food handling behaviors that were not observed (Appendix C provides the interview guide). We audio recorded the interviews and had typed transcripts prepared using the service TranscribeMe. We coded the transcripts and analyzed the data using QSR International NVivo, Version 11 software.

We administered separate interview guides for the treatment and control groups. Participants in the treatment group answered questions about their reaction to the thermometer video that they watched before cooking and the extent to which watching the video influenced their actions in the kitchen. Control group participants, who did not watch the thermometer video, answered questions about how they get information about safely preparing foods and preferred methods for receiving such information.

Questions posed to all participants during the interview were influenced by the trigger behaviors that were observed during meal preparation (see Table 2-1) and related to

- handwashing,
- determining doneness (including thermometer use),
- handwashing after touching raw turkey or packaging,
- washing cutting board and utensils, and
- touching personal mobile devices while cooking (if applicable).

For each behavior, the interviewer prompted the participant based on the actions observed and asked why he or she did the behavior and whether that is a behavior he or she typically does at home.

Following data collection and transcription, analysts uploaded the transcripts from all recorded interviews into NVivo for coding and analysis. We assigned a unique case number to each participant to link the screener data and post-observation data. We coded the following variables presented in this report:

- food poisoning:
  - participant ever experienced food poisoning
  - family member of participant ever experienced food poisoning
- perception of how common it is for people to get food poisoning because of the way food is prepared at home.
- view on risk of getting food poisoning
- thawing practices
  - method used
  - days before cooking or discarding thawed meat if not prepared the same day

- storing leftovers
  - types of containers used to store large quantity of leftovers, such as soup
  - whether leftovers are stored immediately or allowed to cool
  - days before discarding leftovers

In addition, we coded the following variables for the treatment group to describe their response to the thermometer video (yes/no) and the reasons for their response (coding categories developed):

- Did the video influence your actions in the kitchen today?
- Do you think the video will influence how you cook at home in the future?
- Did you relate to the people or situations in the video?

We tabulated the responses for the treatment and control groups and conducted statistical testing to test for differences between the two groups.

3. Results

This section describes the characteristics of the study sample and presents the results of the meal preparation experiment for thermometer use, handwashing compliance, and cross-contamination. Additionally, we provide information on self-reported usual practices for thawing and storing leftovers based on responses to the post-observation interviews. When available, the results from the current study are compared with results from national surveys and the published literature.

3.1 Sample Characteristics

Of the 383 participants in the study sample, 66% were White and 86% were non-Hispanic. Participants represented a variety of ages with 35% in the 18 to 34 age category, 40% in the 35 to 54 age category, and 25% in the 55 or older age category. Fifty percent of participants had at least a 4-year college degree, and 46% had at least one child living in the household (≤17 years). About 34% of participants had at least one individual in the household at risk for foodborne illness (i.e., adult aged 60 years or older; pregnant woman; child aged 5 years or younger; or individual diagnosed with diabetes, kidney disease, or another condition that weakens the immune system) (see Table 3-1). Section 2 compared the study sample with the most recent Census data. Although there are some differences in the distribution for age, education, and presence of a child in the household, the study sample is still diverse regarding the demographic characteristics of interest.

When comparing participants in the treatment and control groups, the two groups were similar in terms of ethnicity, age, education, and presence of a child in the household. The two groups were significantly different for the distribution of race (p = .05); the control group had a larger percentage of White participants (71 vs. 61%) and a smaller percentage of Black participants (26 vs. 35%) compared with the treatment group. In addition, participants in the control group (40%) were significantly more likely than participants in the treatment group (27%) to have at least one individual in the household at risk for foodborne illness (p = .04).

Table 3-1 also provides information on participants' experience and perceptions regarding foodborne illness, as reported in the post-observation interviews. These are factors that may influence participants' food safety behaviors. We saw no significant differences between responses to these questions for the treatment and control group participants. We summarize the responses to these questions below and compare them with results from the 2016 Food and Drug Administration (FDA) Food Safety Survey, a national telephone survey of 4,169 adults (18 years or older) (Lando et al., 2016).

Many participants in the study sample had experience with food poisoning; 34% reported they have personally had food poisoning, and 55% reported a family member has had food

poisoning.[6] Participants' responses suggest that they have some concerns about food safety. On a scale of 1 to 7, with "1" being not at all concerned, "4" being neutral, and "7" being extremely concerned, 68% of participants had concerns (response of 5, 6, or 7) "about bacteria or viruses on or inside the food [they] cook" (mean value = 5.1). About 66% of participants reported that it is "very" or "somewhat common" for people in the United States to get food poisoning because of the way food is prepared in the home, and 33% reported that it is "not very common." Comparing these results with those from the 2016 Food Safety Survey, 12% of respondents to the national survey believed that it is "very common," 33% believed it is "somewhat common," and 53% believed it is "not very common." Thus, the study sample appears to be more concerned about food safety than the study sample for the national survey.

Almost half of participants (46%) shared the view "All types of people have about the same risk of getting food poisoning" versus 28% of participants who shared the view "Certain types of people have a higher risk of getting food poisoning." One-fourth of participants (25%) shared the view "It depends; certain types of people are at higher risk for some types of food poisoning." Comparing these results with those from the 2016 Food Safety Survey, 49% of respondents to the national survey shared the view "All types of people have about the same risk of getting food poisoning," and 48% of respondents shared the view "Certain types of people have a higher risk of getting food poisoning." Only 1% of respondents agreed with the statement "It depends; certain types of people are at higher risk for some types of food poisoning." Thus, the study sample appears to have different views about the risk of getting foodborne illness than the study sample for the national survey.

Table 3-1. Sample Characteristics

Characteristic	All Participants (*n* = 383)	Control (*n* = 201)	Treatment (*n* = 182)	*p* value[a]
Race				.05
Caucasian or White	66% (253)	71% (142)	61% (111)	
Black or African American	30% (117)	26% (54)	35% (63)	
Other race[b]	3% (13)	3% (5)	4% (8)	
Ethnicity				.97
Not Hispanic or Latino	86% (330)	86% (173)	86% (157)	
Hispanic or Latino				

(continued)

[6] Participants were asked the following questions: "Have you ever had food poisoning?" and "Has a family member ever had food poisoning?" Information was not collected on whether the person was diagnosed with food poisoning by a health care professional.

Table 3-1. Sample Characteristics (continued)

Characteristic	All Participants (*n* = 383)	Control (*n* = 201)	Treatment (*n* = 182)	*p* value[a]
Age				.78
18–34	35% (134)	36% (71)	34% (61)	
35–54	40% (154)	37% (73)	44% (81)	
55 or older	25% (95)	28% (55)	22% (40)	
Education				.49
Less than high school or high school diploma/GED[c]	24% (93)	25% (49)	24% (44)	
Some college	26% (99)	23% (47)	29% (52)	
Bachelor's degree	31% (119)	33% (65)	30% (54)	
Graduate or professional degree	19% (72)	20% (40)	17% (32)	
Have child 17 or younger living in household	46% (176)	46% (91)	46% (85)	.98
Have at-risk individual living in household[d]	34% (130)	40% (80)	27% (50)	.04
Participant has had foodborne illness (self-reported)	54% (203)	51% (101)	56% (101)	.20
Participant's family member has had foodborne illness (self-reported)	55% (208)	57% (113)	53% (95)	.45
Participant's level of concern about food safety[e]				
Mean value	5.1	5.0	5.2	.33
1–3 (Not concerned)	11% (42)	10% (20)	12% (22)	
4 (Neutral)	21% (79)	18% (35)	25% (44)	
5–7 (concerned)	68% (257)	72% (144)	63% (113)	
Participant's perception of how common it is for people to get food poisoning because of the way food is prepared at home[f]				.87
Very common	17% (66)	17% (34)	18% (32)	
Somewhat common	49% (185)	50% (100)	47% (85)	
Not very common	33% (127)	33% (65)	35% (62)	

(continued)

Table 3-1. Sample Characteristics (continued)

Characteristic	All Participants (*n* = 383)	Control (*n* = 201)	Treatment (*n* = 182)	*p* value[a]
Participant's view on risk of getting food poisoning[g]				.81
Certain types of people have a higher risk of getting food poisoning	28% (105)	30% (59)	26% (46)	
It depends; certain types of people are at higher risk for some types of food poisoning	25% (95)	23% (46)	27% (49)	
All types of people have about the same risk of getting food poisoning	46% (173)	45% (89)	47% (84)	
Don't know	1% (5)	3% (5)	0% (0)	

[a] We calculated *p* value significance testing using a chi-squared test for dichotomous variables and repeated measures of analysis of variance (i.e., ANOVA) for continuous variables for the difference between the control and treatment groups for each characteristic.

[b] Other race includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and two or more races.

[c] Toward the end of data collection, we revised the screening questionnaire to include people with technical or vocational training in this category.

[d] At-risk populations are people who are 60 years of age or older, children 5 years of age or younger, pregnant women, people diagnosed with diabetes or kidney disease, and people diagnosed with a condition that weakens the immune system.

[e] Participants were asked the following question in the post-observation interview: "How concerned are you about bacteria or viruses on or inside the food you cook?"

[f] Participants were asked the following question in the post-observation interview: "How common do you think it is for people in the United States to get food poisoning because of the way food is prepared in their home?"

[g] Participants were asked the following question in the post-observation interview: "Of the following three statements, which one is closer to your view ...?"

Sources: 2017 meal preparation experiment—data are from the screening questionnaire or post-observation interview (as noted in footnotes). For the post-observation interviews, useable data are not available for 5 participants (*n* = 199 control and 179 treatment).

3.2 Intervention-Specific Results: Thermometer Use

The first iteration of the meal preparation experiment focused on participants' food thermometer use and cooking to the safe endpoint temperature when preparing ground turkey patties. Participants were asked to prepare two turkey patties, a chef's salad, and a salad dressing.

At the time of recruitment, 61% of control group and 63% of treatment group participants reported owning a food thermometer (see Table 3-2). These results are generally consistent with the 2016 Food Safety Survey (Lando et al., 2016), in which 67% of consumers reported owning a food thermometer.

Screenshots from USDA Video on Using a Food Thermometer

Source: U.S. Department of Agriculture. (2015). The importance of cooking to a safe internal temperature and how to use a food thermometer [video]. Retrieved from https://www.youtube.com/watch?v=-2KkV2yFiN0

Overall thermometer use data show that of the 383 participants 206 (54%) used a thermometer to measure the temperature of at least one of the ground turkey patties.[7] The control group used a thermometer 34% of the time, while participants who were exposed to the video used a thermometer to check doneness 75% of the time (significant at $p < .001$) (see Table 3-2). Thus, individuals exposed to the video on thermometer use were more than 2 times likely to use a thermometer when cooking ground turkey patties than individuals who were not shown the video. The control group's thermometer usage was higher than the 2016 Food Safety Survey (Lando et al., 2016) self-reported behaviors—10% for hamburgers and 19% for chicken parts—but in line with the International Food Information Council's (2015) Food & Health Survey 2015 where more than 30% of consumers reported always using a food thermometer when cooking poultry.

Attempts to use a food thermometer were further analyzed to demonstrate that 42% of attempts (23% control, 52% treatment, significant at $p < .001$) were in the correct location of the patty; that is, the thermometer was inserted into the side of the turkey patty to reach the center to seek the coldest spot. Previous studies have mainly focused on recording just thermometer attempts (not placement), and, in some cases, the final cook temperature was

[7] Twenty video files were corrupted and could not be recovered. The results for these participants are based on information recorded on the trigger sheets.

measured after some elapsed time (Phang & Bruhn, 2011); therefore, we are unable to compare correct thermometer use with previous work.

Table 3-2. Rate of Thermometer Use

	Control (*n* = 201)	Treatment (*n* = 182)	*p* value[a]
Self-reported thermometer ownership	61.2% (123)	63.2% (115)	.57
Participants using a thermometer	34.3% (69)	75.3% (137)	<.001
Number of total attempts (multiple attempts per observation counted)[b]	168	322	<.001
Correct placement among total attempts (inserted in the side of the patty, to the center)[c]	22.6% (38)	52.2% (168)	<.001

[a] We calculated *p* value significance testing using a chi-squared test for dichotomous variables and repeated measures of analysis of variance (i.e., ANOVA) for continuous variables for the difference between the control and treatment groups for each outcome.

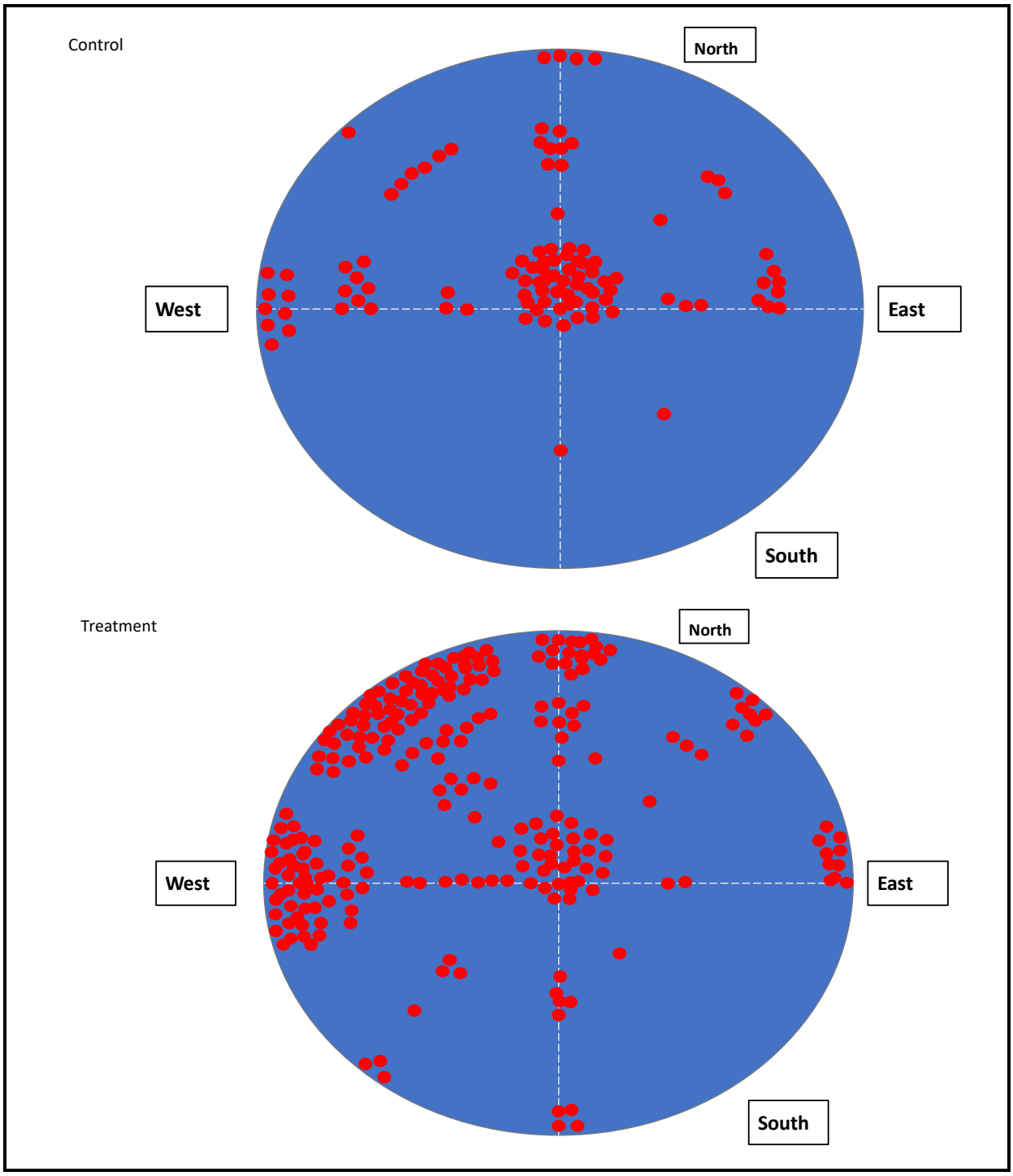
[b] "Attempt" is defined as a participant using a food thermometer to check the doneness of one or both turkey patties.

[c] "Correct placement" is defined as a participant inserting the thermometer into the side of the turkey patty to reach the center and held for at least 5 seconds before the temperature is determined..

Source: 2017 meal preparation experiment—screener (self-reported thermometer use) and coding of food preparation.

The portion of the intervention video that is specific to hamburger patties demonstrated how to insert the thermometer from the side and provided the message to measure the temperature of each patty. Figure 3-1 is a diagram of a turkey patty with a heat map indicating thermometer placement for the control and treatment group participants. The red-colored dots indicate points of thermometer insertion. The brown area represents the top of the turkey patty, and the blue halo represents the side profile of the patty, meaning that a red point in the blue halo indicates that a participant inserted the thermometer through the side of the patty. Comparing the two heat maps indicates the treatment group participants were more likely than the control group participants to insert the thermometer into the side of the patty, which is the recommended practice.

Figure 3–1. Turkey Patty with Heat Maps Showing Thermometer Placement by Group



Note: "North" is the part of the pan that is farthest from the participant. The red dots indicate the placement of thermometer insertion. The brown area represents the top of the turkey patty; the blue halo represents the side profile of the turkey patty. Number of participants who used a food thermometer = 69 control group and 137 treatment group.

Source: 2017 meal preparation experiment—coding of food preparation.

Treatment group participants were significantly more likely than control group participants to check the temperature of both patties (82 vs. 73%, $p < .001$), which is the recommended practice (see Table 3-3).

Table 3-3. Number of Patties for Which Temperature Was Checked Among Participants Who Used a Food Thermometer

	Control (*n* = 60)	Treatment (*n* = 128)	*p* value[a]
One patty	26.7% (16)	18.0% (23)	.067
Two patties	73.3% (44)	82.0% (105)	<.001

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for each outcome.

Notes: *N* = 206 for thermometer; *N* = 188 (obtainable number for analysis). The number of patties checked was undetermined for 18 observations because the videos needed to make this determination were corrupted.

Source: 2017 meal preparation experiment—coding of food preparation.

Two factors that can affect even heating are the state of the product before cooking (e.g., frozen, refrigerated, or room temperature) and the amount of times during cooking the product is turned over (i.e., flipped) (Berry and Bigner-George (2001); Gill, Yang, Uttaro, Badoni, & Liu, 2013; Luchansky et al., 2013). The side of the hamburger that is farthest away from the heat of the grill or the bottom of a frying pan can differ by as much as 80°F. Yang et al. (2017) and Luchansky et al. (2013) demonstrated the impact of flipping meat while cooking, showing that more than three flips with nonintact beef result in the highest reduction of *E. coli* O157:H7. Research has shown that there are substantial differences between heating surface and product endpoint temperatures because the center of the hamburger is not heated directly by the pan temperature but rather by the steam–water interface temperature, which is inside the surface of the hamburger (Juneja, Snyder, Williams, & Marmer, 1997). Berry and Bigner-George (2001) demonstrated substantial temperature variability within patties because of the considerable temperature variability that can exist within patties at the end of cooking. As shown in Table 3-4, about one-third of participants in the treatment and control groups flipped the patties fewer than three flips.

Table 3-4. Number of Flips per Patty (two patties per participant)

	Control (*n* = 374 patties)	Treatment (*n* = 326 patties)	*p* value[a]
No flips (used clamshell grill or baked in oven)	3.2% (12)	2.8% (9)	
One flip	16.3% (61)	15.3% (50)	
Two flips	17.1% (64)	20.2% (66)	
Three or more flips	63.4% (237)	61.7% (201)	
Mean number of flips	2.4	2.4	.958
Total	100.0%	100.0%	

[a] We calculated *p* value significance testing using a *t* test for the difference between the control and treatment groups for the mean number of flips per patty.

