

Research Paper

Consumers' Use of Personal Electronic Devices in the Kitchen

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ABSTRACT

Smartphones, tablets, and other personal electronic devices have become ubiquitous in Americans' daily lives. These devices are used by people throughout the day, including while preparing food. For example, a device may be used to look at recipes and therefore be touched multiple times during food preparation. Previous research has indicated that cell phones can harbor bacteria, including opportunistic human pathogens such as *Staphylococcus* and *Klebsiella* spp. This investigation was conducted with data from the 2016 Food Safety Survey (FSS) and from subsequent focus groups to determine the frequency with which consumers use personal electronic devices in the kitchen while preparing food, the types of devices used, and hand washing behaviors after handling these devices. The 2016 FSS is the seventh wave of a repeated cross-sectional survey conducted by the U.S. Food and Drug Administration in collaboration with the U.S. Department of Agriculture. The goal of the FSS is to evaluate U.S. adult consumer attitudes, behaviors, and knowledge about food safety. The FSS included 4,169 adults that were contacted using a dual-frame (land line and cell phone interviews) random-digit-dial sampling process. The personal electronics module was the first of three food safety topics discussed by each of eight consumer focus groups, which were convened in four U.S. cities in fall 2016. Results from the 2016 FSS revealed that of those individuals who use personal electronic devices while cooking, only about one third reported washing hands after touching the device and before continuing cooking. This proportion is significantly lower than that for self-reported hand washing behaviors after touching risky food products such as raw eggs, meat, chicken, or fish. Results from the focus groups highlight the varied usage of these devices during food preparation and the related strategies consumers are using to incorporate personal electric devices into their cooking routines.

Key words: Consumer; Food safety; Personal electronic devices

Since their introduction in the mid 2000s, smartphones and other personal electronic devices (PEDs), such as tablets, have become ubiquitous in Americans' daily lives. According to Pew Research (22), as of November 2016, 77% of U.S. adults reported having a smartphone, up from 35% in 2011, and, 51% of U.S. adults own tablet computers. People use their PEDs throughout the day for many different functions, including talking and texting, getting directions, watching movies or TV, listening to music, and shopping (4).

Consumers play an important role in the safety of the food they eat and are the last line of defense for preventing foodborne disease, because safe in-home preparation and consumption practices can reduce the risk of illness. Since the late 1990s, most consumer food safety education has focused on one or more behaviors that consumers can practice at home to reduce foodborne illness. Although each food safety education campaign is unique, many include information encouraging consumers to wash their hands often while cooking and to think about and take preventive actions to mitigate the transfer of pathogens from raw foods onto hands and food contact surfaces such as cutting boards (1, 20, 21). Pathogens such as Shiga toxin-producing

Escherichia coli, *Listeria monocytogenes*, and *Salmonella* can then be transferred to other foods that may be eaten raw or unheated.

Previous research has shown that cell phones can harbor bacteria, including opportunistic human pathogens (10, 19). Most of these findings were obtained for mobile devices used by patients, visitors, and health care workers in hospital settings. Bacteria reported include *Acinetobacter* spp., methicillin-sensitive and -resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, *Enterococcus*, *Streptococcus*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Bacillus*, and epidemic viruses (5, 7, 13, 23, 28). In a study comparing mobile phone use by health care providers, Lee et al. (17) found significantly higher contamination by potentially pathogenic bacteria on smartphones (34.8%) than on other types of mobile phones (20.5%).

Research on pathogen contamination on smartphones in nonclinical settings, especially food preparation settings, remains limited. Meadow et al. (19), using a metagenomics approach, found that 22% of the bacterial species on fingers of randomly chosen study participants were also present on their phones. Akinyemi et al. (2) randomly sampled 400 mobile phone users in Nigeria and found that mobile phones of marketers and food vendors had higher contamination rates than did those of students, teachers, public servants, and health care workers, probably because the marketers and

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food vendors had inadequate hygienic and sanitary practices. Bacteria found on their mobile phones included *Staphylococcus*, *Enterococcus*, *Escherichia*, *Klebsiella*, and *Bacillus*. The levels of bacterial contamination on smartphone screens declined with proper cleaning of the screens (i.e., wiping with a microfiber cloth or alcoholic lens wipe) (10). However, certain areas of mobile devices kept in protective cases are hard to reach during cleaning and may encourage biofilm formation, which may make cleaning and sanitizing more difficult (29).

