Food Protection Trends, Vol. 31, No. 11, Pages 672–679

6200 Aurora Ave., Suite 200W, Des Moines, IA 50322-2864

Relationship between Cleaning Practices and Microbiological Contamination in Domestic Kitchens

FUR-CHI CHEN,* SANDRIA L. GODWIN and AGNES KILONZO-NTHENGE
*Dept. of Family and Consumer Sciences, College of Agriculture, Human and Natural Sciences, Tennessee State University, 3500 John A. Merritt Blvd., Nashville, TN 37209-1561, USA

ABSTRACT

A study was conducted to evaluate the effectiveness of consumers' kitchen cleaning practices in reducing microbiological contamination in home kitchens. One hundred fifty participants completed an in-home survey. A total of 747 samples of kitchen surfaces and 100 samples of kitchen cleaning tools were collected and analyzed for the indicator microorganisms. The reported cleaning practices were compared with various bacterial counts. Kitchen sinks and faucet handles were the most contaminated places in the kitchens. Dishcloths and sponges used for cleaning often contained more bacterial contamination than kitchen surfaces. Our results indicated inefficient cleaning procedures applied by the respondents even though most of them reported incorporating sanitizing agents in their cleaning scheme. Kitchens of respondents who reported cleaning kitchen surfaces on a regular basis had significantly lower contamination levels than those of respondents who reported cleaning the surfaces only when they look dirty. Respondents who "worry about" food safety at home were more likely than others to have clean kitchens. In contrast, respondents who think they have done all they can to keep food safe were less likely than others to have clean kitchens. We have identified several practice patterns and socioeconomic characteristics that may contribute to higher microbiological contamination in home kitchens.

A peer-reviewed article

*Author for correspondence: Phone: +1 615.963.5410; Fax: +1 615.963.1557
E-mail: fchen1@tnstate.edu

INTRODUCTION

Foodborne diseases caused by microbiological hazards in major outbreaks have received widespread attention as a result of broad coverage by the media. In contrast, the sporadic foodborne illnesses linked to domestic kitchens are less often reported and sometimes difficult to document. As a result, cases of foodborne illnesses related to home-prepared foods are often underestimated *(11, 14)*. Studies have indicated that cross-contamination during food handling, preparation, and storage in the home is a major contributing factor in the transmission of foodborne diseases *(4, 7, 16)*. Many foods, such as raw poultry, meat, eggs, fish, shellfish, fruits and vegetables, have been cited as potential sources of foodborne pathogens, including *Salmonella*, *Campylobacter*, *Listeria*, *E coli* O157:H7, and *Staphylococcus aureus* in the kitchen environment *(5, 13, 15, 16)*.

Although researchers have repeatedly stressed the importance of effective hygiene procedures in prevention of cross-contamination *(1, 2, 18)*, consumer hygiene practices have been shown frequently to be inefficient in controlling bacterial growth and survival in the kitchen environment *(8, 9, 12, 19)*. Several locations and utensils in home

TABLE 1. Demographic summary of respondents

Demographic factors (N=150)	Response	(%)
Gender	Male	24.0
	Female	76.0
Age	18–29	19.3
	30–44	26.0
	45–59	38.7
	60–69	5.3
	70+	10.7
Race	White	18.0
	African American	74.0
	Others	8.0
Education	Less than high school	13.3
	High school diploma or GED	26.0
	Some college	28.7
	College or higher	32.0
Employment status	Work full time	35.9
	Work part time	20.9
	Unemployed	12.8
	Retired	17.6
	In school/homemaker, not working	12.8
Marital status	Married	29.3
	Single	42.7
	Divorced, widowed, or separated	28.0
Household income	Less than $15,000	33.3
	$15,000 – $34,999	27.3
	$35,000 – $49,999	14.0
	$50,000 – $74,999	16.7
	$75,000+	8.7
People in the household	1	32.7
	2–3	42.0
	4–5	20.6
	6+	4.7

kitchens, including kitchen sinks, faucet handles, refrigerators, wash sponges, and dishcloths, have been found to be highly contaminated *(3, 6, 10, 17)*. Studies are needed to better understand consumers' cleaning patterns and to identify the hurdles to effective hygiene practices.

The purpose of this study was to evaluate the effectiveness of consumers' cleaning practices in controlling microbiological contamination in home kitchens. We examined the relationship between cleaning patterns and levels of indicator microorganisms on kitchen surfaces and kitchen tools. The information obtained from this study can be used to provide evidence-based educational messages to improve the effectiveness of cleaning practices and to reduce the risk of cross-contamination in home kitchens.

MATERIALS AND METHODS

Consumer survey

Participants were recruited by a multi-project research team investigating consumers' food safety practices at home. The protocols and instruments for in-home interviews were reviewed and approved by the Institutional Review Board (IRB) at Tennessee State Univer-sity prior to implementation of the study. The participants signed up for the project in response to recruitment brochures posted at community organizations, senior housing communities, churches, and other sites of social gatherings. The survey targeted low to middle income communities, with a majority represented by the African-American population. It was required that the participants be residents of middle Tennessee, at least 18 years old, and responsible for food purchasing, storage, and preparation at home. The researchers contacted the participants by phone to verify their eligibility and to schedule the time of the visit. Participants (n = 150) completed an in-home survey that included questions regarding handling of foods and cleaning practices for kitchens and refrigerators. At the end of the interview, the respondents received a twenty-five dollar grocery gift card as remuneration for participation.