N = 700 patties (obtainable number for analysis).

Source: 2017 meal preparation experiment—coding of food preparation.

Each time a participant used a thermometer to check for doneness, a data logger recorded the temperature of the patty every second to determine whether it reached a safe endpoint temperature, either 165°F instantaneously or a time–temperature relationship that would result in the same level of reduction of potentially harmful bacteria (e.g., 164°F for 11.2 seconds). We determined safe endpoint time–temperature combinations using USDA FSIS's Appendix A: Times for given temperature and fat level of turkey needed to obtain 7-log lethality of *Salmonella* (USDA, FSIS, 2017). Among participants who used a thermometer and for whom a temperature was available, 67% of patties (54% control, 73% treatment, significant at $p < .008$) reached an instant 165°F, which represents the final thermometer reading for the turkey patty (see Table 3-5); no patties reached a safe temperature for other time and temperature combinations. Thus, patties cooked by the treatment group participants were significantly more likely to reach an instant 165°F compared with the control group participants. Although there are differences between handling beef and poultry products, these results are comparable to Phang and Bruhn's (2011) results, which showed that for 83% of participants who were asked to prepare ground beef hamburger patties at home, the burger temperature was above the recommended safe temperature threshold. About 20% (27 out of 137) of the endpoint temperature recordings for the current study were below 150°F; the lowest recorded endpoint temperature was 65°F (see Table 3-6). It is important to note that these participants could have continued to cook the patties and used a subjective measure (such as cutting) to determine doneness. Additional analysis is being conducted to determine whether these 27 participants continued to cook the patties or considered the patties to be done after checking the temperature.

Table 3-5. Time–Temperature Combinations for Turkey Patties Deemed Safe

	Control (*n* = 44)	Treatment (*n* = 91)	*p* value[a]
Instant 165°F	54% (24)	73% (66)	.008
Time–temperature combination[b]			
164°F for 11.2 seconds	0	0	—
163°F for 13.8 seconds	0	0	—
162°F for 17 seconds	0	0	—
161°F for 21 seconds	0	0	—
160°F for 25.8 seconds	0	0	—
155°F for 72 seconds	0	0	—

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups.

[b] Time–temperature combinations are from USDA FSIS, Appendix A: Times for given temperature and fat level of turkey needed to obtain 7-log lethality of *Salmonella* (USDA, FSIS, 2017).

Notes: *N* = 206 for thermometer use; *N* = 135 (obtainable number). Data are not available for 71 participants because participants submerged the data logger (25 control and 46 treatment recordings unrecoverable).

Source: 2017 meal preparation experiment—data logger.

Table 3-6. Distribution of Endpoint Temperatures Among Participants Who Used a Food Thermometer

Degrees	Control (*n* = 44)	Treatment (*n* = 91)
165+	54% (24)	73% (66)
160–164.9	11% (5)	3% (3)
155–155.9	2% (1)	4% (4)
150–154.9	5% (2)	3% (3)
145–149.9	7% (3)	1% (1)
140–144.9	0	0
135–140	0	0
130–135	2% (1)	1% (1)
125–130	2% (1)	2% (2)
120–125	0	0
115–120	0	1% (1)
110–115	0	0
105–110	0	0
100–105	0	0
95–100	0	0
90–95	2% (1)	1% (1)
85–90	0	0
80–85	2% (1)	2% (2)
75–80	5% (2)	2% (2)
70–75	5% (2)	3% (3)
65–70	2% (1)	2% (2)
60–65	0	0
Total	100% (44)	100% (91)

Notes: *N* = 206 for thermometer use, *N* = 135 (obtainable number). Data are not available for 71 participants because participants submerged the data logger (25 control and 46 treatment recordings unrecoverable). It is possible that participants could have continued to cook the patties after checking the temperature and used a subjective measure (such as cutting) to determine doneness.

Source: 2017 meal preparation experiment—data logger.

A total of 45% (*n* = 172) of participants used another method to determine doneness besides using a thermometer. Among these participants, 46% of participants in the control group and 29% of participants in the treatment group relied on the firmness/texture of the patty to determine if the patty was done (see Table 3-7). Twenty-five percent of participants in the control group and 42% of participants in the treatment group were

observed using more than one method—firmness and color of the patty—to determine doneness.

Table 3-7. Methods Used to Determine Doneness for Participants Who Did Not Use a Food Thermometer

Method	Source	Control (*n* = 127)	Treatment (*n* = 31)	*p* value[a]
Only used color	Self-reported: inside color	26% (33)	16% (7)	.27
	Self-reported: outside color	0% (0)	7% (3)	
	Observations	4% (5)	16% (5)	.08
Only used touch (firmness or texture of burger)	Self-reported	5% (7)	5% (2)	.92
	Observations	46% (59)	29% (9)	.11
Used more than one method (color and touch)	Self-reported	70% (93)	71% (29)	.92
	Observations	25% (32)	42% (13)	.09
Unobservable method (e.g., cooking time)	Observations	24% (31)	10% (3)	.02
Total	Self-reported/observations	100%	100%	

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for each method.

Notes: *N* = 172; *N* = 158 (obtainable number); data are not available for 14 participants because of corrupted/unrecoverable video files. The unobservable methods include participants who relied on cooking time and those who might have looked at the outside color (without touching the patty).

Sources: 2017 meal preparation experiment—coding of food preparation (observed) and screening questionnaire data (self-reported usual behavior).

Among participants who used a food thermometer and useable data were available (*n* = 191), 38% of participants in the control group and 42% of the participants in the treatment group relied solely on the food thermometer (see Table 3-8). However, self-reported rates from the screener for thermometer use as the sole method were considerably lower: 6% for the control group and 5% for the treatment group. One possible explanation for this is the use of turkey burgers. The screener did not specifically mention turkey; rather, it asked, “How do you determine whether the burgers are done and ready to eat?” From the post-observation interviews, many participants mentioned feeling less comfortable determining doneness from color and/or texture with turkey burgers than with hamburgers made from ground beef. This lack of experience or comfort with cooking turkey burgers could be one possible reason for the higher rate of thermometer use as the sole method for determining doneness. The most common observed methods to determine doneness among thermometer users using multiple methods were thermometer use and the firmness/texture of the patty (70% control and 79% treatment).

Table 3-8. Other Methods Used to Determine Doneness for Participants Who Did Use a Food Thermometer

Method	Source	Control (*n* = 60)	Treatment (*n* = 131)	*p* value[a]
Only used thermometer	Self-reported	6% (4)	5% (7)	.87
	Observations	38% (23)	42% (55)	.63
Only used color	Self-reported: inside color	22% (13)	26% (36)	.35
	Self-reported: outside color	0% (0)	0% (0)	
	Observations	0% (0)	0% (0)	
Only used touch (firmness or texture of burger)	Self-reported	1% (1)	2% (3)	.26
	Observations	0% (0)	0% (0)	
Used more than one method	Self-reported	30% (50)	68% (97)	.38
	Observations	62% (37)	58% (76)	
Method used, if more than one method used (from observations)	Used therm. & touch	70% (26)	79% (60)	.75
	Use therm. & color	3% (1)	5% (4)	.53
	Use therm., touch, & color	27% (10)	16% (12)	.17
Total	Self-reported/observations	100%	100%	

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for each method.

Notes: *N* = 212; *N* = 191 (obtainable number); data are not available for 21 participants because of corrupted/unrecoverable video files.

Sources: 2017 meal preparation experiment—coding of food preparation (observed) and screening questionnaire data (self-reported usual behavior).

Overall, these results suggest that the intervention (USDA video on thermometer use) was effective in encouraging participants in the treatment group to use a thermometer and to place it in the correct location of the patty; among the temperatures we were able to measure when a thermometer was used, the patty was cooked to a safe temperature 67% of the time (treatment = 73% correct and control = 54% correct ($p < .008$).

3.3 Handwashing Compliance

Inadequate handwashing has been identified as a contributing factor to foodborne illness, especially when preparing raw meat and poultry. Hands can become vectors that move pathogens around sites for foodborne pathogens found in raw meat and poultry and that contribute to home-acquired foodborne illnesses. Frequency and level of contamination of hands have not been well studied.

The USDA video on thermometer use does not provide information on the need to wash hands before and during cooking and or on proper handwashing procedures. However, we

measured handwashing compliance in this study because FSIS needs information on consumer adherence to the recommended practices for each study year for all four key food safety messages (clean, separate, cook, and chill). Also, we wanted to assess whether a food safety video on thermometer use influences other food safety behaviors.

The total handwashing attempts required per observation are determined during the coding for each observation. For example, a handwashing event is required for each of the following instances:

- before touching RTE foods at the onset of food preparation
- anytime between touching raw meat or packaging and then touching a nonmeat item
- after touching another person or self
- after touching cell phone
- after multitasking (chores)
- after touching contaminated (post-meal) trash or trash can

The total number of attempts per observation is the number of times a participant washed their hands. Each handwashing event was coded as adequate or inadequate based on the criteria set by the Center for Disease Control and Prevention (CDC): wet hands with water; rub hands with soap for at least 20 seconds; rinse hands with water; and dry hands using a clean, one-use towel. For example, participant 001T was required to wash her hands nine times but attempted only two times. Of these two times, neither was coded as successful because she did not scrub her hands for a total of 20 seconds.

We observed 2,249 cases in which a handwashing event was required to control pathogens; of these, handwashing was attempted 31% of the time (see Table 3-9). Among handwashing events attempted, only 4% of attempts contained all steps of a correct handwashing event. As shown in Table 3-10, the most common reason for unsuccessful handwashing was not rubbing hands with soap for at least 20 seconds (76% in the control group and 83% in the treatment group), followed by not wetting hands with water (40% in the control group and 44% in the treatment group). Nearly a third of all attempts did not include proper drying. Drying hands using a clean or one-use towel is an important step in handwashing because it can physically remove microbes and contaminants from hands, resulting in up to a 1 log reduction (Huang, Ma, & Stack, 2012). There were no significant differences between the treatment and control groups.

Table 3-9. Handwashing Compliance

	Control (*n* = 185)	Treatment (*n* = 165)	*p* value[a]
Handwashing event required	1,195	1,054	.429
Attempts[b]	30.5% (365)	32.5% (343)	.175
Successful attempts[c,d]	0.8% (10)	1.5% (16)	.066
Before meal preparation	100% (10)	100% (16)	
After touching raw turkey	(0%) 0	(0%) 0	
Undetermined	1	2	
Missing	8	12	

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for handwashing compliance.
[b] "Attempt" is defined as any time that a participant appeared to clean their hands; the attempt could be adequate or inadequate.
[c] A successful attempt is defined as a participant meeting all the criteria set by CDC: wet hands with water; rub hands with soap for at least 20 seconds; rinse hands with water; and dry hands using a clean, one-use towel.
[d] All successful attempts at handwashing occurred before beginning meal preparation. No successful attempts occurred after directly handling raw turkey.

Notes: Number of events in which handwashing was required = 1,195 control group and 1,054 treatment group. Number of observations coded: control = 185 and treatment = 165. Data for the remaining participant observations are not recoverable because of damaged/corrupted/incomplete video files.

Source: 2017 meal preparation experiment—coding of food preparation.

Table 3-10. Reasons for 0-Unsuccessful Handwashing Attempts

	Control		Treatment		
Reason[a]	Attempts Needed (*n* = 1,170)	Total Unsuccessful Attempts (*n* = 355)	Attempts Needed (*n* = 1,049)	Total Unsuccessful Attempts (*n* = 327)	*p* value[b]
Did not wet hands with water		39.7% (141)		44.3% (145)	.11
Did not use soap		23.9% (85)		18.0% (59)	.36
Did not rub hands with soap for at least 20 seconds		75.8% (269)		82.6% (270)	.39
Did not rinse hands with water		0.6% (2)		0.9% (3)	.31
Did not dry hands		13.0% (46)		10.1% (33)	.77
Dried hands with surface other than clean, one-use towel (e.g., wiped hands on clothing or used previously used towel)		16.3% (58)		23.2% (76)	.67

(continued)

Table 3-10. Reasons for Unsuccessful Handwashing Attempts (continued)

	Control		Treatment		
Reason[a]	Attempts Needed (*n* = 1,170)	Total Unsuccessful Attempts (*n* = 355)	Attempts Needed (*n* = 1,049)	Total Unsuccessful Attempts (*n* = 327)	*p* value[b]
Undetermined		1		2	
Missing		8		12	

[a] There may be multiple reasons for a handwashing event to be unsuccessful, so the percentages sum to more than 100%.

[b] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for each reason.

Notes: Number of participant observations coded = 185 control and 165 treatment. Number of events in which handwashing was required among coded observations = 1,170 control group and 1,049 treatment group. Number of unsuccessful handwashing attempts among coded observations = 355 control group and 327 treatment group. Data for the remaining participant observations are not recoverable because of damaged/corrupted/incomplete video files.

Source: 2017 meal preparation experiment—coding of food preparation.

3.4 Cross-Contamination and Microbiological Analysis

We also analyzed the spread of MS2 from the spiked turkey patties to various surfaces and RTE food products. Lack of or failed handwashing attempts can spread pathogens to high touch surfaces through contact of contaminated hands to surfaces and foods. *Campylobacter* and *Salmonella*, pathogens found in poultry products, have been shown to be viable on food contact surfaces for 4 to 32 hours respectively (De Cesare, Sheldon, Smith, & Jaykus, 2003) posing a potential health risk in the home if contaminated surfaces are not adequately cleaned and sanitized.

We used the microbiological data to identify both the direct and indirect cross-contamination events that occurred during the meal preparation experiment. Direct cross-contamination is defined as when raw meat or raw meat packaging (in this case ground turkey) comes into direct contact with a RTE food or a food handling surface or utensil and the area is not cleaned and sanitized after contact. Indirect cross-contamination is when utensils, surfaces, and/or hands make contact with a contaminant and then are not cleaned and/or sanitized adequately before the next use, any time between touching raw meat or packaging and then touching a nonmeat item, touching a mobile device, or touching trash. For the draft report, we analyzed the data for mobile devices (if used), the refrigerator handle, spice containers, and the faucet handle. Table 3-11 shows the prevalence and level of contamination for these four sites, as well as the prevalence and level of contamination in the salad lettuce. This section describes the results and whether differences between the treatment and control groups are statistically significant.

Table 3-11. Prevalence of MS2 Contamination and Level of Contamination for Four Locations in the Kitchen and Salad Lettuce

Location		All Participants	Control	Treatment	*p* value[a]
Refrigerator handle	Prevalence contaminated % (*n*)	8.09% (372)	10.55% (199)	5.23% (172)	.0615
	Level of contamination ± SD, log genome copies[b]/handle (*n*)	5.50 ± 0.37 (30)	5.47 ± 0.38 (21)	5.51± 0.34 (9)	
Spice containers	Prevalence contaminated, % (*n*)	48.79% (372)	48.24% (199)	49.42% (172)	.8139
	Level of contamination ± SD, log genome copies/bottle (n)	6.18 ± 0.82 (181)	6.28 ± 0.83 (96)	6.07 ± 0.78 (85)	
Faucet handle	Prevalence contaminated, % (*n*)	12.13% (372)	11.06% (199)	13.37% (172)	.4939
	Level of contamination ± SD, log genome copies/bottle (*n*)	5.47 ± 0.52 (45)	5.51 ± 0.47 (22)	5.44 ± 0.56 (23)	
Mobile device (if used)	Prevalence contaminated, % (*n*)	7.79% (78)	5.71% (35)	9.30% (43)	.5565
	Level of contamination ± SD, log genome copies/device (*n*)	5.73 ± 0.79 (6)	5.54 ± 1.51 (2)	6.11 ± 0.39 (4)	
Salad lettuce	Prevalence contaminated (total)[c, d] % (*n*)	5.96% (367)	5.05% (199)	6.43% (168)	.5688
	Prevalence contaminated[e,d] % (*n*)	9.90% (222)	9.17% (109)	9.73% (113)	.8869
	Level of contamination (SD), log genome copies/18–25g (*n*)	5.52 ± 0.45 (22)	5.64 ± 0.74 (10)	5.46 ± 0.44 (11)	

Notes: Microbiological samples are available for 369 of the 383 participants. Samples are not available for 10 participants because toward the end of data collection there was insufficient daily lab capacity to process their samples. The control sample used to validate cleaning was positive in one sample and was excluded from all microbiological analyses. The microbiological analysis for three participants needs to be repeated because of inhibition in the PCR.

A positive result was one within 5 logs of the total inoculum (approximately log 10).

We would not expect contamination levels of pathogens in USDA-regulated food products to exceed log 5, in step with data-supported assumptions found in 9 CFR Parts 301, 317, 318, 320, and 381.

(*n*) = number of samples used in the analysis; SD = standard deviation.

[a] We calculated *p* value significance testing using a chi-squared test for prevalence and repeated measures of analysis of variance (i.e., ANOVA) for level of contamination for the difference between the control and treatment groups.

(continued)

Table 3-11. Prevalence of MS2 Contamination and Level of Contamination for Four Locations in the Kitchen and Salad Lettuce (continued)

[b] A genome copy is the RT-qPCR equivalent of one bacteriophage particle, as calculated using a standard curve generated from a sample with known genome copy concentration as described in Appendix F.

[c] Results include the salad lettuce samples that were not tested (*n* = 222) because these participants prepared the salad before preparing the turkey patties; thus, the samples are assumed to be negative because there was no opportunity for cross-contamination (i.e., contact with raw turkey or its packaging). These results are more representative of overall prevalence of salad lettuce contamination.

[d] Three samples were unusable because the lettuce from the salad and the lettuce from the burger garnish were combined, and lettuce was not taken for one observation; these participants were excluded from the lettuce analysis but included in the surface analysis.

[e] Results are for the salad lettuce samples that were actually tested, that is, the salad lettuce that potentially could have been contaminated because the participant prepared the salad after preparing the turkey patties.

Source: 2017 meal preparation experiment—microbiological samples.

The spice containers were the most frequently contaminated sample of those analyzed to date, with approximately 50% of participants contaminating these surfaces (independent of control/treatment). While coding for behaviors leading up to their contamination has not yet been conducted (to be provided in report supplement with final microbiological results in July 2018), it is likely that participants handled raw turkey patties immediately before picking up spice containers to season the patties. Similarly, for the faucet handle, which was found to be contaminated approximately 12% of the time (independent of control/treatment), it is likely that participants contaminated this surface in an attempt to perform a handwashing event following the contamination of hands by turkey patties or their packaging. Interestingly, the refrigerator handle was shown to be contaminated less frequently in the treatment group (approximately 5% of the time) compared with the control group (approximately 11% of the time); however, this difference was not significant (p = .0615). It is possible the treatment group collected all needed ingredients for the meal preparation in fewer trips to the refrigerator than the control group, resulting in fewer touch events; we will confirm this hypothesis in the final microbiological report supplement to be delivered in July 2018.