The purpose of this study was to investigate how consumers are using PEDs in the kitchen, with a focus on how hand washing practices may interact with PED use. Data from the 2016 U.S. Food and Drug Administration (FDA) Food Safety Survey (16) and from subsequent focus groups were used to determine the frequency with which consumers use PEDs in the kitchen while preparing food, the types of devices used, and hand washing behaviors after handling these devices.

MATERIALS AND METHODS

Survey sample. Questions related to the use of phones and other electronic devices were included in the 2016 Food Safety Survey conducted by the FDA in collaboration with the U.S. Department of Agriculture. The respondents for this survey were noninstitutionalized adults 18 years of age or older in the 50 U.S. states and the District of Columbia who speak either English or Spanish. Respondents were randomly selected from an overlapping dual-frame process consisting of both landline telephones and cell phones. Landline telephone and cell phone numbers were selected using the random-digit-dial process of the GENESYS sampling system (Marketing Systems Group, Horsham, PA), which yields an equal probability of selection and a single-stage sample of telephone numbers. Regional coverage was controlled to assure the survey could reach sufficient numbers of African-American and Hispanic respondents. In the landline portion of the survey, the most recent birthday method was used to select the eligible respondent in a household.

Each respondent was randomly assigned to one of two versions of the survey. Many of the questions had been used in previous FDA Food Safety Surveys and were included for tracking purposes (11). Other questions were developed to generate new information.

Survey data were weighted to account for sampling design (overlapping dual frame), probability of selection in the landline sample (number of landline telephone numbers and number of adults in a household), and key demographic characteristics (age, education, gender, and race or ethnicity). The raking technique was applied to match the sample to the population targets based on the 2014 National Health Interview Survey (8), which includes phone status information with demographic information and has been used to investigate the composition of cell phone and landline households.

This study protocol was approved under exempt review by the institutional review board of the FDA.

Survey questionnaire design. Prior to the administration of the survey, nine cognitive interviews and 17 pretests were conducted with potential survey respondents to enhance the survey's understandability and to evaluate the survey administration plan. Other procedures used to increase the response rate included sending advance notification letters to available landline

households, providing a toll-free help line, calling at different times of the day and on different days of the week, and monitoring the interviews for quality. The average length of the interview for both landline and cell phone interviews was about 17 min.

Survey variables. Regardless of the survey version, all respondents were asked the same sequence of questions about use of PEDs while preparing food. These questions were in a section of the survey concerning food preparation frequency and handling practices. Only respondents who said they have cooking facilities (refrigerator and either a stove or microwave) and who prepared the main meal at least some of the time were asked about using PEDs while preparing food because these respondents were considered best able to answer the questions about PED use. Due to a discrepancy in the survey skip pattern, those respondents in version 1 of the survey who did not prepare the main meal at least some of the time were mistakenly asked the question about use of PEDs while cooking. Because the intent was to study habits of those who prepared the main meal at least some of the time, data from respondents in version 1 who answered this question were omitted.

Respondents were asked, "Do you ever use a telephone, cell phone, smart phone, tablet, laptop, or computer while preparing food (for example to look up recipes or take a call)?" Respondents could answer either yes or no. Those who said they had used a PED were asked, "Which one do you handle most often while preparing food? Would it be your telephone, cell phone, smart phone, tablet, laptop, or computer?" They were then asked, "After you touch your [most frequently used device] while preparing food, what do you usually do next? Do you continue preparing food, or do you first rinse your hands with water, or wipe them, or wash with soap?"

Statistical analysis. Because the primary goals of this study were to describe the demographic characteristics of individuals who use PEDs in the kitchen and the type of PEDs used and to compare hand washing practices used after touching PEDs with those used after touching raw meat, raw fish, and raw eggs, bivariate relationships were examined between use of PEDs while preparing food and age, gender, race or ethnicity, education, and income. Bivariate relationships were also explored between respondents with the same demographic characteristics who did and did not wash hands with soap after touching a PED while preparing food. All frequencies and chi-square tests were estimated with SAS 9.4 (SAS Institute, Cary, NC).