A total of 78 participants used their mobile device at some point after handling turkey packaging, and six devices were found to be contaminated. Table 3-12 shows the sequences of contacts leading to contamination based on the prevalence and level of contamination among the six positive samples for mobile devices. In four out of the six cases, there was a direct contamination event where the contaminated patty/and or packaging was touched directly to the mobile device. In the other two cases, a failed handwashing event led to the contamination. As the entire surface area of the mobile devices were swabbed, and they varied in surface area, no conclusions can be drawn from the level of contamination on the devices. However, these results show the need for improving handwashing practices in the home, studies to determine how long pathogens remain viable on mobile devices and their cases to determine potential public health risk, and data on how potentially contaminated mobile devices are shared in the home or used by individuals at higher risk (e.g., young children) during meal preparation, including for viewing and following recipe instructions.

Table 3-12. Sequences of Contact Leading to Contamination Based on Prevalence and Level of Contamination for Mobile Phones (*n* = 6, out of 77)

Positive Mobile Device	*n*	Level of Contamination Genome Copies/Mobile Device
Turkey patty → Mobile device	2	5.58 ± 0.02
Turkey patty packaging → Mobile device	2	5.51 ± 0.66
Turkey patty → Failed handwashing attempt → Another surface → Mobile device	1	7.17
Turkey patty → Failed handwashing attempt → Another surface → Another surface → Mobile device	1	5.03

Source: 2017 meal preparation experiment—coding of food preparation.

Discretionary samples of cloth towels were collected for some participants, and microbiological analysis is forthcoming. Kitchen towels have been shown to be a harborage site for surrogates in previous studies. Both paper towels and cloth towels were available to participants in this study, and participants opted to use paper towels over cloth towels most of the time. Discrepancies between the current study and the observation meal preparation experiment conducted by Sneed and colleagues (2015) may be due to different surrogates, differences in the tasks that were required of participants, and sample demographic differences.

Salad lettuce samples were only taken if the participant handled the turkey patties in any way before preparing the salad; if the salad was prepared before touching the turkey, the salad was assumed to be negative and the garnish lettuce was sampled instead. The salad lettuce was contaminated 6% of the time, including all unsampled salad lettuce assumed to have 0% contamination and 10% from those samples actually taken with no significant difference between the treatment and control groups in either case. The garnish lettuce used for the burger was not fully analyzed because of the small sample obtained (less than 20 g); a high proportion of positives is unlikely. The lack of difference between the treatment and control groups indicates that safe thermometer behavior does not necessarily influence cross-contamination behaviors. Thus, separate messaging is likely needed to change such behaviors.

The relatively low rate of contamination of salad lettuce (6%) indicates that cross-contamination was not necessarily frequent but did occur with some regularity. This finding suggests an increased risk of foodborne disease associated with these cross-contamination events. However, the very low concentrations of the surrogate that occurred on salad due to cross-contamination would reduce that risk to some extent. Consequently, the role of cross-contamination alone in elevating foodborne disease risk at the consumer level remains uncharacterized, until further risk assessment work is done. It should be noted that cross-contamination has often been highlighted in previous studies attempting to characterize

consumer behaviors. Preliminary, although as yet incomplete, coding of the observations suggests that a missed or failed handwashing attempt was part of the sequence that led to cross-contamination of the salad lettuce. Direct contamination of the salad lettuce by the turkey patties seems much less likely to be the contaminant source, in contrast to contamination of the spice containers, which was likely direct.

3.5 Self-Reported Usual Practices for Thawing and Storing Leftovers

The post-observation interviews collected information on behaviors that we were unable to observe regarding thawing frozen meat or poultry and storing leftovers (see Table 3-13). As previously noted for handwashing compliance, although these behaviors are not discussed in the intervention video, the project is designed so that information is collected on the key food safety messages (clean, separate, cook, and chill) in each iteration of the meal preparation experiment. As discussed below, responses were similar for the treatment and control groups.

About 79% of participants in the treatment group and 81% of participants in the control group reported they would use a USDA-recommended method (refrigerator, microwave, or cold water) to thaw raw meat or poultry. Thawing on the countertop and in a hot water bath and/or in a bowl without changing the water were methods used by some participants. One participant who thaws in water without changing the water noted that she normally places the meat in cold water before leaving for work, comes home after 8 hours, and then cooks it that evening, *"It's like eight hours [laughter] when I get home. Eight. I just go straight and cook it, so."*

Behaviors coded as "other methods" (n = 5) included setting meat on top of a running clothes dryer *"because it heats, it unfreeze the meat more quickly"* and a dish-rack (not the counter) because it is *"faster if you put it on so air is getting all the way around it. And I know I'm not supposed to but hey, I'm 67 and nobody's gotten sick."*

If participants thawed raw meat or poultry but were unable to cook it on the same day, 87% of participants in the treatment group and 86% of participants in the control group reported they would cook or discard the meat or poultry within 2 days per USDA recommendations for refrigerator thawing.

Regarding storage of leftovers (see Table 3-13), if participants cooked a large pot of soup or chili and had enough to eat the next day, 55% of participants in the treatment group and 46% of participants in the control group reported they would store the leftovers in multiple small containers. In addition, 8% of participants in the treatment group and 12% of participants in the control group reported they would refrigerate the leftovers "immediately" per USDA recommendations, instead of letting the leftovers cool before placing them in the refrigerator. Information on the amount of time that participants consider to be "immediate"

is not available. The 2016 FDA Food Safety Survey reports that 19% of respondents would refrigerate similar leftovers immediately and 76% of respondents would refrigerate after letting the soup or chili cool to room temperature. Finally, about 70% of both treatment and control group participants reported they would store leftovers in the refrigerator or discard them within 4 days. Some participants noted they use different discard times for different foods and meats:

- *"Depending on the food, usually no more than 2 or 3 days. Yeah. Usually, I'll try to eat it the next day and the day after that."*
- *"We have food labels that we bought at the restaurant. We give everything 2 weeks and things like fish get 1 week."*
- *"It depends on what it is. If it's chicken, 2 days max. If it's chili with ground beef, then 3 to 5 days, but not longer than that."*
- *"It does depend on what it is. But if we're talking specifically soup, I would say 5 days."*

Table 3-13. Self-Reported Practices for Thawing and Storing Leftovers

	Control (*n* = 200)	Treatment (*n* = 182)	*p* value[a]
Thawing method[b]			.95
Microwave	6% (12)	4% (8)	
Refrigerator	70% (141)	69% (127)	
Water in sink—use cold water and change water	5% (9)	6% (11)	
Water in sink—unsafe method (e.g., used hot water or did not change water)	10% (20)	9% (16)	
On countertop	8% (16)	10% (17)	
Other method	1% (2)	2% (3)	
Total	100%	100%	
If thawed meat or poultry but didn't cook it the same day, number of days store in refrigerator before cooking or discarding it[c]			.95
Discard	10% (20)	7% (13)	
1	45% (91)	53% (97)	
2	31% (62)	27% (48)	
3	10% (20)	10% (18)	
4	1% (2)	<1% (1)	
5 or more days	3% (5)	3% (5)	
Total	100%	100%	
Method of leftover storage (for large pot of soup or chili)[d]			.92
Place leftovers in one container	53% (106)	42% (77)	
Place leftovers in multiple small containers	46% (92)	55% (99)	

(continued)

Table 3-13. Self-Reported Practices for Thawing and Storing Leftovers (continued)

	Control (*n* = 200)	Treatment (*n* = 182)	*p* value[a]
Method of leftover storage (for large pot of soup or chili)[d] (continued)			.92
Place leftovers in multiple large containers	1% (2)	3% (6)	
Total	100%	100%	
Timing of leftover storage (for large pot of soup or chili)[d]			.97
Let leftovers cool before placing in refrigerator	88% (176)	92% (168)	
Refrigerate leftovers immediately	12% (24)	8% (14)	
Total	100%	100%	
Length of time would store leftovers before eating or discarding them			.98
1 to 4 days	69% (138)	71% (129)	
5 or more days	31% (62)	29% (53)	
Total	100%	100%	

[a] We calculated *p* value significance testing using a chi-squared test for the difference between the control and treatment groups for each response options.

[b] Participants were asked the following question: "Imagine you have meat or chicken in the freezer, and you plan to cook it for dinner later in the week. How would you thaw it?"

[c] If participants provided a range of days (e.g., 3 to 5 days), the latest date were coded (e.g., 5).

[d] Participants were asked the following question: "Imagine you just cooked a large pot of soup or chili so that you would have enough to eat the next day. What do you do with the leftovers?"

Note: Interview data are not available for one participant because the interview was not conducted because of time constraints.

Source: 2017 meal preparation experiment—post-observation interviews.

3.6 Participant Response to USDA Video on Thermometer Use (Treatment Group Only)

Post-observation interviews included collecting information about the participants' response to the USDA video on thermometer use viewed by participants in the treatment group before cooking. Table 3-14 shows the results from these questions and common reasons for participants' responses.

Table 3-14. Participants' Responses to USDA Video on Thermometer Use

Question	Response/Reasons, % (*n*)	
	Yes	**No**
Did the video influence your action in the kitchen today? Why or why not?[a]	**67% (121)**	**33% (60)**
Used thermometer to check doneness of patties	61% (74)	0% (0)
Comfortable with cooking experience and other methods of determining doneness	0% (0)	8% (5)
New information about temperatures	9% (11)	0% (0)
Learned about correct placement of thermometer	8% (10)	0% (0)
Reinforced existing thermometer use/normally use a thermometer at home	4% (5)	55% (33)
Other	7% (8)	8% (5)
Not answered/answer not clear/answer not relevant	11% (13)	28% (17)
Total	100% (121)	100% (60)
Do you think the video will influence how you cook at home in the future? Why or why not?[b]	**67% (115)**	**33% (61)**
Used thermometer to check doneness of patties	57% (66)	3% (2)
Comfortable with cooking experience and other methods of determining doneness	0% (0)	18% (11)
New information about temperatures	12% (14)	0% (0)
Learned about correct placement of thermometer	11% (13)	2% (1)
Reinforced existing thermometer use/normally use a thermometer at home	3% (3)	40% (24)
Other	2% (2)	8% (5)
Not answered/answer not clear/answer not relevant	15% (17)	30% (18)
Total	100% (115)	100% (61)
Did you relate to the people or situations in the video? Why or why not?[c]	**83% (148)**	**17% (31)**
Similar, believable people	16% (24)	0% (0)
Prepare similar food	34% (51)	2% (1)
Cooking at home for family, others	18% (26)	13% (4)
Thermometer use	7% (10)	3% (1)
Family size similar/participant cooks for self or one other person	5% (8)	50% (15)
Other	7% (10)	20% (6)

(continued)

Table 3-14. Participants' Responses to USDA Video on Thermometer Use (continued)

Question	Response/Reasons, % (*n*)	
	Yes	No
Not answered/answer not clear/answer not relevant	13% (19)	27% (8)
Total	100% (148)	100% (31)

[a] Number of participants = 181. One interview was not conducted because of time constraints.

[b] Number of participants = 176. Data are not available for five participants because the question was not presented clearly to participants. One interview was not conducted because of time constraints.

[c] Number of participants = 179. One interview was not conducted because of time constraints and this question was not asked in two interviews that were coded for this report.

Source: 2017 meal preparation experiment—post-observation interviews.

Approximately two-thirds of participants responded that watching the video influenced their cooking behavior in the test kitchen. Of these participants, 61% reported using a thermometer to check the doneness of the turkey patties as a result of watching the video. More specifically, 9% of the participants mentioned learning about the specific safe temperature for poultry as a primary reason for using a thermometer in the test kitchen, and 8% cited learning about correct placement of the thermometer. Inserting the thermometer into the side of the turkey patty was new information for several participants:

- "*Watching that video, I would have tested the meat differently probably. I wouldn't have even thought to put it through the side. I've always just kind of poked it in there in the center."*
- *"Don't know if I would have known to stick the meat thermometer in the side of the turkey burgers. That was something I learned. I would probably just stick it in the center."*
- *"I think I was a lot more conscientious of how to place the thermometer in the burger. Typically, I would just stab it in there and hope it wouldn't go all the way down to the bottom, but I've never done it flat."*

Thirty-four percent of participants reported that the video did not influence their cooking behavior in the kitchen; however, 55% of these participants reported that they use a thermometer on a regular basis in their home kitchen, and the video simply reaffirmed this practice. The most frequently cited reason (8%) for not using a thermometer in the test kitchen was participants' own experiences and confidence with other methods of determining doneness:

- *"I haven't had a victim yet … my record is good."*
- *"No, because I cook at home all the time, so I know what done food looks like. So I'm extra-cautious, not because of me, but for my child."*

About 67% of participants responded that the thermometer video will influence future cooking behaviors. Of these participants, 57% responded that they will use food thermometers more regularly with meats, especially with poultry, and some respondents were committed to purchasing a thermometer: *"Because like I said watching that video I was like, honestly, I was like, "damn. I need to get to Walmart and get a [laughter] meat thermometer." That's exactly what I thought to myself. I've been bad. All these years, never knew it [laughter]."*

About 33% of participants reported that watching the video will not influence their cooking behaviors in the future; however, 40% of the participants reported already using a thermometer when cooking meats. The most often cited reason (18% of participants) for not using a thermometer in the future is a reliance on other methods and general confidence in cooking experience and practices. Interestingly, one participant used a thermometer in the test kitchen but explained that she will not use it in the future—at least on thin cuts and burgers—because the thermometer reading in the kitchen supported her normal methods of doneness, *"No, because I was right on target. I mean, it actually matched what I do. Now I am quite interested in using one for the turkey dinner. I would like to start using one for my pork roast because that's something that, even after I cook it it's still pink. And then I will fry it afterwards."*

Approximately 83% of participants felt as if they related to either the people or situations in the video. The most common reasons included preparation of similar food items (34%), preparing home-cooked meals for dinners and leftovers (18%), and relating to the types of people/family structure in the video (16%). Approximately 17% of the participants felt that they did not easily relate to the people or situation in the video. About half of these participants reported that the family size in the video did not reflect their current situation because they only cook for themselves or one other person:

- *"I mean it's not that they're unrelatable, it's just like, "Oh, we're a happy little couple with our little kid and we cook at home every day," and that's not the way that I live I guess."*
- *"So, yeah, and the types of meals, too, because a lot of their meals were large scale for a family, and what I make is a little salad for one, one hamburger, one sandwich. So it's different when you cook just for one person or you cook for four people."*
- *"I mean, I would like the nice food that they cooked, but I think they were a lot more competent in feeding a much bigger family than my family of me."*
- *"Not to me, because they're young, a young family. I'm an older woman with a husband and a 42-year-old son that I cook for. So no, I really couldn't relate to them because I'm totally different than they are. They seemed like a nice family, though."*

One other reason cited for not relating to the people or situations included in the video was the use of a thermometer for all meals, specifically the casserole. Interestingly, one participant mentioned that she was surprised that the video failed to show what she

considered standard chicken preparation practice: *"I never saw her wash her meat. I didn't see her wash that chicken, but I'm going to suppose that she did. I mean once you open the package then you wash everything, but I didn't see none of that going on."* USDA does not recommend washing chicken before cooking because it can cause cross-contamination in the cooking environment.

3.7 Additional Analysis

We plan to conduct additional analyses of the post-observation interview data using NVivo to identify and code common themes in the information shared by participants. Additionally, we will associate common themes (nodes) with participant demographic data and conduct regression analyses to help identify whether there were trends among thermometer users compared with participants who did not use thermometers. Ultimately, we will determine the differentiators for whether a participant uses a thermometer or does not use one (e.g., whether the participant had prior experience with foodborne illness). We will provide the results of this analysis in a forthcoming manuscript. A separate forthcoming manuscript will provide information on the directional analysis of microbiological samples for each of the kitchen surfaces included in the microbiological analysis, similar to how the results are presented in Table 3-12. We plan to provide analyses on all paths related to how kitchen surfaces became contaminated. Although not a requirement of this contract, we envision our additional analysis to result in a total of five manuscripts to be co-authored with FSIS focusing on 1) handwashing, 2) evaluation of thermometer use and temperature behaviors and the intervention, 3) cross-contamination to RTE salad, 4) cross-contamination to food contact surfaces and the kitchen environment, and 5) results of the post-observation interviews and the predictive nature of self-reported antecedents on food safety behavior.

4. Discussion and Implications

Section 4 concludes the report by discussing implications for message development that FSIS may want to consider as it refines 1) the messages and delivery mechanisms used to inform consumers on the importance of using a food thermometer and correct thermometer usage and 2) communications regarding other recommended food safety practices. These recommendations are based on the literature in combination with considering the results of this study.

Consumers play a role in ensuring food safety

CDC has identified contributing factors to foodborne illness including food from unsafe sources, improper holding/time and temperature, inadequate cooking, poor personal hygiene, and contaminated equipment/prevention of contamination; four of these factors are linked directly to food handler behaviors (Bean et al., 1996; CDC, n.d.). Five of the top 10 food–pathogen combinations with the highest estimated annual disease burden are directly related to consumer handling (either controlled by cooking or reducing cross-contamination), and some of these combinations contain food groups that are regulated by USDA: poultry, pork, and beef (Batz, Hoffmann, & Morris, 2012). Pathogens such as *Campylobacter* and *Salmonella* can be fully controlled in consumer homes through cooking to safe internal temperatures and cross-contamination prevention. Risky preparation and handling of food have been linked to multiple outbreaks of foodborne illness and identified as a factor in public health burden (Nesbitt et al., 2009; Redmond & Griffith, 2003).

More focus on proper thermometer usage

It is encouraging that overall thermometer usage was high (54%) and participants were responsive to the video intervention (the control group used a thermometer 34% of the time, while participants who were exposed to the video used a thermometer to check doneness 75% of the time, significant at $p < .001$). Getting the message in front of consumers at decision-making time is important.

Thirty-four percent of participants in the treatment group reported that the video did not influence their cooking behavior in the kitchen; however, 55% of these participants reported that they use a thermometer on a regular basis in their home kitchen, and the video simply reaffirmed this practice. There is likely some optimism bias here, because the most frequently cited reason (8%) for not using a thermometer in the test kitchen was the participants' own experiences and confidence with other methods of determining doneness.

Among total attempts to use a thermometer, 42% were correct (23% control, 52% treatment, significant at $p < .001$), which highlights the need for future materials to not just discuss thermometer use, but also demonstrate proper placement. The higher rate of proper

placement by the treatment group compared with the control group suggests that the information in the video on proper placement was useful to some participants.

More emphasis on not using subjective indicators to determine doneness

Previous studies looking at popular cooking shows have similarly found that subjective indicators (e.g., color, touch) are more commonly used to determine doneness than thermometers (Borda et al., 2014; Maughan, Chambers, & Goodwin, 2016; Mathiasen, Chapman, Lacroix, & Powell, 2004; Woods & Bruhn, 2016). A study of egg-based recipes also showed that recipes used a variety of indicators not related to temperature, but most frequently time (Godwin, Maughan, & Chambers, 2016). Relying on subjective indicators is a riskier way to determine doneness because some indicators, like the color of meat and poultry and their juices, do not correlate with safe internal cooking temperatures (Hague et al., 1994; Røssvoll et al., 2014). Some sources of cooking information match gradations (e.g., rare, medium rare, medium, medium well, well done) to internal cooking temperatures as well as visual descriptions, but no peer-reviewed scientific evidence supports these temperature gradations. Educational materials on thermometer use should continue to emphasize that subjective indicators of doneness are not reliable, and using a food thermometer is the only way to ensure foods are cooked to a safe internal temperature.

Further need to improve clean, separate, and chill behaviors

In addition to the message cook, the study collected information on the other key food safety messages of clean, separate, and chill to provide FSIS with information for year-over-year comparisons during later phases of the study. The study results described in this report suggest that improvements are warranted in these behaviors based on observed behavior and the results of microbiological sampling (for the clean and separate messages) and self-reported usual behavior (for chill messages).

Clean. We observed 2,249 cases in which a handwashing event was required to control pathogens; of these, handwashing was attempted 31% of the time. Among handwashing events attempted, only 4% of attempts contained all steps of a correct handwashing event. A study using survey data and propensity score matching methodology found that washing hands with soap before food preparation leads to a reduction in the probability of reported foodborne illness (Ali, Verrill, & Zhang, 2014).

Separate. The spice containers were the most frequently contaminated sample of those analyzed to date: approximately 50% of participants contaminated these surfaces (independent of control/treatment). While coding for behaviors leading up to their contamination is yet to occur, it is likely that participants handled raw turkey patties immediately before they picked up the spice containers to season the patties. The faucet handle was contaminated approximately 12% of the time (independent of

control/treatment). A total of 78 participants used their mobile devices at some point after handling turkey packaging, and six devices were contaminated. It is not known how long pathogens can remain viable on mobile devices, and future studies could explore how long pathogens stay viable on different materials, including phones/phone covers, to determine the significance of this to public health.

The relatively low rate of contamination of salad lettuce (6%) indicates that cross-contamination was not necessarily frequent but did occur with some regularity. Preliminary, although as yet incomplete, coding of the observations suggests that a missed or failed handwashing attempt was part of the sequence that led to cross-contamination of the salad lettuce. Direct contamination of the salad lettuce by the turkey patties seems much less likely to be the contaminant source, in contrast to contamination of the spice containers, which was likely direct.

Chill. Many participants self-reported following USDA-recommended practices for thawing meat or poultry (79% for treatment group and 81% for control group), and most reported they would cook or discard the product if it was not cooked within 2 days, as recommended. About half of participants self-reported storing leftovers in multiple small containers, as recommended (55% for treatment group and 46% for control group), and few refrigerate the leftovers immediately (8 to 12%) and instead let the leftovers cool before placing them in the refrigerator.

More knowledge is not the key, it is actionable skills and compelling reasons

Verbeke, Frewer, Scholderer, and De Brabander (2007) reported that experts in food risk management tend to view the general public as deficient in understanding food hazards and associated risks; the general public displays behavioral patterns and makes choices that seem irrational or illogical or at least inconsistent with expert opinions and scientific knowledge. As noted by Bob Lalasz, the director of science communication for the Nature Conservancy regarding the public's response to scientific innovations and influences on behavior, there is the assumption by experts that "the public isn't getting the gravity of the problem—because if they did, how could they fail to act?" (Contractor & DeChurch, 2014). In other words, to connect directly to food safety risks, if people had more knowledge of or a different attitude about foodborne illness risks, their food safety practices would improve. However, this deficit-of-knowledge premise has been criticized for its lack of appreciation of the social, cultural, and practical complexities in which consumers' everyday practices are embedded (Halkier & Jensen, 2011) and is not supported by evidence. Generally, people do not respond to information in the straightforward way that communicators hope; communicators need to examine how people will think about and use the information they provide and relate that information to peoples' everyday lives (Eden, Bear, & Walker, 2008).

People often respond differently to messages about risk than communicators expect; hence, to effectively communicate about risk, communicators must consider how people will think

about and use the information provided (Eden et al., 2008). Bruhn (2005) argued that risk communicators should first identify the full range of audiences, describe how risk is determined and monitored, and show how risk can be controlled or reduced. To be effective, messages must be tailored to an audience's needs, concerns, and interests (Lundgren, 1994).

Communications efforts will be wasted if people already know the information or consider it irrelevant (Fischhoff & Downs, 1997). Providing generalized risk messages will be ineffective, unless the risk affects everyone equally (Cope et al., 2010). Messages about risks should be clear and specific and tailored for the audience's estimated level of comprehension (Lundgren, 1994; Covello, 2003). Galarace and Viswanath (2012) recommended that communication planners be mindful of factors related to the communication process, such as culture, gender, age, language, race/ethnicity, and income and education levels of the target audience, as well as factors that might influence implementation of desired behaviors, including financial resources, location, transportation, and health care access. Combining written, verbal, and visual formats can also improve effectiveness (Durant, 2002). Important points should be highlighted throughout the material and information presented should be concise and written in plain language. Research suggests that many people misunderstand quantitative information, leading to a misinterpretation of risk (Cunningham & Boom, 2013). Providing too much information is a common problem (Foster & Käferstein, 1985) and should be avoided; messages that are difficult to decipher or burdensome to receive are easily ignored (Verbeke, 2005). Research indicates that people can have difficulty remembering more than three messages, and recall of technical messages may also be poor (Sugerman et al., 2012).

Although information is a prerequisite to action, knowledge does not always translate into action (Rudd, Comings, & Hyde, 2003). Consumer motivation to take action is increased by the perception of a personal ability to control risk (Redmond & Griffith, 2003; Mullan & Wong, 2009). Messages that provide direction and to which audiences can personally relate are particularly persuasive (Frewer, Howard, Hedderley, & Shepherd, 1997; Eden et al., 2008). Perceptions about food-related risks are influenced by cultural and social factors (Knox, 2000). Risk communicators who do not consider factors that affect the way the general public perceives risks are unlikely to foster the appropriate level of risk perception (Verbeke et al., 2007). People tend to categorize risks as tolerable or intolerable according to subjective attributes, including familiarity and perceived catastrophic potential (Rodricks, 2002; Lofstedt, 2006). This suggests that people's familiarity with food and cooking in the home could influence their perceived risk of foodborne illness.

Even with careful attention to message framing and language, consumers may find it difficult to apply risk control measures in their daily practices. Wills, Meah, Dickinson, and Short (2015) studied domestic kitchen practices to gain insight on how food stored, prepared, and eaten in the home may contribute to foodborne disease. They observed that

kitchen practices were entangled in people's habits and cultural practices and were embedded within sequences comprising many small events that also included non-food-related activities. Their study found that food preparation, laundry, childcare, pet care, social life, school and office work, arts and crafts activities, music practice, reading, gardening, and bicycle repairs also took place in people's kitchen spaces. Cleaning was one action carried out within these sequences of events, but its purpose was to make the area tidy and nice, or cleaning was part of a habitual routine rather than to prevent foodborne illness. The youngest children, oldest adults, and family pets were all engaged in the kitchen, which has implications for preventing foodborne diseases as well.

Meah (2014) also collected qualitative and ethnographic data to examine how concerns about food safety were negotiated into everyday domestic kitchen practices in the United Kingdom and found that common sense logic was used to balance food safety against experiential knowledge and sustainability concerns (e.g., reducing food waste). These findings conflict with the widely held assumption that consumers' failures to follow safe food handling instructions are often due simply to a lack of knowledge (Verbeke et al., 2007). Meah (2014) proposed that authorities' advice would have more impact if it took more account of consumers' practical knowledge and routine practices and incorporated current levels of public understanding and knowledge base rather than assuming a deficit of knowledge.

Using narratives to convey food risk information and provide context within peoples' lives can help individuals better understand their role in controlling risk (Jacob et al., 2010). Storytelling is a basic form of human interaction, and one of the oldest techniques for transmitting knowledge (Hinyard & Kreuter, 2007). It plays an important role in making sense of experiences and interpreting the world (Matthews & Stephens, 2010). Compared with scientific information, stories relate life lessons and values and are effective because they are relatable and easily remembered (Cunningham & Boom, 2013). The use of narratives in foodservice settings has been shown to influence food safety behaviors of food handlers, increasing handwashing frequency and reducing cross-contamination events (Chapman et al., 2010). Elements of surprise, such as humorous graphics or sobering data, can help make the narrative memorable (Chapman et al., 2010). Emphasizing the human rather than statistical aspects can increase the interest and relevance of the information to an audience (Food and Agriculture Organization, 1999), and identifying individual victims enhances the perception of personal risk (Covello, Peters, Wojtecki, & Hyde, 2001). Recapping a persuasive narrative with a nonnarrative summary may help reinforce the take-away messages (Slater & Rouner, 2002).

General information about risk is not enough; consumers will practice safe food behavior only when they perceive a direct risk to themselves. Consumer knowledge and awareness of foodborne illness and pathogens do not always result in a positive change in food handling behavior. It is thus important to learn more about consumer attitudes and behaviors to

create awareness of safe food handling practices, to promote public trust and credible information sources, to encourage food safety education, to create familiarity, and to incorporate everyday context into food safety communications. Foodborne illness prevention messages should stimulate perceptions of risk and bolster self-efficacy to increase the adoption of safe food handling behaviors. Food safety messages for consumers should address the behaviors that lead to the highest incidence of foodborne illness causing the most serious consequences. Risk messages directed to specific concerns are more relevant to the public than general messages. Consumers may be more receptive to risk communication and education messages at "teachable moments," for example, following publicized outbreaks of foodborne illness.

References

Ali, M. M., Verrill, L., & Zhang, Y. (2014). Self-reported hand washing behaviors and foodborne illness: A propensity score matching approach. *Journal of Food Protection*, *77*(3), 352–358.

Anderson, J. B., Gee, E., Mendenhall, V. T., Shuster, T. A., Hansen, K., & Volk, A. (2004). A camera's view of consumer food handling and preparation practices. *Journal of the American Dietetic Association, 104*, 186–191.

Badman, L. (2001). Water matters: Proposed changes to ANSI/NSF standard 55- Ultraviolet microbiological water treatment systems. *Water Conditioning and Purification, 43*.

Batz, M. B., Hoffmann, S., & Morris, J. G., Jr. (2012). Ranking the disease burden of 14 pathogens in food sources in the United States using attribution data from outbreak investigations and expert elicitation. *Journal of Food Protection*, *75*(7), 1278–1291.

Bean, N. H., Goulding, J. S., Lao, C., & Angulo, F. J. (1996). Surveillance for foodborne-disease outbreaks — United States, 1988–1992. *Morbidity and Mortality Weekly Report*, *45*(SS-55), 1–66.

Berry, B. W., & Bigner-George, M. E. (2001). Postcooking temperature changes in beef patties. *Journal of Food Protection, 64*(9), 1405–1411. doi:10.4315/0362-028X-64.9.1405

Borda, D., Thomas, M. R., Langsrud, S., Rychli, K., Jordan, K., van der Roest, J., & Ioana Nicolau, A. (2014). Food safety practices in European TV cooking shows. *British Food Journal*, *116*(10), 1652–1666.

Bruhn, C. M. (2005). Explaining the concept of health risk versus hazards to consumers. *Food Control, 16*, 487–490.

Bruhn, C. M. (2014). Chicken preparation in the home: An observational study. *Food Protection Trends*, *34*(5), 318–330.

Centers for Disease Control and Prevention. (n.d.). CDC's most common contributing factors to foodborne illness outbreaks. Retrieved from https://ehseleafio.cdc.gov/training/docs/Contributing_Factors.pdf

Chapman, B., Eversley, T., Fillion, K., MacLaurin, T., & Powell, D. (2010). Assessment of food safety practices of food service food handlers (risk assessment data): Resting a communication intervention (evaluation of tools). *Journal of Food Protection, 73*, 1101–1107.

Clayton, D. A., & Griffith, C. J. (2004). Observation of food safety practices in catering using notational analysis. *British Food Journal, 106*(3), 211–227.

Conn, K. E., Habteselassie, M. Y., Blackwood, A., & Noble, R. T. (2012). Microbial water quality before and after the repair of a failing onsite wastewater treatment system adjacent to coastal waters. *Journal of Applied Microbiology, 112*, 214–224.

Contractor, N. S., & DeChurch, L. A. (2014). Integrating social networks and human social motives to achieve social influence at scale. *Proceedings of the National Academy of Sciences*, *111*(Supp. 4), 13650–13657.

Cope, S., Frewer, L. J., Houghton, J., Rowe, G., Fischer, A. R. H., & De Jonge, J. (2010). Consumer perceptions of best practice in food risk communication and management: Implications for risk analysis policy. *Food Policy*, *35*(4), 349–357.

Covello, V. (2003). Best practices in public health risk and crisis communication. *Journal of Health Communication, 8*, 5–8.

Covello, V. T., Peters, R. G., Wojtecki, J. G., & Hyde, R. D. (2001). Risk communication, the West Nile virus epidemic, and bioterrorism: Responding to the communication challenges posed by intentional or unintentional release of a pathogen in an urban setting. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *78*, 383–391.

Cunningham, R. M., & Boom, J. A. (2013). Telling stories of vaccine-preventable diseases: why it works. *The Story of Immunization: A Special Edition of South Dakota Medicine*, 21–26.

De Cesare, A., Sheldon, B. W., Smith, K. S., & Jaykus, L-A. (2003). Survival and persistence of *Campylobacter* and *Salmonella* species under various organic loads on food contact surfaces. *Journal of Food Protection, 66*(9), 1587–1594.

DeDonder, S., Jacob, C. J., Surgeoner, B. V., Chapman, B., Phebus, R., & Powell, D. A. (2009). Self-reported and observed behavior of primary meal preparers and adolescents during preparation of frozen, uncooked, breaded chicken products. *British Food Journal, 11*, 915–929.

Durant, D. (2002). Take a look at real magic: Disney and food safety. *The Food Safety Educator*, 7–2.

Eden, S., Bear, C. & Walker, G. (2008). The sceptical consumer? Exploring views about food assurance. *Food Policy*, *33*(6), 624–630.

Fischhoff, B., & Downs, J. S. (1997). Communicating foodborne disease risk. *Emerging Infectious Diseases, 3,* 489–495.

Food and Agricultural Organization (FAO). (1999). Report of a Joint FAO/WHO Expert Consultation: The application of risk communication to food standards and safety matters. Rome. *FAO Food and Nutrition Paper, 70*.

Foster, G. M., & Käferstein, F. K. (1985). Food safety and the behavioral sciences. *Social Science & Medicine, 21*, 1273–1277.

Frewer, L. J., Howard, C., Hedderley, D., & Shepherd, R. (1997). The elaboration likelihood model and communication about food risks. *Risk Analysis*, *17*, 759–770.

Galarce, E. M., & Viswanath, K. (2012). Crisis communication: An inequalities perspective on the 2010 Boston water crisis. *Disaster Medicine and Public Health Preparedness, 6*, 349–356.

Gentry-Shields, J., & Jaykus, L. A. (2015). Comparison of process control viruses for use in extraction and detection of human norovirus from food matrices. *Food Research International, 77*, 320–325.

Gill, C. O., Yang, X., Uttaro, B., Badoni, M. & Liu, T. (2013). Effects on survival of *Escherichia coli* O157:H7 in non-intact steaks of the frequency of turning over steaks during grilling. *Journal of Food Research*, *2*(5), 77–89.

Godwin, S., Maughan, C., & Chambers, E. (2016). Food safety: Recommendations for determining doneness in consumer egg dish recipes and measurement of endpoint temperatures when recipes are followed. *Foods*, *5*(3), 1–10.

Green, L. R., Selman, C. A., Radke, V., Ripley, D., Mack, J. C., Reimann, D. W., Stigger, T., … Bushnell, L. (2006). Food worker hand washing practices: An observation study. *Journal of Food Protection, 69*, 2417–2423.

Hague, M. A., Warren, K. E., Hunt, M. C., Kropf, D. H., Kastner, C. L., Stroda, S. L., & Johnson, D. E. (1994). Endpoint temperature, internal cooked color, and expressible juice color relationships in ground beef patties. *Journal of Food Science*, *59*(3), 465–470.

Halkier, B., & Jensen, I. (2011). Doing "healthier" food in everyday life? A qualitative study of how Pakistani Danes handle nutritional communication. *Critical Public Health*, *21* (4), 471–483.

Hinyard, L. J., & Kreuter, M. W. (2007). Using narrative communication as a tool for health behavior change: A conceptual, theoretical, and empirical overview. *Health Education & Behavior*, *34*(5), 777–792.

Huang, C., Ma, W., & Stack, S. (2012). The hygienic efficacy of different hand-drying methods: A review of the evidence. *Mayo Clinical Proceedings, 87*(8), 791–798. Retrieved from http://europeantissue.com/wp-content/uploads/Mayo-Clinic-The-Hygienic-Efficacy-of-Different-Hand-Drying-Methods.pdf

Hughes, M., & Franks, I. (1997). *Notational analysis of sport*. London: E. & F. N. Spon.

International Food Information Council Foundation. (2015). *Food & Health Survey 2015*. Retrieved from http://www.foodinsight.org/sites/default/files/2015%20Food%20and%20Health%20Survey%20-%20FINAL.pdf

Jacob, C., Mathiasen, L. & Powell, D. (2010). Designing effective messages for microbial food safety hazards. *Food Control, 21,* 1–6.

Jay, L. S., Comar, D., & Govenlock, L. D. (1999). A national Australian food safety telephone survey. *Journal of Food Protection, 62*(8), 921–8.

Juneja, V. K., Snyder, Jr., O. P., Williams, A. C., & Marmer, B. S. (1997). Thermal destruction of *Escherichia coli* 0157:H7 in hamburger. *Journal of Food Protection 60*(10), 1163-1166. doi:10.4315/0362-028X-60.10.1163

Kendall, P. A., Elsbernd, A., Sinclair, K., Schroeder, M., Chen, G., Bergmann, V., … Medeiros, L. C. (2004). Observation versus self-report: Validation of a consumer food behavior questionnaire. *Journal of Food Protection, 67*(11), 2578–2586.

Knox, B. (2000). Consumer perception and understanding of risk from food. *British Medical Bulletin, 56,* 97–109.

Lando, A., Verrill, L., Liu, S., & Smith, E. (2016). 2016 FDA Food Safety Survey. Retrieved from https://www.fda.gov/downloads/Food/FoodScienceResearch/ConsumerBehaviorResearch/UCM529453.pdf

Lofstedt, R. E. (2006). How can we make food risk communication better: Where are we and where are we going? *Journal of Risk Research*, *9*(8), 869–890.

Luchansky, J. B., Porto-Fett, A. C. S., Shoyer, B. A., Phillips, J., Chen, V., Eblen, D.R., Cook, V., … Bauer, N. (2013). Fate of shiga toxin-producing O157:H7 and non-O157:H7 *Escherichia coli* cells within refrigerated, frozen, or frozen then thawed ground beef patties cooked on a commercial open-flame gas or a clamshell electric grill. *Journal of Food Protection*, *76*(9), 1500–1512.

Lundgren, R. (1994). *Risk communication: A handbook for communication of environmental safety and health risks*. Columbus: Battelle Press.

Mathiasen, L. A., Chapman, B. J., Lacroix, B. J., & Powell, D. A. (2004). Spot the mistake: television cooking shows as a source of food safety information. *Food Protection Trends*, *24*(5), 328–34.

Matthews, P., & Stephens, R. (2010, November). Sociable knowledge sharing online: Philosophy, patterns and intervention. In *Aslib Proceedings*, *62*(6), 539–553. United Kingdom: Emerald Group Publishing Limited.

Maughan, C., Chambers, E., & Godwin, S. (2016). Food safety behaviors observed in celebrity chefs across a variety of programs. *Journal of Public Health*, *39*(1), 105–112. doi:10.1093/pubmed/fdw026

Mazengia, E., Fisk, C., Liao, G., Huang, H., & Meschke, J. (2015). Direct observational study of the risk of cross-contamination during raw poultry handling: Practices in private homes. *Food Protection Trends*, *35*(1), 8–23.

Meah, A. (2014). Still blaming the consumer? Geographies of responsibility in domestic food safety practices. *Critical Public Health, 2*(1), 88–103.