Focus group study design. A series of eight focus groups were convened in focus group facilities in four U.S. cities: Alexandria, VA; Atlanta, GA; Louisville, KY; and Los Angeles, CA. The sites were chosen because they are geographically separated and in large population centers. Alexandria was selected for its proximity to the FDA headquarters.

The groups met in September and October 2016, and the meetings were audio and video recorded. The focus group recordings were later transcribed. Each meeting lasted about 2 h (including the time needed for signing in before the meeting started and signing out after the meeting ended). Each participant received a \$75 incentive. The group meetings were facilitated by trained, non-FDA moderators who ensured that all the topics were covered and everyone in the group could participate.

The personal electronics module was the first of three food safety topics discussed in each of the groups, and the conversation on this topic lasted about 0.5 h in each group meeting. The focus group guide covered three distinct aspects about using PEDs: (i)

usage frequency and purpose while cooking, (ii) hand washing and PED washing while cooking, and (iii) level of concern for cross-contamination from PEDs while cooking. For the PED frequency and purpose questions, participants were asked, "How often do you use a cell phone, tablet, or computer while you are cooking?," "Which do you use most often?," "What do you use it for?," and "Tell me about the last time you used a cell phone, tablet, or computer while cooking. What were you making? What did you use your device for? When did you use it?" For the hand washing and PED washing section, participants were asked, "Did you wash or wipe your hands after touching your cell phone, tablet, or computer? Tell me about how you washed or wiped your hands. How did you wash them? Why did you wash them? What about before you touched your cell phone, tablet, or computer? Did you wash your hands before touching it and after you have started cooking? How does washing your hands after touching your cell phone, tablet, or computer compare to how often you wash your hands in general while cooking?" For the cross-contamination section, participants were asked, "Does washing your hands before you use your cell phone, tablet, or computer depend on what type of food you are preparing? What about washing your hands after touching the cell phone, tablet, or computer? Does it depend on what type of food you are preparing? How concerned are you about germs getting on your cell phone, tablet, or computer while you cook? What about germs from your cell phone, tablet, or computer getting into the food you are cooking?"

After the discussion about PEDs, the groups discussed two other topics: (i) health inspection scores posted in restaurants and (ii) consumer use and understanding of a consumer advisory located on restaurant menus about the risks of eating raw and undercooked protein foods.

Focus group participants. Purpose sampling was used to recruit participants from lists maintained by the focus group companies in each city. To qualify, participants had to be at least 18 years old and able to read and speak English; not work for a market research firm, the food industry, a public health organization, or any federal, state, or local food agency or have a family member that worked in these industries; not have a ServSafe (24) or other food handling certificate; and not have participated in a focus group in the past 6 months. For the Los Angeles groups, requirements also included that no one from a participant's immediate family worked for a market research firm, the food industry, a federal, state, or local food agency, or a public health organization for the last 5 years. All participants were required to have cooked the main meal at home at least some of the time and to have used a PED at least once while they were cooking. They also had to eat at a full-service restaurant at least once per month. A screening questionnaire was developed and administered by phone to determine whether potential participants met these criteria and could be invited to join a focus group.

The focus groups were segregated by level of education, placing those who had attended 1 to 3 years of college toward a bachelor's degree or had a bachelor's degree or advanced degree into the higher education groups and those who had not graduated from high school, had graduated from high school or attained a general education degree, or had attended technical or vocational school or community college into the lower education groups. In each city, there was one higher and one lower education group. Segregation by education was used to help make the discussion more accessible to all participants within a group. Each group included 7 to 10 participants with a mix of genders, ages, and races or ethnicities, for a total of 73 participants.

Methods of analysis. One of the authors and an assistant to the moderator observed the group meetings either online or in person and took extensive notes on the discussions, consisting of impressions and verbatim transcriptions. The author used the notes to write a detailed summary for each pair of group meetings in each city. The summary was structured by the discussion topics in the moderator's guide. Video recordings and transcripts were used to cross-check the authors' notes and summaries. The independent focus group moderators and staff conducted a separate analysis and provided a written summary report to the first author. All summaries and notes were systematically analyzed for common attitudes, behaviors, and beliefs.