Mullan, B., & Wong, C. (2009). Hygienic food handling behaviors: An application of the theory of planned behavior. *Appetite, 52*, 757–761.

Nesbitt, A., Majowicz, S., Finley, R., Marshall, B., Pollari, F., Sargeant, J., … Sittler, N. (2009). High-risk food consumption and food safety practices in a Canadian community. *Journal of Food Protection, 72*(12) 2575–2586.

Phang, H. S., & Bruhn, C. M. (2011). Burger preparation: What consumers say and do in the home. *Journal of Food Protection*, *74*(10), 1708–16.

Porto-Fett, A. C., Oliver, M., Daniel, M., Shoyer, B. A., Stahler, L. J., Shane, L. E., … Luchansky, J. B. (2016). Effect of deep-frying or conventional oven cooking on thermal inactivation of shiga toxin-producing cells of *Escherichia coli* in meatballs. *Journal of Food Protection, 79*, 723–731.

Redmond, E. C., & Griffith, C. J. (2003). Consumer food handling in the home: A review of food safety studies. *Journal of Food Protection*, *66*(1), 130–161.

Redmond, E. C., Griffith, C. J., Slader, J., & Humphrey, T. J. (2004). Microbiological and observational analysis of cross contamination risks during domestic food preparation. *British Food Journal, 106*(8), 581–97.

Rodricks, J. V. (2002). Risk communication between risk assessors and managers. *Food, Nutrition and Agriculture*, *31,* 21–26.

Røssvoll, E., Sørheim, O., Heir, E., Møretrø, T., Olsen, N. V., & Langsrud, S. (2014). Consumer preferences, internal color and reduction of shigatoxigenic *Escherichia coli* in cooked hamburgers. *Meat Science*, *96*(2), 695–703.

Rudd, R. E., Comings, J. P., & Hyde, J. N. (2003). Leave no one behind: Improving health and risk communication through attention to literacy. *Journal of Health Communication, 8*, 104–115.

Scott, E., & Herbold, N. (2010). An in-home video study and questionnaire questionnaires of food preparation, kitchen sanitation, and hand washing practices. *Journal of Environmental Health, 72*, 8–13.

Slater, M. D., & Rouner, D. (2002). Entertainment—Education and elaboration likelihood: Understanding the processing of narrative persuasion. *Communication Theory, 12*, 173–191.

Sneed, J., Phebus, R., Duncan-Goldsmith, D., Milke, D., Sauer, K., Roberts, K. R., & Johnson, D. (2015). Consumer food handling practices lead to cross-contamination. *Food Protection Trends, 35*(1), 36–48. Retrieved from http://www.foodprotection.org/files/food-protection-trends/JAN-FEB-15-sneed.pdf

Su, X., & D'Souza, D. H. (2011). Grape seed extract for control of human enteric viruses. *Applied and Environmental Microbiology, 77*, 3982–3987.

Sugerman, D. E., Keir, J. M., Dee, D. L., Lipman, H., Waterman, S. H., Ginsberg, M., & Fishbein, D. B. (2012). Emergency health risk communication during the 2007 San Diego wildfires: Comprehension, compliance, and recall. *Journal of Health Communication*, *17*(6), 698–712.

Tung-Thompson, G., Libera, D. A., Koch, K., de los Reyes, F. L., & Jaykus, L. A. (2015). Aerosolization of a human norovirus surrogate, bacteriophage MS2, during simulated vomiting. *PLOS One, 10*, e0134277.

U.S. Census Bureau. (n.d.). 2012-2014 American Community Survey 5-Year Data Profiles. Retrieved from https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2014/

U.S. Department of Agriculture, Food Safety and Inspection Service. (2016, October). Food Safety and Inspection Service strategic plan. 2017-2021. Retrieved from https://www.fsis.usda.gov/wps/wcm/connect/317d14d6-1759-448e-941a-de3cbff289e5/Strategic-Plan-2017-2021.pdf?MOD=AJPERES

U.S. Department of Agriculture, Food Safety and Inspection Service (USDA, FSIS). (2017, June). FSIS *Salmonella* compliance guidelines for small and very small meat and poultry establishments that produce ready-to-eat (RTE) products and revised Appendix A. Appendix A: Times for given temperature and fat level of turkey needed to obtain 7-log lethality of *Salmonella*. Retrieved from https://www.fsis.usda.gov/wps/wcm/connect/bf3f01a1-a0b7-4902-a2df-a87c73d1b633/Salmonella-Compliance-Guideline-SVSP-RTE-Appendix-A.pdf?MOD=AJPERES

U.S. Food and Drug Administration (FDA). (2013). Food code. Retrieved from http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/UCM374510.pdf

Verbeke, W. (2005). Agriculture and the Food Industry in the Information Age. *European Review of Agricultural Economics, 32,* 347-68.

Verbeke, W., Frewer, L. J., Scholderer, J., & De Brabander, H. F. (2007). Why consumers behave as they do with respect to food safety and risk information. *Analytica Chimica Acta*, *586*, 2–7.

Wills, W. J., Meah, A., Dickinson, A. M., & Short, F. (2015). 'I don't think I ever had food poisoning'. A practice-based approach to understanding foodborne disease that originates in the home. *Appetite*, *85*, 118–125.

Woods, R. D., & Bruhn, C. M. (2016). Television celebrity chefs as role models for consumers' safe food handling in the home. *Food Protection Trends*, *36*(6), 443–457.

World Health Organization. (2014). Food safety: Microbiological risks. Retrieved from http://www.who.int/entity/foodsafety/areas_work/microbiological-risks/en/index.html

Yang, X., Devos, J., & Klassen, M. D. (2017). Inactivation of *Escherichia coli* O157:H7 in minute steaks cooked under selected conditions. *Journal of Food Protection*, *80*(10), 1641–1647.

Appendix A:
Screening Questionnaire

Hello. My name is _____. Thank you for your interest in our research study, which is funded by the U.S. Department of Agriculture and conducted by researchers from North Carolina State University and RTI International.

If you are eligible for the study, you will be asked to prepare two recipes while being videotaped and participate in an interview at a day and time convenient for you. The study will last no more than 2 hours, and you will receive $75 and a small gift for taking part in the study.
To determine whether you are eligible, I need to ask you a few questions. These questions will take less than 10 minutes to complete. Your participation in this study is completely voluntary. All of your answers and your contact information will be kept private.

May I please ask you a few questions to determine whether you are eligible to participate in our study?

☐ Yes
☐ No → Refusal. Terminate.

1. Great! Let's get started then. When it comes to grocery shopping in your household, would you say…? (Read list. Select one.)
   ☐ You do all of it.
   ☐ You do most of it.
   ☐ You do about half of it. →Ineligible. Terminate.
   ☐ Someone else does most of it; you do some of it. →Ineligible. Terminate.
   ☐ Someone else does all of it. →Ineligible. Terminate.

2. Have you ever received any type of food safety training, such as ServSafe? (Select one.)
   ☐ Yes → Ineligible. Terminate.
   ☐ No

3. Have you ever cooked or worked professionally in a food preparation setting? (Select one.)
   ☐ Yes →Ineligible. Terminate.
   ☐ No

4. Are you a vegetarian or vegan? (Select one.)
   ☐ Yes → Ineligible. Terminate.
   ☐ No

5. How many times per week do you prepare a meal at home? (Read list. Select one.)
   ☐ Never →Ineligible. Terminate.
   ☐ 1 to 3 times per week → Ineligible. Terminate.
   ☐ 4 or more times per week

6. In the past three months, have you, yourself, prepared and cooked a meal using any of the following foods? (Read list. Select all that apply.)
   ☐ Raw turkey or chicken

☐ Raw beef
☐ Raw pork
☐ None of the above (DO NOT READ) → Ineligible. Terminate.

7. When following a recipe for the first time, do you…? (Read list. Select one.)
   ☐ Read the whole recipe before you start cooking
   ☐ Read the recipe while you are cooking

8. Which of the following items do you have in your kitchen? (Read list. Select all that apply.)
   ☐ Chef's knife
   ☐ Garlic press
   ☐ Citrus zester
   ☐ Food thermometer to check the doneness of meat/poultry
   ☐ Manual can opener
   ☐ Can puncher
   ☐ Cheese grater
   ☐ Wine opener
   ☐ Corkscrew
   ☐ None of the above (DO NOT READ)

9. Imagine you are cooking hamburgers at home for dinner. How do you determine whether the burgers are done and ready to eat? Do you…? (Read list. Select all that apply.)
   ☐ Rely on cooking time
   ☐ Insert a knife, toothpick, or other utensil into one of the burgers, and check to see that it comes out clean
   ☐ Use a food thermometer
   ☐ Cut one of the burgers and check that it is no longer pink or red in the middle
   ☐ Check that the outside of the burger is the right brownness
   ☐ Touch one of the burgers with your finger to see if it is firm
   ☐ Taste one of the burgers

10. Which of the following categories best describes your age? (Read list. Select one.)
    ☐ Under 18 →Ineligible. Terminate.
    ☐ 18 to 34 [RECRUIT 28%]
    ☐ 35 to 54 [RECRUIT 36%]
    ☐ 55 or older [RECRUIT 36%]

11. Are you Hispanic or Latino? (Select one.)
    ☐ Yes [RECRUIT 17%]
    ☐ No [RECRUIT 83%]

12. What is your race? (Read list. Select all that apply.)
    - ☐ American Indian or Alaska Native
    - ☐ Asian
    - ☐ Black or African American
    - ☐ Native Hawaiian or Other Pacific Islander
    - ☐ White [RECRUIT ≤74%]

13. What is the highest level of education that you have completed? (Read list. Select one.)[8]
    - ☐ Less than high school or high school graduate or GED [RECRUIT 42%]
    - ☐ Some college or 2-year degree [RECRUIT 29%]
    - ☐ College degree [RECRUIT 18%]
    - ☐ Post-graduate degree [RECRUIT 11%]

14. Do you have any children living in your household who are less than 18 years of age? (Select one.)
    - ☐ Yes [RECRUIT 66%]
    - ☐ No [RECRUIT 34%]

15. Are you or any members of your household …? (Read list. Select all that apply.)
    - ☐ 60 years of age or older
    - ☐ 5 years of age or younger
    - ☐ Pregnant
    - ☐ Breastfeeding
    - ☐ Diagnosed with an allergy to any food or food ingredient
    - ☐ Diagnosed with diabetes or kidney disease
    - ☐ Diagnosed with a condition that weakens the immune system, such as cancer, HIV, or AIDS; a recipient of a transplant; or receiving treatments, such as chemotherapy, radiation, or special drugs or medications to treat these conditions
    - ☐ None of the above (DO NOT READ)

16. Where did you hear about this study? (DO NOT READ. Select all that apply.)
    - ☐ Post on social media
      Specify: _____
    - ☐ Email from the Expanded Food and Nutrition Education Program
    - ☐ Sign in grocery store
    - ☐ Don't know

17. Great! You qualify for the study. Would you like to participate in the study?
    - ☐ Yes
    - ☐ No → Terminate.

Great! We are conducting the interviews the week of [DATE]. The interviews will be held each day between [TIME] and [TIME]. The study will last no more than 2 hours, and you will receive $75 and a small gift for taking part in the study. What day and time is convenient for you to participate?

[8] Toward the end of data collection, we revised the screening criteria to include people with a technical or vocational training in the "Less than high school or high school graduate or GED" category.

[SCHEDULE DAY AND TIME]

I have you scheduled for [DATE] at [TIME]. Your interview will last 2 hours and will be held on NC State's campus. May I please have your name, telephone number, and email address so we can send you a confirmation email with directions?

[ENTER NAME]

[ENTER TELEPHONE NUMBER]

[ENTER EMAIL ADDRESS].

☐ No Email

[If no email] May I please have your mailing address? [ENTER STREET ADDRESS, CITY, NC, ZIP]

Thank you for your time.

If you have any questions about the study or need to reschedule or cancel, you may contact [NAME] at [PHONE NUMBER]. If you have concerns about how participants are being treated in the study, you may contact North Carolina State University's Office of Research Protection at 919-515-4514.

Ineligible/Terminate Screen
Thank you for your time. Unfortunately you are not eligible to take part in our study. Have a great day.

Appendix B:
Observation Script and Recipes

Check-in Script

Welcome! My name is , and I'll be walking you through what you'll be doing as part of our study today.

Today you will be preparing two recipes: a salad and turkey burgers, and we will interview you after you finish cooking. The cooking and interview will last no more than 2 hours total. Before we start, I need you to read and sign the consent form. Please let me know if you have any questions or concerns. You will receive a copy of the form to take home.
We have a few more items to prepare before you begin. While you wait, please watch this video (provide iPad, video depends on random number assignment for participant).

Observation Script

Hello, my name is _____, and I'll be walking you through what you'll be doing as part of our study today.

Today you will be preparing two recipes to test a new product formulation: a salad and turkey burgers. The recipes are provided on this card, one recipe is on the front and one is on the back. Prepare the foods in the order that you would usually do so at home.
After preparing the recipes, please clean up the kitchen as you normally would at home.
We will interview you after you are finished cooking. The cooking and interview will last no more than 2 hours total.

This is the area where you will be cooking. All the available utensils and dishes are in these drawers/cabinets (indicate). Feel free to use whatever you need. Please make yourself at home, you are welcome to use your phone to listen to music, or whatever you usually do when cooking at home.

Restrooms are located _____, and in case of an emergency, the exits are _____. The fire extinguisher is located _____ , and the first aid kit is located _____.

Before you begin, do you have any questions?

If you have any questions or concerns while you're cooking, I will be in the office next door. Before you eat anything, please let us know when you are finished cooking by pushing this button.

[after cooking]
Now that you have finished the cooking portion of the study, we are ready to begin the interview. It should take no more than 20 minutes to complete. Do you need a break before we begin that portion?

[Note: The two recipes were printed front-and-back on a laminated card.]

Turkey Burger Recipe

Ingredients

For the patties:

- 2 turkey burger patties
- Salt
- Pepper
- Garlic powder
- Onion powder

For serving:

- Hamburger buns
- Sliced tomato
- Sliced onion

Directions

1. Season the burger patties with salt, pepper, garlic powder and onion powder on both sides.
2. Cook the burgers at medium-high heat to your desired level of doneness.
3. Assemble cooked burgers with sliced tomato and sliced onion

Chef's Salad

Salad Ingredients

- 2 stalks romaine lettuce
- Salt and pepper
- 1 cup dressing (recipe below)
- 3/4 cup shredded Swiss cheese
- 3/4 cup ham
- 1 hot house tomato

Dressing Ingredients

- 1/2 cup olive oil
- 1/4 cup balsamic vinegar
- 1 teaspoon honey
- 1 teaspoon Dijon mustard
- 1 shallot, minced
- 1 clove garlic, minced
- Salt and ground pepper to taste

Directions

1. Cut lettuce into bite-size pieces
2. Cut ham into matchstick-sized pieces
3. Dice tomato
4. Mix all ingredients together
5. Serve with dressing on the side

Appendix C:
Post-observation Interview Guide

Post-observation interview guide		
ID No:		Date:
Treatment group	Y/N	

Introduction script:

Thank you so much for your time today and allowing us to record your actions while you prepared a meal just like you would in your home. If it is okay with you, I'm going to ask you a few follow-up questions that will focus on some of the activities you participated in while in the model kitchen.

Is it okay with you if I record your answers? The recording is confidential and will only be used to accurately capture our conversation (allowed recording y/n).

We mentioned in our recruiting materials that we were interested in cooking practices and how you evaluate recipes. However, the specific focus of our study is on food safety and how to prevent food poisoning. The aim of this study is to measure handling and preparation practices and investigate the movement of bacteria from raw foods, so we can better understand exactly how contamination can spread. In addition, a biological tracking agent was in the food to help us track where contamination might occur. This biological tracking agent is a bacteriophage called MS2, and it does not pose any health hazard to you. We purposely did not tell you exactly what our specific research objectives were in advance to capture your behaviors in a natural way. You can request to be removed from the study at any time, and if you decide to exit the study at this point, we will destroy the recordings of your actions, and you will not be included in the data set.

We want to confirm with you now that you understand the focus of our study and that you wish to remain as a participant.

If no: Thank you so much for your time, your participation in our study is now complete, and we will remove your data from our dataset and destroy any records.

If yes: Thank you for your consent.

If it is okay with you, I'd like to begin this interview, which will take about 20 minutes.

A study team member is collecting micro samples from the kitchen surfaces and equipment. We noticed you touched your [device] while cooking, would you mind if we took a swab of your phone?

If no: no problem.

If yes: thank you.

Observation follow up (semi-structured, to be filled in by observer during the meal preparation to allow for in-depth information specific actions and values).

[Provide context] I saw that you washed your hands before you started cooking today, can you tell me why you did that? Is that something you typically do when cooking at home? Why?

Or

[Provide context] I saw that you did not wash your hands for a full 20 seconds before cooking today, can you tell me why not? When you cook at home, do you usually not wash your hands before cooking? Why not?

[Provide context] I saw that you used a food thermometer today, can you tell me why you used it? What information were you looking for? Is that something you typically do when cooking at home? Why?

[If participant mentions referring to label/cooking directions] Do you recall what you read? [Probe to see if referring to Safe Handling Instructions vs. cooking directions provided by manufacturer]

[If participant does not mention referring to label/cooking directions] Did you notice any cooking instructions on the label. If yes, do you recall what it said? [Probe to see if referring to Safe Handling Instructions vs. cooking directions provided by manufacturer]

How important do you think it is to use a food thermometer when cooking? Would you say …

Very important
Somewhat important
Not important at all
[Don't know]

Or

[Provide context] I saw that you did not use a food thermometer today, can you tell me why not? Do you usually not use a thermometer when cooking at home? Why not?

How do you usually determine doneness?

[If participant mentions referring to label/cooking directions] Do you recall what you read? [Probe to see if referring to Safe Handling Instructions vs. cooking directions provided by manufacturer]

[If participant does not mention referring to label/cooking directions] Did you notice any cooking instructions on the label. If yes, do you recall what it said? [Probe to see if referring to Safe Handling Instructions vs. cooking directions provided by manufacturer]

How important do you think it is to use a food thermometer when cooking? Would you say …

Very important
Somewhat important
Not important at all
[Don't know]

[Provide context] I saw that you washed your hands after handling raw meat/poultry today, can you tell me why you did that? Is that something you typically do when cooking at home? Why?

Or

[Provide context] I saw that you did not wash your hands after handling raw meat/poultry today, can you tell me why not? When you cook at home, do you usually not wash your hands after handling raw/meat poultry? Why not?

[Provide context] I saw that you washed the cutting board and utensils today with soap and water, can you tell me why you did that? Is that something you typically do when cooking at home? Why? Or [Provide context] I saw that you did not wash the cutting board and utensils today with soap and water, can you tell me why not? When you cook at home, do you usually not wash the cutting board with soap and water? Why not?
[Provide context] I saw that you touched your [device] while cooking. Is that something you typically do when cooking at home? Why? Or [Ask if device was accessible, but not used] I saw that you didn't touch your [device] while cooking. When you cook at home, do you usually avoid touching your [device]? Why?
Imagine you just cooked a large pot of soup or chili so that you would have enough to eat the next day. What do you do with the leftovers? Probe: Do you place the leftovers in one container or multiple containers? How big are the containers? Probe: Do you refrigerate the leftovers immediately or wait awhile to put them in the refrigerator? How long do you wait? How long do you store the leftovers in the refrigerator before someone eats them or you throw them away?
Imagine you have meat or chicken in the freezer, and you plan to cook it for dinner later in the week. How would you thaw it? Probe: Do you thaw it the day you're cooking it or a couple days before? Probe: What method of thawing do you use: in the microwave, in the refrigerator, in water in the sink, or on the countertop? If water in sink, do you use hot or cold water? Running or standing water? Do you change the water at some point? When do you cook it? If in refrigerator, where do you place the frozen meat? On the top, bottom, or middle shelf? What, if anything, do you place it on? When do you cook it? If in the microwave, do you cook it immediately or wait awhile before cooking it? How long do you wait? Let's say you thawed the meat or poultry for dinner tonight, but something came up and you were not able to cook it. How many days would you leave it in the refrigerator before cooking it or throwing it away?

Antecedents
How concerned are you about bacteria or viruses on or inside the food you cook? On a scale of 1-7, with 1 being not at all concerned, 4 being neutral, and 7 being extremely concerned, how concerned are you?
Do you feel like you have control in your home about the safety of the food you cook? Why or why not?
Have you ever had food poisoning? Y/N Follow-up: Can you tell me about your experience? What were the symptoms, what food do you think made you sick? Do you believe your illness was contracted from cooking at home, or eating prepared food away from home?
Of the following three statements, which one is closer to your view…? ▪ Certain types of people have a higher risk of getting food poisoning ▪ It depends, certain types of people are at higher risk for some types of food poisoning [Probe: what types of people are more likely to get sick?] ▪ All types of people have about the same risk of getting food poisoning ▪ Don't know
How common do you think it is for people in the United States to get food poisoning because of the way food is prepared in their home? Would you say that it is… ▪ Very common ▪ Somewhat common ▪ Not very common
Has a family member ever had food poisoning? Y/N Follow-up: Can you tell me about his/her experience? What were his/her symptoms, what food do you think made him/her sick? Do you believe their illness was contracted from eating at home, or eating prepared food away from home?
Intervention specific follow-up (treatment group)
Think back to the second video we showed you today, what were the key takeaway points? (may need to show the start of the video again as a reminder, not the full video)
Did watching the video influence your actions in the kitchen today or not? If yes, in what way?
Do you think the video will influence how you cook at home in the future, or not? Why?
Do you relate to the situations and the people shown in that video or not? Explain.

Intervention specific follow-up (control)
We are planning on creating educational material about safe food handling. What messages would you want to see in these materials?
What situations and topics would you want to see in this material to make it relevant to you?
How do you usually get information on how to safely prepare food when cooking at home?
How would you like to get information on how to safely prepare food when cooking at home?
Conclusion
Thank you again for your time and for your participation in our study today. Are there any questions that you have for me? Please see the greeter on your way out to receive the $75 and gift.

Appendix D:
List of Equipment Provided in Each Test Kitchen

The picture below shows one of the test kitchens used for the meal preparation experiment. The equipment provided in each test kitchen is listed below.

Kitchenware

Grill

- ❏ George Foreman grill

Skillet

- ❏ Medium sized skillet (9-12 inch)

Frying pans (store frying pans in the cabinets)

- ❏ Small (8 inch) non-stick
- ❏ Medium or large (10-12 inch)

Sauce pans

- ❏ Small (2-3 quarts)
- ❏ Medium or large (4-5 quarts)

Knives
- ❑ Chef's knife
- ❑ Paring knife/fruit knife

Baking dishes
- ❑ 9x13 baking dish (rectangular)
- ❑ Smaller square, rectangular, or oval baking dish

Utensils
- ❑ Wooden or plastic stirring spoons (1-2)
- ❑ Heat-resistant plastic or silicone spatula
- ❑ Slotted spoon
- ❑ Ladle
- ❑ Flat spatula (for flipping burgers)
- ❑ Cooking tongs
- ❑ Digital tip-sensitive instant read thermometer
- ❑ Dry measuring cups
- ❑ Liquid measuring cup (1 cup)
- ❑ Measuring spoons
- ❑ Can opener
- ❑ Liquid measuring cup (2 cup)
- ❑ Whisk
- ❑ Rolling pin
- ❑ Peeler
- ❑ Zester/grater
- ❑ Large cutting boards
- ❑ Splatter guard
- ❑ Serving bowl
- ❑ Serving utensils (serving fork, spoon, and tongs)
- ❑ Salt and pepper shaker (must be glass)
- ❑ Garlic and onion powder
- ❑ Utensil holder

Other essential tools
- ❑ Small, medium, and large mixing bowls
- ❑ Colander
- ❑ Salad spinner

Silverware/Dinnerware
- ❑ Set of spoons, knives and forks
- ❑ Dinner plates
- ❑ Salad plates
- ❑ Bowls

Cleaning/dishwashing supplies
- ❑ Kitchen towels
- ❑ Dish cloths

- ❑ Hand soap
- ❑ Dish drain board/dish rack
- ❑ Paper towels
- ❑ Sponge
- ❑ Sponge caddy
- ❑ Paper towel holder
- ❑ Apron
- ❑ Oven mitts
- ❑ Pot holders
- ❑ Dishwashing detergent

Cleaning stuff for under sink

- ❑ Bucket
- ❑ Windex
- ❑ Simple green cleaner
- ❑ Clorox bleach
- ❑ 409 cleaner
- ❑ Lysol spray

Leftover kit supplies

- ❑ Ziploc bags (gallon and quart sizes)
- ❑ Plastic wrap
- ❑ Plastic containers with lids

Note: Containers must be sanitized between observation events. Ziploc bags and plastic wrap must be taken out of retail packaging and placed in kitchen drawers.

Housekeeping items

- ❑ Trash can for kitchen (13 gallon, with a cover but no step to open feature). Note: position the trash can near the cooking area.
- ❑ Trash bags (13 gallon)
- ❑ First-Aid Kit
- ❑ Label maker
- ❑ Toolbox

Electronics

- ❑ Tool boxes
- ❑ Gaffer tape
- ❑ Blue painter's tape
- ❑ Super glue
- ❑ Scissors
- ❑ HDMI cable (25 feet, 2x)
- ❑ HDMI female-to-female adapter
- ❑ Zip ties (11 inch)
- ❑ Surge protector (2x)
- ❑ Gallon Ziplocs
- ❑ AAA batteries (batteries for label maker)
- ❑ AA batteries (batteries for mouse)

Paperwork

- ❑ Gift cards
- ❑ Thermometers

Cameras

- ❑ Tripods

Appendix E:
Power Analysis

The purpose of the meal preparation study was to evaluate the impact of FSIS educational materials on consumers' demonstrated use of recommended safe food handling practices (clean, separate, cook, and chill). For the initial iteration of the study, the primary outcome of interest is use of a food thermometer to check the doneness of meat and poultry. Using a food thermometer is an important but not commonly practiced behavior in American kitchens. Based on recent estimates, we anticipated observing food thermometer use 5% of the time among the control group participants (Anderson et al., 2004; Phang & Bruhn, 2011; Bruhn, 2014; Mazengia, Fisk, Liao, Huang, & Meschke, 2015; Scott & Herbold, 2010). Additionally, we anticipated that the food safety messaging materials will provide medium effects among the treatment group participants. Table E-1 provides potential observed differences between the control and treatment groups ranging from 4 to 12 percentage points. We anticipated that the food safety messaging materials will be sufficient to generate differences in the middle of this range (i.e., the observed difference between the control and treatment groups is 8 percentage points); thus, the study design used a sample size of 400 (200 in each group).

Table E-1. Sample Size Requirements for Different Observed Differences between the Control and Treatment Groups

Proper Thermometer Use: Control Group	Proper Thermometer Use: Treatment Group	Observed Difference Between Control and Treatment Groups	Total Sample Size (N)
5%	9.0%	4%	1,270
5%	11.0%	6%	636
5%	13.0%	8%	394
5%	15.0%	10%	276
5%	17.0%	12%	206

Appendix F:
Microbiological Methods

F.1 Preparation of Bacteriophage MS2 Stocks

We prepared bacteriophage MS2 (ATCC 15597-B1) stock solutions using the double agar method as described in National Science Foundation standard 55 (Badman, 2001) and Tung-Thompson, Libera, Koch, de los Reyes, & Jaykus (2015). We plated ten-fold serial dilutions of MS2 on tryptic soy agar (TSA) supplemented with 0.1% glucose, 2 mM CaCl2, and 10 µg/ml thiamine and incubated it overnight at 37°C. We flooded plates showing complete lysis with 3 ml of tryptic soy broth (TSB) and scraped off the soft agar layer into a sterile 50 ml tube. We increased the volume to 40 ml with TSB and added 0.2 g EDTA and 0.026 g lysozyme to each tube. We incubated the tubes for 2 hours at 37°C with shaking. We recovered the supernatant by centrifugation at 9,300 x g for 10 min followed by filter sterilization using a 0.22 µm filter. We enumerated the stocks as described below. We considered aliquots of this supernatant as high titer MS2 stock (approximately 10^{10} plaque-forming units per milliliter [PFU/ml]). We aliquoted the stocks and stored them at −80°C until use.

F.2 Enumeration of Bacteriophage MS2 Stocks

We enumerated the MS2 stocks using the double agar layer method in accordance with the method of Su and D'Souza (2011) with minor modifications. Briefly, we incubated the E. coli C3000 host for 4 to 6 hours with gentle shaking (100 RPM, 37°C). Simultaneously, we melted 8 mL tubes of 0.6% TSA and tempered them in a 42°C water bath. We allowed previously prepared petri dishes containing 1.2% TSA to warm to room temperature. Then, we prepared 10-fold serial dilutions of MS2 stock. We added a volume of 0.7 mL of each dilution to the tempered 8 ml TSA tube after which we added 0.3 ml of E. coli solution, and we quickly vortexed the suspension and poured it on top of the 1.2% TSA plates. Upon solidification, we inverted the plates and incubated them overnight at 37°C and then counted plaques. Counts are expressed as plaque-forming units per milliliter. We also processed serially diluted MS2 stocks for nucleic acid extraction and RT-qPCR quantification as described in Section F.6 to produce a standard curve. Plaque-forming units were plotted against corresponding cycle threshold (CT) values and analyzed by linear regression to produce the standard curve. We produced the standard curve by three independent RT-qPCR assays.

F.3 Spiking Meat Products with Bacteriophage MS2

We used MS2 stocks prepared according to the steps described in Section F.1. The raw meat/poultry food products were spiked with MS2 at a concentration of 10^{8} plaque-forming units/gram of meat (PFU/g) during the grinding process, performed at NCSU as described

by Porto-Fett et al. (2016). We prepared meat products and acquired them on a weekly basis during the study. We sanitized the meat laboratory after production using the methods outlined in Section F.7.

F.4 Environmental Swabbing and Lettuce Sample Collection

During each observation, we collected a minimum of 10 environmental samples, one food sample (either lettuce in the RTE salad if it was prepared after the burger or lettuce from the burger if the RTE salad was prepared before the burger),[9] and one sample pre-observation to validate cleaning. We collected up to two additional environmental samples based on the behaviors of the person being observed; the observing coder determined the additional site(s) for sampling, if required, and based this determination on the behavior observed in the kitchen during meal preparation.

Environmental swabs may include utensils, cutting boards, sink, dish cloths or sponges, tap handles, refrigerator handles, door handle, and drawer pulls. Surface samplers recorded sample information on sample collection forms (see the Attachment), and they were trained and their technique examined 1 week before samples were taken.

Samplers did not touch/clean/disinfect surfaces before they took the swab samples. Sterile, disposable templates of a 100 cm^2 area were placed on flat surfaces to be swabbed and disposed of after a single use. Samplers swabbed irregularly shaped surfaces (e.g., utensil handles) over the entirety of the surface. While wearing gloves, samplers pressed the swab head against the surface of its container to release excess moisture and rubbed it slowly and thoroughly over the target area one time, reversing direction with each stroke. This procedure was repeated twice using different swabbing directions for each replicate. The swab was deposited back in the broth and sealed and was placed on cold packs for transportation. Samplers wore a new pair of gloves each time they took a swab.

Wearing clean gloves, samplers transferred 25g lettuce samples from test kitchen containers to numbered Ziploc bags for transport. We provided participants with no more than 100g of lettuce to prepare the RTE salad. Lettuce samples were kept on cold packs during transportation to the NCSU laboratory. We stored swabs and lettuce samples at 4°C and processed them for microbial nucleic acid extraction (Section F.6) within 48 hours of collection.

F.5 Elution and Concentration of MS2 from Lettuce Samples

We eluted MS2 from lettuce samples as described by Gentry-Shields and Jaykus (2015) with a few modifications to optimize extraction. Briefly, we placed 25g from each lettuce sample taken from salads prepared in the test kitchen in polypropylene bags containing a filter

[9] The order in which the participants prepare the two foods was not specified, so some participants may have prepared the burgers first, and some may have prepared the salad first.

compartment and soaked them with 20 ml elution buffer (Tris-HCl 0.1 M, glycine 0.05 M, beef extract 3%, pH 9.5). We stomached the sample for 1 minute at 230 rpm using a stomacher. We removed the rinse fluid via the filter compartment of the bag to a 50 ml centrifuge tube and adjusted it to pH 7.0 ± 0.5 with 0.1 M HCl.

We concentrated the MS2 from the lettuce eluates using PEG precipitation. The eluates of approximately 20 ml volume were subjected to precipitation with the addition of PEG MW 8000 and NaCl in a final concentration of 12% (w/v) and 5%, respectively. We incubated the samples on a shaking platform at 4°C for at least 2 hours and centrifuged them at 8,500 rpm for 20 minutes at 4°C. The pellet was suspended in 1 ml of PBS and stored at −20°C. To remove residual inhibitory substances, we further subjected the virus concentrates to a chloroform:butanol purification step. Briefly, we treated 1 ml of the suspended pellet with one volume of chloroform:butanol (1:1, v/v) and vortexed the mixture for 2 minutes at room temperature and centrifuged it again at 12,000 rpm for 20 minutes. We isolated and stored the aqueous phase (supernatant) at −80°C until RNA extraction and RT-qPCR were performed as described in Section F.6.

F.6 RNA Extraction and Detection of MS2 Bacteriophage by RT-qPCR

We performed RNA extraction and detection of bacteriophage MS2 as described by Gentry-Shields and Jaykus (2015). We performed extraction of MS2 RNA from 1 ml swab buffer and MS2 concentrated from lettuce samples using the automated bioMérieux NucliSENS easyMAG system, as per the manufacturer's instructions. We then eluted the final purified RNA into 25 µl of proprietary buffer. RNA extracts were stored at −80°C until analysis by RT-qPCR.

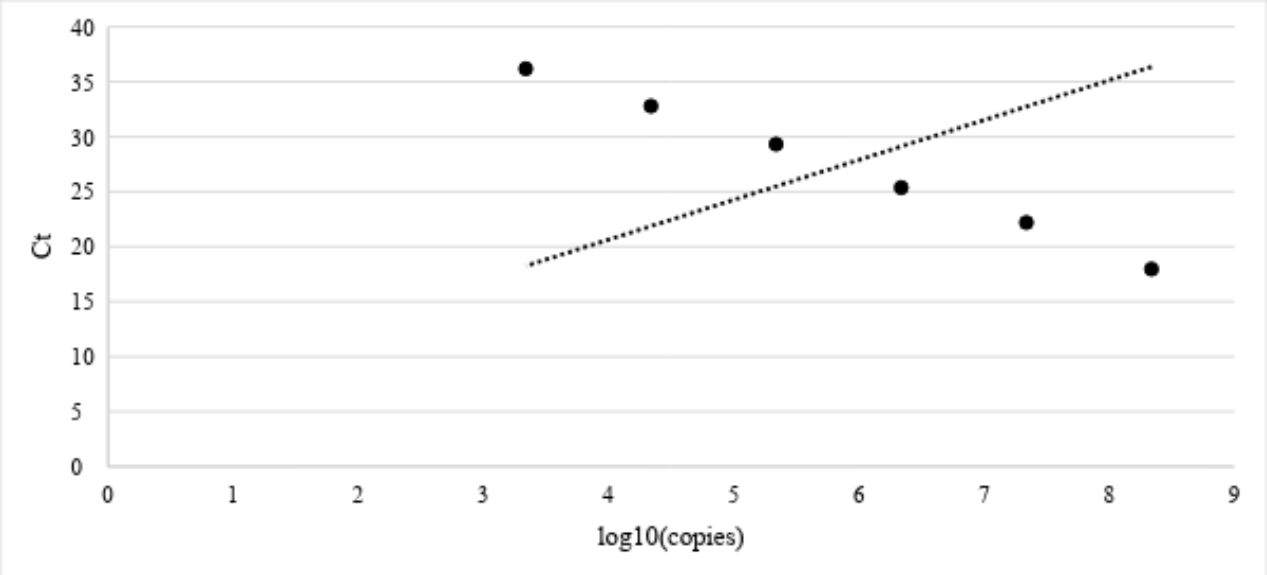
Table F-1 lists the primers and probe we used to detect MS2 (Conn, Habteselassie, Blackwood, & Noble, 2012). The probe was located at position 1689 in the MS2 coat protein gene *MS2g2*. The 25 µl RT-qPCR mixture consisted of 2.5 µl RNA, 400 nM of forward and reverse primers, 200 nM of fluorescently labeled TaqMan probe, 12.5 µl 2 µ reaction buffer (SuperScript III One-Step qRT-PCR Kit, Invitrogen), and 0.5 µl RT/Platinum Taq Mix. The reaction mixture was subjected to a one-step thermal cycling profile using a CFX96 Touch Real Time PCR Detection System from Bio-Rad under the following amplification conditions: (1) reverse transcription for 30 minutes at 50°C, (2) initial denaturation for 15 minutes at 95°C, and (3) 45 cycles of 15 seconds at 95°C and 30 seconds at 60°C. We calculated bacteriophage MS2 concentration by comparing it to standard curves produced as described in Section F.2 (see Figure F-1).

Table F-1. Primers and Probe Identities, Sequences, and Genome Location for RT-qPCR Detection of Bacteriophage MS2

Name	Sequence (5′-3′)	Location
MS2qfor	ATTCCGACTGCGAGCTTATT	1630
MS2qrev	TTCGACATGGGTAATCCTCA	1758
MS2qProbe	6-FAM-ATTCCCTCAGCAATCGCAGCAAACT-BHQ1	1689

Source: Conn et al. (2012).

Figure F-1. Standard Curve MS2 Stock



F.7 Sanitation of Test Kitchens Following Meal Preparation

We sanitized the kitchens following meal preparation in accordance with NCSU's guidelines for sanitizing laboratory work surfaces, a requirement of the University. We applied household bleach diluted to a 10% concentration to hard surfaces with a contact time of 60 seconds before wiping them clean with a disposable paper towel. We repeated this step twice for a total of three sanitation steps. The efficacy of this sanitation procedure was confirmed during in-lab optimization studies and the pilot conducted in the test kitchen. All utensils, including knives, cutting boards, and bowls, for example, were cleaned in dishwashers.