RESULTS

Survey. Telephone interviewing began on 6 October 2015 and continued through 17 January 2016. A total of 4,169 respondents completed the survey, for a 21% dual-frame combined response rate (based on the 2015 American Association for Public Opinion Research Standard Definitions Response Rate 3) (3). The completed interviews included 2,021 landline interviews and 2,148 cell phone interviews. Of the 4,169 survey respondents, the analysis included 3,870 who had both cooking facilities (refrigerator and stove or microwave) and who had prepared the main meal at least some of the time. Forty-nine percent reported using a PED while cooking. Reported PED use was significantly more likely among certain demographic groups: those younger than 35 years, those with a college degree or higher, women, non-Hispanic whites, and those with household income of \$75,000 or more per year (Table 1). Cell phones (including smartphones) were the PED most commonly used while preparing food (Fig. 1), with 65% of respondents reporting use of a cell phone.

To determine the potential for cross-contamination of microorganisms between PEDs and food, respondents were asked about hand washing behaviors after touching each of the following while cooking: PEDs, raw eggs, raw meat or chicken, and raw fish. Among the food handlers that engaged in each behavior, respondents were less likely to say they washed their hands with soap after touching their PED (40%) than after handling raw eggs (45%) and much less likely than after handling raw meat or chicken (85%) or raw fish (85%) (Fig. 2). However, certain demographic groups, including respondents 36 to 65 years old, women, and non-Hispanic and nonwhite respondents, were significantly more likely to wash their hands after touching their PED (Table 2).

Focus groups. All group participants were required to have cooked the main meal at least some of the time and to have used PEDs at least once while cooking. Therefore, as expected, participants in all the groups used PEDs while cooking at least some of the time. Although frequency of use was variable, many participants talked about using PEDs often while cooking, from a few times per week to almost every day. The most common PED used was a smartphone, and the most common use was for finding and checking recipes. Other common uses included talking on the phone,

TABLE 1. Demographic characteristics of food preparers who use personal electronic devices (PEDs) while preparing food and those who do not use such devices, 2016 FDA Food Safety Survey^a

Respondent variable ^b	Those who use devices (n = 1,771)	Those who do not use devices (n = 2,099)	P value ^c
% respondents that use a PED while preparing food	49	51	
Age (n = 3,652)			<0.001
18–35 yr	62	38	
36–65 yr	47	53	
65+ yr	29	71	
Education (n = 3,799)			<0.001
Some high school or high school graduate	37	63	
Some college or associate's degree	53	47	
Bachelor's degree or higher	60	40	
Gender (n = 3,870)			<0.001
Female	53	47	
Male	43	57	
Race or ethnicity (n = 3,801)			<0.001
Hispanic white	42	58	
Non-Hispanic white	51	49	
Hispanic, not white	46	54	
Not Hispanic, not white	43	57	
Income (n = 3,300)			<0.001
<\$35,000	40	60	
\$35,000 to <\$75,000	50	50	
≥\$75,000	59	41	

^a PEDs include landline telephone, cell phone, smartphone, tablet, or computer.

^b Sample size for all food preparers. Sample sizes for bivariate comparisons varied as indicated because of missing values for the demographic variables.

^c P value from Pearson chi-square test for significant associations between demographic characteristic and use or no use of a PED while preparing food.

texting, using social media sites, watching videos, and listening to music.

Many participants talked about being vigilant about washing their hands with soap and water when preparing foods, especially after touching raw meat or poultry. Many had thought about how to incorporate using PEDs into their cooking routines. Most participants thought that their PEDs were dirty from daily use and were worried about getting food (especially raw chicken) and grease on their phones

while cooking. Therefore, many had developed their own strategies for not cross-contaminating the PED and food: washing hands after touching raw meat or chicken before touching the phone; using pinkies, elbows, or knuckles to swipe the phone; waiting until a good time in the cooking process (such as only having to stir things or after handling raw meat) to touch the phone; and putting the PED in a special holder and keeping it away from the food or sink.

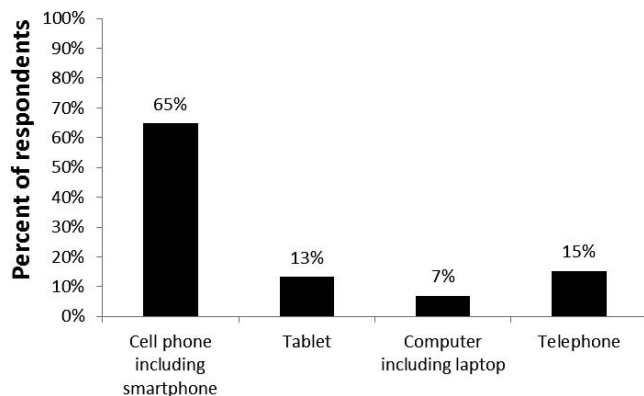


FIGURE 1. Types of personal electronic devices consumers in the 2016 FDA Food Safety Survey most often reported using when preparing foods.

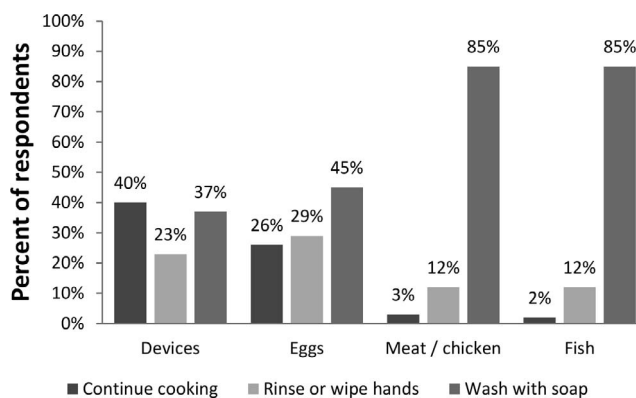


FIGURE 2. Percentage of respondents in the FDA 2016 Food Safety Survey who continue cooking, rinse or wipe hands, or wash hands with soap after handling PEDs, raw eggs, raw meat or chicken, or raw fish.

TABLE 2. Demographic characteristics of food preparers who practice good hand hygiene versus those who do not after touching personal electronic devices (PEDs) while preparing food, 2016 FDA Food Safety Survey

Respondent variable ^a	Wash with soap (n = 612)	Rinse or continue cooking (n = 1,088)	P value ^b
% respondents that wash their hands after touching a PED while preparing food	37	63	
Age (n = 1,617)			<0.001
18–35 yr	29	71	
36–65 yr	43	57	
65+ yr	37	63	
Education (n = 1,672)			0.56
Some high school or high school graduate	38	62	
Some college or associate's degree	36	64	
Bachelor's degree or higher	36	64	
Gender (n = 1,700)			<0.01
Female	39	61	
Male	33	67	
Race or ethnicity (n = 1,673)			0.01
Hispanic white	34	66	
Non-Hispanic white	35	65	
Hispanic, not white	41	59	
Not Hispanic, not white	44	56	
Income (n = 1,474)			0.1
<\$35,000	39	61	
\$35,000 to <\$75,000	37	63	
≥\$75,000	33	67	

^a Sample size for all food preparers. Sample sizes for bivariate comparisons varied as indicated because of missing values for the demographic variables.

^b P values from Pearson chi-square test for significant associations between demographic characteristic and washing hands with soap or rinsing or continuing cooking after touching PEDs while cooking.

Participants were generally more concerned about washing hands after touching raw meat or chicken than about washing hands after touching raw vegetables before moving to the next task, even when the next task was touching a PED. Some thought it was important to at least rinse or wipe hands after touching vegetables, but that action was often to prevent water or other moisture from wet vegetables such as tomatoes from ruining the PED.

Many said they cleaned their PEDs. Some cleaned the PED regularly (one or more times per week) and some said they cleaned the PED when they thought about it or noticed it was dirty. Some said they used various types of wipes, such as Clorox, Lysol, alcohol, or baby wipes, and others used screen cleaners or cloths. One participant had a special device for sanitizing cell phones.