ATTACHMENT 1

SAMPLE COLLECTION FORM

ID: _____
Date: _____
Sample collector: _____

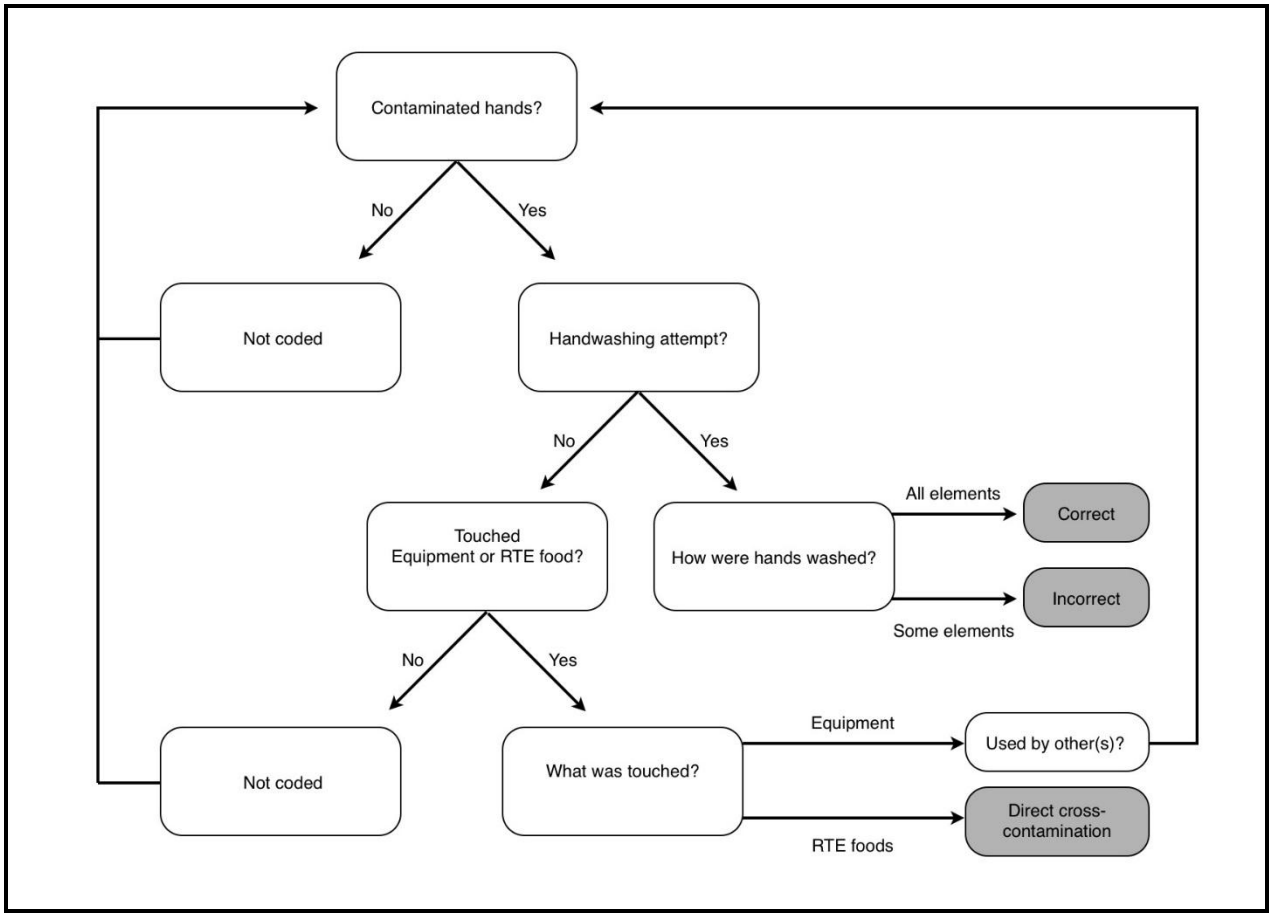
Sample Number	Sample Type	Irregular/Flat	Time Taken
	Sanitation Validation		
0	Counter space	Flat	
	Utensils		
1	Knife handle	Irregular	
2	Cutting board	Flat	
3	Frying pan handle	Irregular	
	Cleaning Areas		
4	Inner sink surface	Flat	
5	Dish cloth/sponge	Irregular	
6	Tap handle	Irregular	
7	Soap dispenser	Irregular	
	Kitchen Surfaces		
8	Refrigerator handle	Irregular	
9	Spice containers	Irregular	
10	Trash bin lid	Irregular	
	Other Surfaces		
11	Specify_____		
12	Specify_____		
	Lettuce sample (from salad if prepared after burgers or garnish if salad prepared before burgers)		

Appendix G:
Observation Rubric

To compare the food safety practices of primary meal preparers, we developed a decision tree to code actions using definitions from the U.S. Centers for Disease Control and Prevention's contributing factors for foodborne illness, coupled with the World Health Organization's (WHO's) factors leading to foodborne illness (Bean, Goulding, Lao, & Angulo, 1996; WHO, 2014). These definitions were supported by a review of scientific literature that focused on risky food safety practices (Anderson et al., 2004; Clayton & Griffith 2004; Green et al., 2006; Redmond et al., 2004). Definitions of food safety practices from the literature coupled with foodservice inspection criteria (FDA, 2013) led to the decision to focus the video observation methodology on capturing and cataloguing handwashing and cross-contamination incidents.

We used notational analysis to record actions and their frequencies. Notational analysis is a generic tool used to collect observed events and place them in an ordered sequence (Hughes & Franks, 1997). Notational analysis has been used to track food safety behaviors, enabling the recording of specific details about events in the order in which they occur by associating a time stamp with those actions (Clayton & Griffith, 2004). Using a time stamp is especially useful when looking at sanitation steps limiting cross-contamination or the use of common food contact surfaces and equipment. Notational analysis has been used in consumer food safety behavior observations studies as well as participant foodservice observation (Clayton & Griffith, 2004; Green et al., 2006; Redmond et al., 2004). The study team developed action decision trees for handwashing (Figure G-1), direct cross-contamination (Figure G-2), indirect cross-contamination (Figure G-3), and thermometer usage (Figure G-4).

Figure G-1. Handwashing Action Decision Tree

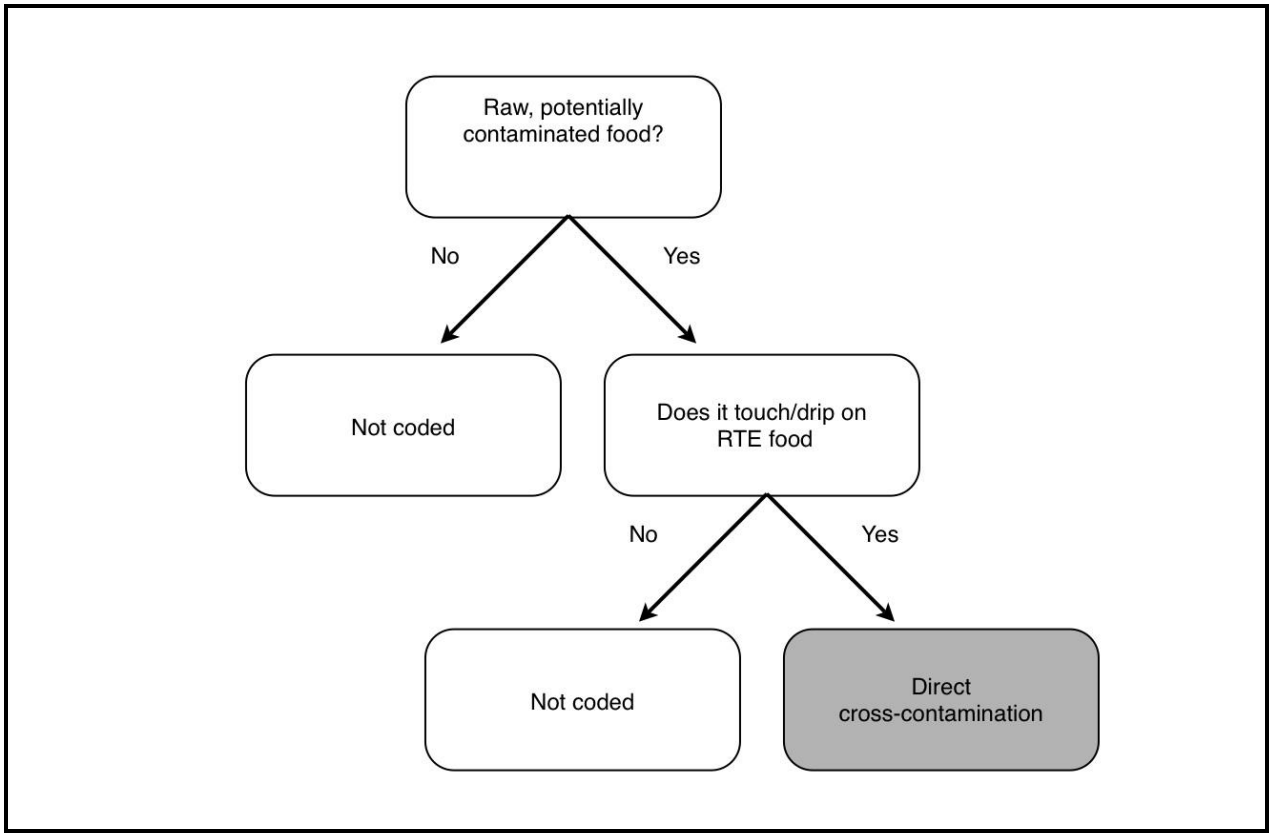


Contaminated hands: Hands that have come into contact with potentially contaminated material (raw food, contaminated equipment, touching of face or other parts of body or clothing) and that have not been washed according to CDC's recommended guidelines for proper handwashing.

- Elements of handwashing:
- Wet your hands with clean, running water (warm or cold), turn off the tap, and apply soap.
- Lather your hands by rubbing them together with the soap. Be sure to lather the backs of your hands, between your fingers, and under your nails.
- Scrub your hands for at least 20 seconds.
- Rinse your hands well under clean, running water.
- Dry your hands using a clean towel or air dry them.

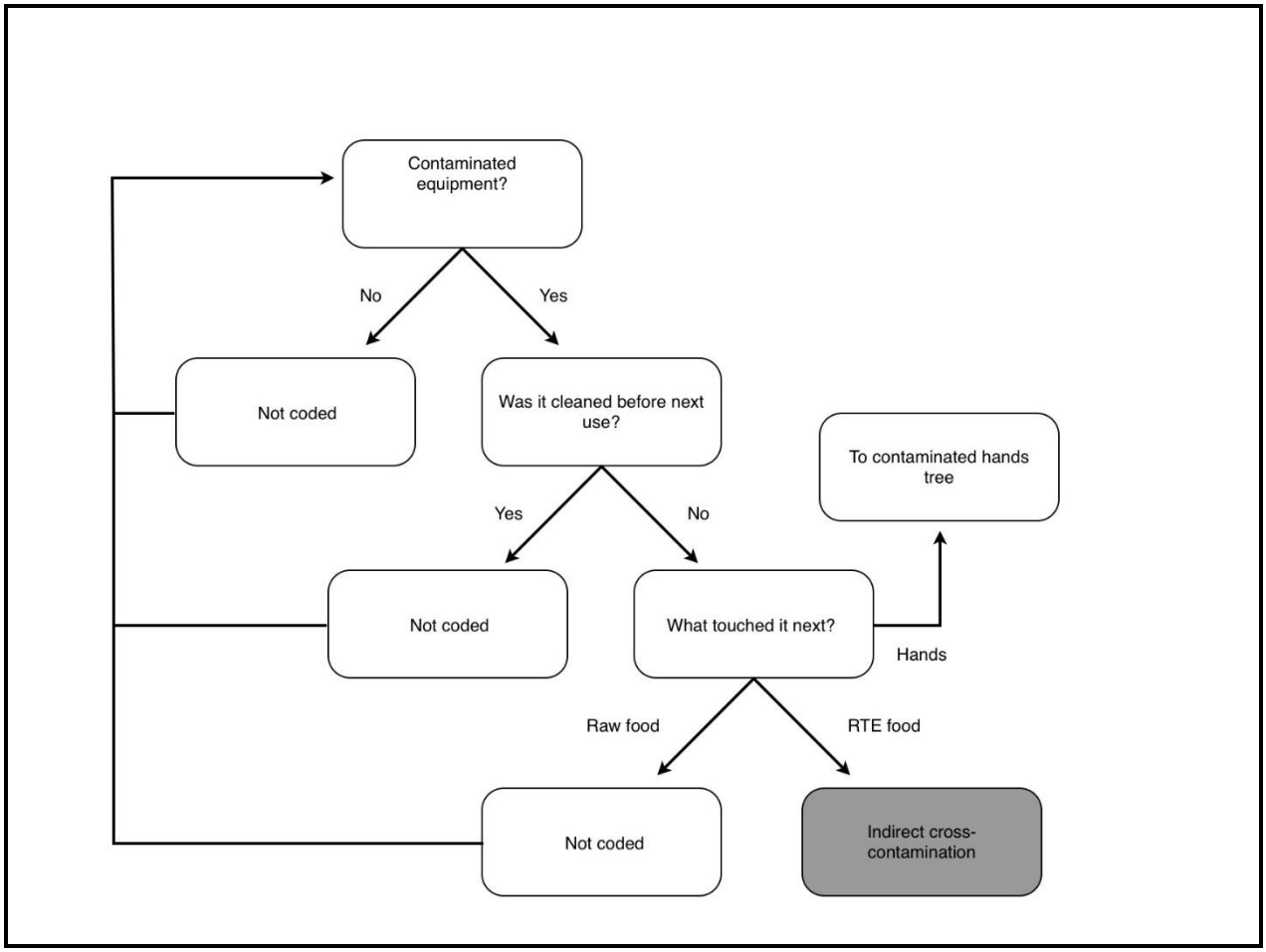
https://www.cdc.gov/handwashing/when-how-handwashing.html

Figure G-2. Direct Cross-Contamination Action Decision Tree



Raw, potentially contaminated food: Food that may contain harmful bacteria that can cause illness due to lack of a cooking step or coming into contact with a contaminated surface.

Figure G-3. Indirect Cross-Contamination Action Decision Tree

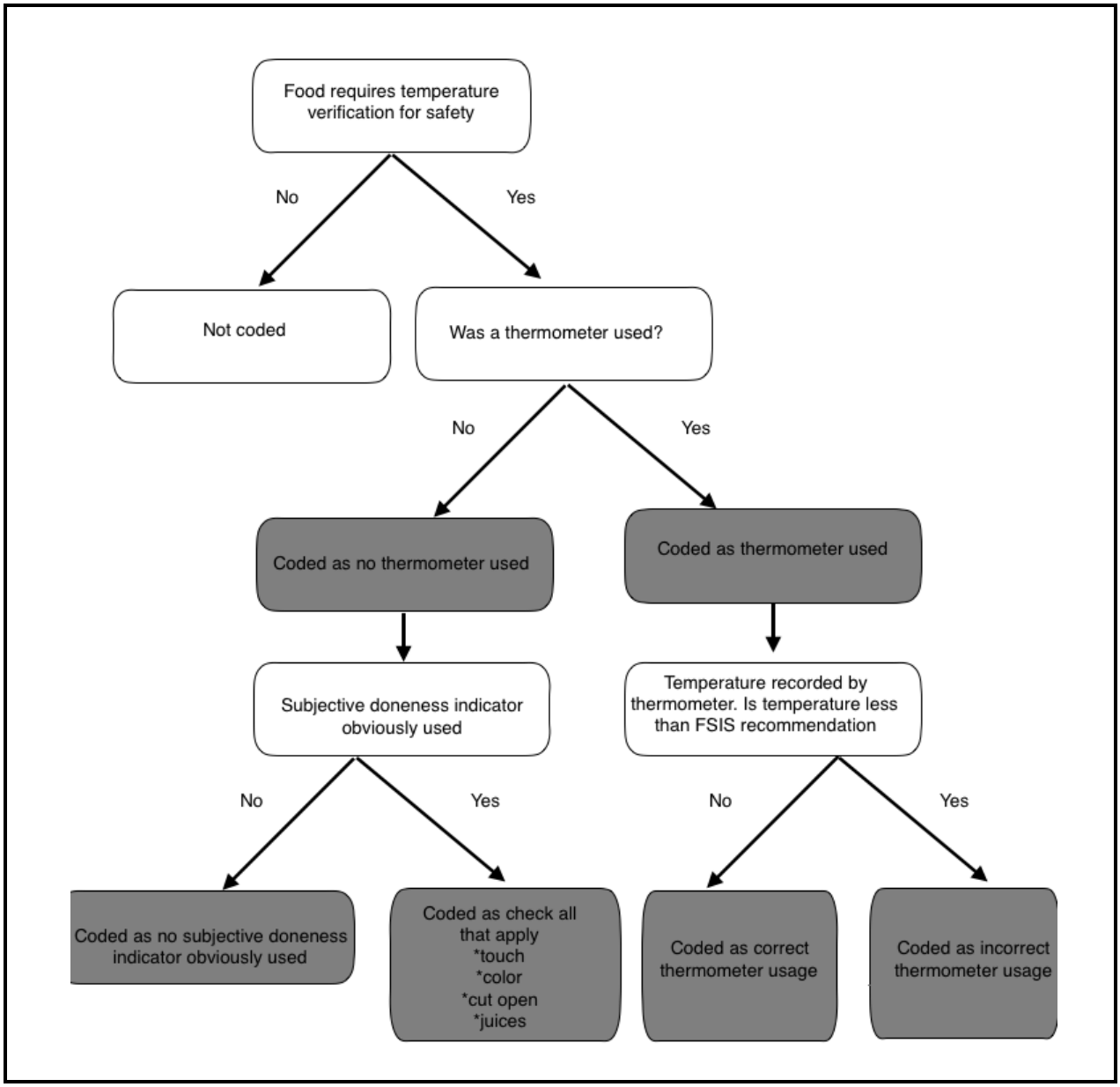


Contaminated equipment: Equipment that has come into contact with potentially contaminated food or another potentially contaminated surface and that has not been properly washed and sanitized.

Was it cleaned before next use?

All surfaces and components of equipment are washed using running water and soap.

Figure G-4. Thermometer Use Decision Tree



RTI Project Number
0215472

Food Safety Consumer Research Project: Meal Preparation Experiment Related to Thermometer Use

Addendum to Final Report: Microbiological Analysis

August 28, 2018

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Contents

Tables

1. Introduction

This report is an addendum to the Food Safety Consumer Research project final report. The report provides the results of the microbiological analysis for all of the locations sampled throughout the kitchen.

2. Methods

The final report describes the study design, selection of MS2 as a tracer organism, and inoculation of the turkey patties; therefore, this information is not included in this addendum. Additional information on the sampling technique and the detection method is provided below.

2.1 Environmental Sampling

Trained sample collectors used sponge sticks from 3M to complete the environmental sampling. Fourteen samples were taken for each observation: 1 as a cleaning control before the participant started cooking, 1 lettuce sample, 10 kitchen surfaces, and 2 discretionary samples based on triggers noted during the observation. Among the 10 kitchen surface samples taken, there were three types of surfaces: utensils, cleaning areas, and general kitchen surfaces. A 100 cm^2 template was used for sample collection on flat surfaces, and the entirety of the surface was sampled for irregularly shaped surfaces.

2.2 MS2 Detection and Analysis

As described in the final report, MS2 was detected using a four-step protocol: concentration, purification, RNA extraction, and RT-qPCR (Dawson et al., 2005; Jones et al., 2012; Turgeon et al., 2014). A sample with log 5 MS2 genome units or greater was considered a positive result. Statistical analyses of the results using *t* tests and ANOVAs were completed in R, and 371 samples were used for all analyses unless otherwise noted.