When directly asked which they were most concerned about, about half of the participants agreed that they were more concerned about transferring bacteria from food onto their phones, and about half agreed that they were more concerned about transferring bacteria from their phones to food. Those who were more concerned about bacteria from their phone getting onto their food talked about how their phone was dirty because they carry it around with them and it is placed in “dirty” places such as the gym, bathroom, or office. They did not want those “germs” getting onto their foods. Those who were more concerned about food getting onto the phone while cooking were concerned both about

getting sick from bacteria from raw meat getting onto the phone, which they then put up to their face, and about residue from wet or greasy food making the phone dirty or potentially ruining it. A few participants had not thought much about cleaning their phones or about cross-contamination of bacteria between phones and food. Some participants said they would be more concerned about this now after participating in the focus group, whereas others were still not concerned about this issue.

DISCUSSION

To our knowledge, this study is the first to investigate how consumers use PEDs in the kitchen. Borrusso and Quinlan (6) found that foodborne pathogens are often present in consumers' kitchens. *L. monocytogenes* prepared in tap water and inoculated on stainless steel, polytetrafluoroethylene, and glass surfaces can form biofilms and survive a few hours, even after air drying at ambient temperature (12). When nutrients are available, very low levels of *L. monocytogenes* can survive on stainless steel, rubber, plastic, and glass surfaces for at least 24 h after drying (25). *E. coli* O157:H7, *Salmonella* Enteritidis, and *S. aureus* can adhere and survive on polystyrene and glass surfaces (18). Adherence, biofilm formation, and survival of *L. monocytogenes* and *Salmonella* on rubber and plastic surfaces, which are frequently used as protective cases for electronic devices, have also been reported (9, 14, 26, 27).

Protection cases, which contain holes and seams, can harbor biofilms of foodborne pathogens. When the biofilms are transferred onto foods that support the growth of foodborne pathogens in the kitchen, consumers are at risk. Therefore, consumer use of PEDs while preparing foods may be a source for cross-contamination with foodborne pathogens.

In the survey, about half of all food preparers used a PED while preparing food. Although the focus group data suggest that many consumers believe that their phones and other devices are “dirty,” because they bring them to places such as the bathroom and the gym, most survey respondents did not wash their hands with soap after touching a PED while preparing food. Consumers are more likely to wash their hands with soap after touching raw meat, chicken, or fish—foods that leave hands feeling sticky and are associated with bacteria such as *Salmonella* and *E. coli*—than after touching a PED.

At least two avenues exist for reducing the potential for bacterial cross-contamination of foods from PEDs. The first is to provide helpful messaging about how to safely use PEDs while cooking, including reminders about the importance of washing hands before and after touching PEDs. Because some focus group participants mentioned having their own strategies to prevent cross-contamination, such as swiping the device with a pinky or touching the phone only during certain times in the cooking process, this suggests that consumers are already thinking about this issue and therefore may be open to this type of messaging. Second, new tools, which use voice activation instead of touch screens to perform tasks, might reduce the number of times that people touch their devices while preparing food, ultimately reducing cross-contamination. New voice activation functions on PEDs also will allow less manual contact with these devices, and as technology continues to evolve, these options likely will be expanded.

The main strengths of this study include the use of both quantitative survey data to estimate the use of PEDs and qualitative focus group data to understand the range of attitudes and beliefs about using PEDs while preparing food. Focus groups have been shown to be an effective method for exploring the range of attitudes, preferences, and behaviors associated with a topic (15). However, the present study is limited by the nature of self-report data, which may not perfectly reflect actual behavior. The decline in survey response rates typical of phone surveys also must be considered when evaluating the generalizability of the results. Findings from focus groups are also not generalizable to the larger population. Although the literature suggests that PEDs are a potential source of cross-contamination in the kitchen, no information was available on transfer of foodborne pathogens from PEDs to food (or vice versa) or the level of risk that this transfer may pose to consumers. Future work should quantify the actual risk to consumers from using PEDs while preparing food and could include targeted microbiological sampling of PEDs, their owners, and the kitchen environment. The transfer of bacteria from PEDs to prepared food by consumers can be modeled using artificial inoculation of PEDs and simulation of food preparation while using contaminated PEDs.

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