3. Results

3.1 Prevalence

MS2 was detected on all surfaces sampled in the study, but the prevalence varied by type of surface and ranged from 6.4 to 48.8% (see Table 1). For most of the surfaces sampled, the prevalence was between 12 and 22% with a few exceptions. Spice containers had the highest prevalence: nearly half of the samples were contaminated with MS2 (48.8%). Based on coding of the observations, it appeared that hands spread the MS2 from the turkey patties to the spice containers, which could account for the high prevalence of positive spice containers. Conversely, the refrigerator handle, inner sink surface, and knife handle were positive less than 8% of the time. Of the possible 371 inner sink surface samples and knife

handle samples, only the first 219 were processed because of their extremely low prevalence (below 10%). All 371 of the refrigerator door handle samples were processed and still yielded a low prevalence overall.

Table 1. Prevalence of Contamination and Level of Contamination of MS2 for Sampled Surfaces

Surface		All Participants	Treatment	Control	*p* value[a]
Knife handle[b]	Prevalence contaminated, % (*n*)	6.42 (218)	4.37 (108)	9.09 (110)	.1659
	Level of contamination ± SD, log genome copies[c]/handle (*n*)	5.53 ± 0.64 (14)	5.52 ± 0.43 (4)	5.54 ± 0.73 (10)	
Cutting board[b]	Prevalence contaminated, % (*n*)	12.70 (370)	11.11 (171)	14.07 (199)	.3946
	Level of contamination ± SD, log genome copies/ board (*n*)	6.12 ± 0.96 (47)	6.13 ± 1.02 (29)	6.11 ± 0.94 (28)	
Frying pan/ George Foreman (GF) handle[b]	Prevalence contaminated, % (*n*)	18.38 (370)	17.54 (171)	19.10 (199)	.6997
	Level of contamination ± SD, log genome copies/handle (*n*)	5.69 ± 0.67 (68)	5.71 ± 0.71 (30)	5.69 ± 0.64 (38)	
Inner sink surface	Prevalence contaminated, % (*n*)	6.39 (219)	5.50 (109)	7.27 (110)	.5931
	Level of contamination ± SD, log genome copies/surface (*n*)	5.56 ± 0.47 (14)	5.61 ± 0.42 (6)	5.52 ± 0.53 (8)	
Dishcloth/ sponge	Prevalence contaminated, % (*n*)	18.33 (371)	17.44 (172)	19.10 (199)	.6807
	Level of contamination ± SD, log genome copies/ surface (*n*)	5.49 ± 0.47 (68)	5.43 ± 0.40 (30)	5.54 ± 0.52 (38)	
Tap/faucet handle	Prevalence contaminated, % (*n*)	12.13 (371)	13.37 (172)	11.06 (199)	.4939
	Level of contamination ± SD, log genome copies/ handle (*n*)	5.47 ± 0.52 (45)	5.44 ± 0.56 (23)	5.51 ± 0.47 (22)	
Soap dispenser	Prevalence contaminated, % (*n*)	22.37 (371)	22.67 (172)	22.11 (199)	.8974
	Level of contamination ± SD, log genome copies/ surface (*n*)	5.70 ± 0.50 (83)	5.89 ± 0.53 (39)	5.53 ± 0.41 (44)	
Refrigerator door handle	Prevalence contaminated, % (*n*)	8.09 (371)	5.23 (172)	10.55 (199)	.0615
	Level of contamination ± SD, log genome copies/ handle (*n*)	5.50 ± 0.37 (30)	5.51± 0.34 (9)	5.47 ± 0.38 (21)	

(continued)

Table 1. Prevalence of Contamination and Level of Contamination of MS2 for Sampled Surfaces (continued)

Surface		All Participants	Treatment	Control	*p* value[a]
Spice containers	Prevalence contaminated, % (*n*)	48.79 (371)	49.42 (172)	48.24 (199)	.8139
	Level of contamination ± SD, log genome copies/surface (*n*)	6.18 ± 0.82 (181)	6.07 ± 0.78 (85)	6.28 ± 0.83 (96)	
Trash bin lid	Prevalence contaminated, % (*n*)	12.94 (371)	13.95 (172)	12.06 (199)	.5891
	Level of contamination ± SD, log genome copies/surface (*n*)	5.89 ± 0.71 (48)	6.06 ± 0.82 (24)	5.72 ± 0.56 (24)	
Discretionary samples	Prevalence contaminated, % (*n*)	17.12 (742)	15.83 (344)	19.10 (398)	.2751
	Level of contamination ± SD, log genome copies/handle (*n*)	5.72 ± 0.64 (127)	5.73 ± 0.60 (51)	5.72 ± 0.67 (76)	

Notes: A positive result was one within 5 logs of the total inoculum (approximately log 10). We would not expect contamination levels of pathogens in USDA-regulated food products to exceed log 5, in step with data-supported assumptions found in 9 CFR Parts 301, 317, 318, 320, and 381.

(*n*) = number of samples used in the analysis; SD = standard deviation.

[a] We calculated *p* value significance testing using a chi-squared test for prevalence and repeated measures of analysis of variance (i.e., ANOVA) for level of contamination for the difference between the control and treatment groups.

[b] A genome copy is the RT-qPCR equivalent of one bacteriophage particle, as calculated using a standard curve generated from a sample with known genome copy concentration as described in Appendix F of the final report.

[c] For the three utensils—the knife handle, cutting board, and the frying pan/GF handle—results are provided for items washed in the sink and those placed in the dishwasher (i.e., may receive further cleaning and disinfection). Results by where the item was placed are presented and described below.

Source: 2017 meal preparation experiment—microbiological samples.

3.2 Level of Contamination

Just as the prevalence of MS2 varied by surface, the level of MS2 contamination also varied depending on the surface sampled (see Table 2). The sampled utensils and kitchen surfaces had significantly higher levels of MS2 than the sampled cleaning areas. The lower MS2 levels on the cleaning areas may be because cleaning areas often have more water running over them, cleaning areas may be touched more frequently, and soap is more likely to be present on these surfaces. All of these factors could reduce the number of microbes on a surface and are not as likely to be a factor with utensils and general kitchen surfaces. The level of MS2 contamination on kitchen surfaces was significantly higher than the level of MS2 contamination for the discretionary samples. This finding was not expected because the discretionary samples were selected by observers as likely to have a high level of MS2. To investigate this further the log genome copies were examined by individual sample surfaces as described below.

Table 2. Significant Differences in Levels of Contamination of MS2 Among Surfaces Sampled

	Knife Handle	Cutting Boards	Frying Pan / GF Handle	Inner Sink Surface	Dishcloth / Sponge	Tap/Faucet Handle	Soap Dispenser	Refrigerator Door Handle	Spice Containers	Trash Bin Lid
Knife handle									.0063	
Cutting boards			.0099		<.0001	<.0001	.0081	.0010		
Frying pan/GF handle		.0099							<.0001	
Inner sink surface									.0119	
Dishcloth/ Sponge		<.0001							<.0001	.0104
Tap/faucet handle		<.0001							<.0001	.0230
Soap dispenser		.0081							<.0001	
Refrigerator door handle		.0010							<.0001	
Spice containers	.0063		<.0001	.0119	<.0001	<.0001	<.0001	<.0001		
Trash bin lid					.0104	.0230				

Notes: The knife handle, cutting boards, and frying pan/GF handle are considered utensils. The inner sink surface, dishcloth/sponge, tap/faucet handle, and the soap dispenser are considered cleaning areas. The refrigerator door handle, spice containers, and trash bin lid are considered kitchen surfaces.

Significance among the samples is shown on a grid view with each sample compared with all others. Readers should find the first sample they want to look at using the rows and the sample they want to compare it with using the columns. Where the row and column meet is the *p* value for the level of contamination.

The *p* values are indicated as follows: black = a sample being compared with itself, grey = a *p* value of >.05, white = p values < 0.05.

The two samples with the highest average genome units per gram were the spice containers and the cutting boards, with 6.18 and 6.12 average log genome units, respectively (Table 1). This means that, on average, millions of MS2 particles were detected on these surfaces. The spice containers also had the highest prevalence of MS2. This could be due to some of the same factors that were discussed previously regarding the high prevalence of MS2 on spice containers, most notably participants' direct handling of the containers using their contaminated hands. Additionally, study participants did not routinely clean the spice containers like they did other surfaces such as the countertop (although all surfaces including the spice containers were cleaned and sanitized by study team members after each participant). Spice containers are also not necessarily touched as often as other kitchen supplies and are frequently stored on the counter.

As previously noted, not all samples were of the same surface area. A knife handle has an inherently different surface area than a tap/faucet handle, but because of the irregular surface area, the whole knife handle was sampled. A 100 cm^2 template was used to sample flat surfaces. All results are provided as MS2 per surface swabbed (the entire surface area of an irregular object or 100 cm^2 of a flat surface). The larger surface area sampled for some samples may contribute to having a higher MS2 load than other sampled surfaces. However, there is little that could be done to control for the variability in surface area sampled while still being true to the nature of a typical consumer kitchen.

As shown in Table 2, there were significant differences in levels of contamination of MS2 among the types of surfaces sampled. Using a one-way ANOVA, we found that most of the significant differences were driven by the high level of MS2 found on the spice containers. All surfaces sampled, except for the cutting boards and the trash bin lid—the surfaces with the second and third highest MS2 levels, respectively—had a significantly lower level of MS2 compared with the spice containers. To further demonstrate the significant differences observed for spice containers, only five of the other nine surfaces sampled had contamination levels significantly lower than the cutting board, while seven of the other nine surfaces were significantly lower than the spice containers. The only other significant differences were between the trash bin and the dish cloth/sponge and between the tap/faucet handle and the trash bin lid.

3.3 Sink vs. Dishwasher

Kitchen utensils are often washed after they are used to prepare a meal but washing techniques can differ among consumers. To account for this, participants were instructed to either wash their utensils in the sink or leave them in the dishwasher based on whatever method they typically use at home. These utensils were then sampled and marked as a "sink" or "dishwasher." The rationale was that participants who rely on dishwashers to clean and sanitize their kitchen utensils may be more likely to have microbes present from cross-contamination on kitchen utensils than those who rely on washing utensils manually in the sink. Analysis was conducted on the three utensils—the knife handle, cutting board, and the frying pan handle—to determine if there were any differences between the prevalence or level of MS2 on samples washed in the sink versus those placed in the dishwasher.

The prevalence of MS2 varied by sample type but was highest on the frying pan/GF handle compared with the knife handle and cutting board samples. Sampled cutting boards and frying pan/GF handles placed in the dishwasher had significantly higher MS2 prevalence than those placed in the sink (see Table 3). A similar result was not observed for the sampled knife handles; this utensil had the lowest number of samples, the smallest surface area, and the lowest MS2 prevalence overall among the three types of utensils. The level of contamination for all three types of utensils was comparable regardless of whether the utensil was placed in the dishwasher or sink, and the highest MS2 levels were found for

sampled cutting boards (the second highest surface level of MS2 for all sampled areas). There were no significant differences in the level of contamination (results not shown).

Table 3. Prevalence of Contamination and Level of Contamination of MS2 for the Kitchen Utensils Based on Washing Technique

Utensil		All Samples	Dishwasher	Sink	*p* value[a]
Knife handle[b]	Prevalence contaminated % (*n*)	5.52 (181)	8.82 (34)	4.76 (147)	.3516
	Level of contamination ± SD, log genome copies[c]/handle (*n*)	5.39 ± 0.47 (10)	5.16 ± 0.15 (3)	5.50 ± 0.31 (7)	
Cutting board[b]	Prevalence contaminated, % (*n*)	13.08 (321)	22.58 (62)	10.81 (259)	.0137
	Level of contamination ± SD, log genome copies/board (*n*)	6.22 ± 1.00 (42)	6.98 ± 0.98 (14)	5.83 ± 0.72 (28)	
Frying pan/GF handle	Prevalence contaminated, % (*n*)	19.50 (323)	35.09 (57)	16.17 (266)	.0011
	Level of contamination ± SD, log genome copies/handle (*n*)	5.62 ± 1.00 (63)	5.80 ± 0.82 (20)	5.53 ± 1.07 (43)	

Notes: A positive result was one within 5 logs of the total inoculum (approximately log 10). We would not expect contamination levels of pathogens in USDA-regulated food products to exceed log 5, in step with data-supported assumptions found in 9 CFR Parts 301, 317, 318, 320, and 381.

(*n*) = number of samples used in the analysis; SD = standard deviation.

[a] We calculated *p* value significance testing using a chi-squared test for prevalence and repeated measures of analysis of variance (i.e., ANOVA) for level of contamination for the difference between utensils placed in the sink vs. placed in the dishwasher.

[b] Observations in which multiple cutting boards or knives were used or the video was not available were excluded from the analysis. For knife handles, the number of observations analyzed was 181 because of a low frequency of positive results in the first 56% of observations. After this point, we stopped processing these samples.

[c] A genome copy is the RT-qPCR equivalent of one bacteriophage particle, as calculated using a standard curve generated from a sample with known genome copy concentration as described in Appendix F of the final report.

Source: 2017 meal preparation experiment—microbiological samples.

3.4 Treatment vs. Control

The primary purpose of this study was to evaluate the impact of a USDA food safety video on thermometer use.[1] The treatment group was exposed to the video, while the control group was not. The impact of the video on food thermometer use was described in the final report, but the microbiological results were not fully described. For all analyses conducted, there were no significant differences seen between the treatment group and the control group (Table 2 and other data not shown). The refrigerator door handle was contaminated less frequently in the treatment group (approximately 5% of the time) compared with the

[1] "The Importance of Cooking to a Safe Internal Temperature and How to Use a Food Thermometer, https://www.youtube.com/watch?v=-2KkV2yFiN0

control group (approximately 11% of the time); however, this difference was not significant (p = .0615). The lack of statistically significant differences between the treatment and control groups suggests that making consumers aware of and changing one food safety behavior like thermometer use does not necessarily carry over to other food safety behaviors like avoiding cross-contamination.

3.5 Discretionary Samples

The discretionary samples varied for each observation but can be categorized into five general categories as shown in Table 4: cupboard, drawers, and counters; participant items; kitchen tools; cleaning supplies and cloths; and oven, GF, and microwave surfaces. The prevalence of MS2 for the discretionary samples varied by type of surface and ranged from 6.7 to 24.7% (see Table 5). The results for prevalence of MS2 were as expected compared with those presented in Table 1 for nondiscretionary samples. Likewise, the results for average log genome copies of MS2 (i.e., levels) were consistent with those presented in Table 1. The results were within the 5 log range, and there were no significant differences among the surfaces. These findings suggest that the discretionary surfaces were contaminated at a similar frequency and level as other kitchen surfaces with some variation across different surfaces; however, these differences were not statistically significant. (e.g., kitchen tools and participant items had a different prevalence and level of contamination). There was no significant differences between treatment and control for prevalence or level among the discretionary samples.

Table 4. Types of Discretionary Surfaces Sampled

	Cupboards, Drawers, Counters	Participant Items	Kitchen Tools	Cleaning Supplies and Cloths	Oven, GF, and Microwave
Examples	Cupboard	Cell phone	Measuring spoons	Dish soap bottle	GF top
	Countertop	Coffee cup	Spatula	Apron	Stove knobs
	Drawer	Earbuds	Mixing bowl	Paper towel holder	Microwave door
	Cabinet knobs	Water bottle	Tongs	Sink sprayer	Stove surface
	Table surface	Glasses	Recipe card	Dishcloth	GF cord
Total sampled	176	89	231	76	170

Table 5. Prevalence of Contamination and Level of Contamination for the Discretionary Samples

Location		All Participants	Treatment	Control	*p* value[a]
Cupboards, drawers, counters	Prevalence contaminated % (*n*)	13.64 (176)	15.12 (86)	12.22 (90)	.5763
	Level of contamination ± SD, log genome copies[b]/handle (*n*)	5.67 ± 0.59 (24)	5.54 ± 0.44 (13)	5.27 ± 1.87 (11)	
Participant items	Prevalence contaminated, % (*n*)	6.74 (89)	2.33 (43)	10.87 (46)	.2794
	Level of contamination ± SD, log genome copies/ board (*n*)	5.73 ± 0.79 (7)	6.11 (2)	5.54 ± 0.38 (5)	
Kitchen tools	Prevalence contaminated, % (*n*)	17.75 (231)	12.75 (102)	13.95 (129)	.7909
	Level of contamination ± SD, log genome copies/ handle (*n*)	5.91 ± 0.74 (41)	5.93 ± 0.84 (13)	5.84 ± 0.62 (18)	
Cleaning supplies and cloths	Prevalence contaminated, % (*n*)	18.42 (76)	11.43 (35)	24.39 (41)	.1490
	Level of contamination ± SD, log genome copies/ surface (*n*)	5.57 ± 0.53 (14)	5.69 ± 0.50 (4)	5.58 ± 0.57 (10)	
Oven, GF, and microwave	Prevalence contaminated, % (*n*)	24.71 (170)	19.73 (76)	27.70 (94)	.2287
	Level of contamination ± SD, log genome copies/ surface (*n*)	5.61 ± 0.55 (42)	5.84 ± 0.71 (15)	5.50 ± 0.40 (26)	

[a] We calculated *p* value significance testing using a chi-squared test for prevalence and repeated measures of analysis of variance (i.e., ANOVA) for level of contamination for the difference between treatment and control groups.

[b] A genome copy is the RT-qPCR equivalent of one bacteriophage particle, as calculated using a standard curve generated from a sample with known genome copy concentration as described in Appendix F of the final report.

Source: 2017 meal preparation experiment—microbiological samples.

4. Implications

4.1 Spice Containers

Of the kitchen surfaces sampled in this study, the spice containers were the most frequently positive for MS2. This finding was not expected because previous studies have not sampled spice containers when evaluating cross-contamination. Before FSIS' July 2018 media campaign presenting the results of this study, food safety messaging on the handling of spice containers and their role in consumer kitchen cross-contamination was not available. Because of the high levels and prevalence of MS2 on spice containers demonstrated in this study, we recommend that food safety educators develop and test messaging focused on the storage of spices and disinfection of spice containers. Messages could emphasize storing the containers in a cupboard instead of on the countertop and disinfecting the containers after use to prevent cross-contamination. If stored on the counter, the containers may be more likely to come into contact with raw meats and participants may not wash their hands before handling them.

4.2 Cross-Contamination and Handwashing

Among all the surfaces sampled, about 81% of participants had at least one quantifiable positive cross-contamination event during meal preparation. The final report provides the results for handwashing compliance, so those results are not repeated here. The observational data suggest that failure to wash hands correctly is a major factor leading to cross-contamination in consumer kitchens. As previously noted, significant differences in the microbiological results were not found between the treatment and control groups, suggesting that making consumers aware of changing one food safety behavior like thermometer use does not necessarily carry over to other food safety behaviors like avoiding cross-contamination. To affect consumer practices that result in cross-contamination, direct messaging is also needed on proper handwashing and practices to avoid cross-contamination.

5. References

Dawson, D. J., Paish, A., Staffell, L. M., Seymour, I. J., & Appleton, H. (2005). Survival of viruses on fresh produce, using MS2 as a surrogate for norovirus. *Journal of Applied Microbiology*, *98*(1), 203–209.

Jones, T. H., Muehlhauser, V., & Croken, G. (2012). Development of an optimized method for the recovery of infectious F-RNA coliphage MS2 from meat. *Journal of Virological Methods*, *185*(1), 69–73.

Turgeon, N., Toulouse, M. J., Martel, B., Moineau, S., & Duchaine, C. (2014). Comparison of five bacteriophages as models for viral aerosols studies. *Applied and Environmental Microbiology*, *80*(14), 4242–50.