Collection of kitchen samples

During the in-home visit, researchers, with the permission of the participants collected samples from kitchen and refrigerator surfaces. Using Hydra Sponges moistened with Neutralizing Buffer (Biotrace International Inc., Muncie, IN), swab samples were taken from several locations in the kitchens, including the countertop, sink bottom, faucet handle, refrigerator handle, and meat drawer. Sampling areas were approximately 20 cm × 20 cm for countertops, sink bottoms, and meat drawers, and the entire areas of faucet handles and refrigerator handles. After sampling, the Hydra Sponges were placed in sterile bags with appropriate labels. Additionally, cleaning tools (dishcloths, sponges and dish pads) used in the participants' homes were collected in labeled sterile bags. The participants received new items as replacements. All kitchen samples were temporarily held in a cooler containing ice packs and transferred to the laboratory within three hours after collection.

Laboratory analysis

Microbiological assays were performed within two hours after the samples were brought to the Food Microbiology Laboratory in the Department of Family and Consumer Sciences. Aerobic Plate Count (APC), *Enterobacteriaceae* Count (EBC), and *Staphylococcus aureus* Count (SAC) were used to assess the levels of microbiological contamination. Approximately 25 ml of Butterfield's phosphate buffer (pH 7.2) was added to each bag containing a Hydra Sponge and 100 ml to each bag containing a sponge, dishcloth, or dish pad. The contents of the sample bags were mixed using a Stomacher R 400 Circulator (Seward

TABLE 2. Summary of survey questions and answers

Question/Answer	N	%
Frequency of cleaning kitchen countertops		
Several times a day	40	26.7
Just about every day	68	45.3
A few times a week	16	10.7
About once a week	17	11.3
About once every two weeks	5	3.3
About once a month	4	2.7
Items used for cleaning kitchen countertops (Multiple responses)		
Dishcloth	108	72.0
Cloth used just for cleaning	35	23.3
Sponge	57	38.0
Paper towel	98	65.3
Handy-wipe	32	21.3
Brush	16	10.7
Scouring pad	42	28.0
Cut up raw poultry on the countertop		
Always	11	8.4
Usually	2	1.5
Sometimes	20	15.3
Never	98	74.8
Wash the countertop with warm soapy water after cutting up raw poultry		
Always	26	78.8
Usually	2	6.1
Sometimes	3	9.0
Never	2	6.1
Sanitize the countertop after cutting up raw poultry		
Always	18	54.5
Usually	1	3.1
Sometimes	11	33.3
Never	3	9.1
Cleaning compounds used for cleaning kitchen sink (Multiple responses)		
Powder cleaner	50	33.3
Cream cleaner	8	5.3
Vinegar	12	8.0
Bleach	99	66.0
Baking soda	15	10.0
Anti-bacteria cleaner	43	28.7
Dishwashing liquid	108	72.0
Plain water	51	34.0
Wash sink with warm, soapy water or sanitizer after washing poultry in it		
Always	85	85.0
Usually	4	4.0
Sometimes	9	9.0
Never	2	2.0
How often wash the handles on the sink		
Whenever it looks dirty	19	12.7
More than once a day	27	18.0
Once a day	57	38.0
Few times a week	21	14.0
Once a week	14	9.3
Few times a month	8	5.3
Less often or never	4	2.7

TABLE 2. Summary of survey questions and answers *(Continued)*

Question/Answer	N	%
How often wash the refrigerator handles		
Whenever it looks dirty	28	18.7
More than once a day	10	6.7
Once a day	26	17.3
Few times a week	36	24.0
Once a week	21	14.0
Few times a month	15	10.0
Less often or never	14	9.3
How often wash the dishcloth (only the respondents who used dishcloth)		
After each use	22	29.3
Every day	15	20.0
More than once a week	17	22.7
About once a week	17	22.7
About every two weeks	2	2.7
About once a month	2	2.7
Method used for washing dishcloth (only the respondents who used dishcloth)		
Rinse it out with cold water	1	1.4
Rinse it in hot water	29	41.4
Wash it in the washing machine	15	21.4
Soak it or wash it in a bleach solution	23	32.9
Other	2	2.9
How often wash the sponge (only the respondents who used sponge)		
After each use	9	45.0
Every day	7	35.0
More than once a week	3	15.0
About once a week	1	5.0
Method used for washing sponge (only the respondents who used sponge)		
Rinse it in hot water	8	47.1
Wash it in the washing machine	3	17.6
Soak it or wash it in a bleach solution	3	17.6
Some other way	3	17.6
Regularly discard outdated or old foods from refrigerator		
Agree	128	85.3
Disagree	22	14.7
Worry about the safety of the foods eaten at home		
Agree	78	52.3
Disagree	69	46.3
Neither	2	1.3
I think I am doing all I can to keep my food safe at home		
Agree	123	82.6
Disagree	26	17.4

Limited, UK) at 230 rpm for 2 minutes. The liquid contents were serially diluted in Butterfield's phosphate buffer, from 10^{-1} to 10^{-6}, for subsequent plating. Petrifilm plates (3M Microbiology, St. Paul, MN) for Aerobic Count, *Enterobacteriaceae* Count, and Staph Express Count were inoculated with 1 ml of the serially diluted samples. The Petrifilm plates were incubated at 35°C for 24–48 hours per the manufacturer's instructions. Colonies were then enumerated manually and recorded.

Statistical analysis

APC, EBC and SAC were converted to log CFU/sample. Samples with bacterial counts below the detection level were recorded as equal to or less than 1 CFU/sample (0 log CFU/sample). Microbiological and survey data were analyzed using Statistical Package for Social Sciences (SPSS) software, Version 15.0 for Windows. Descriptive statistics were calculated for all microbial and survey data. Means and standard deviations were calculated for microbial data, and percentages were utilized to describe nominal and ordinal data. The reported cleaning practices were correlated with various bacterial counts using Pearson correlation. Significant differences were

TABLE 3. Percentage distribution of aerobic plate count (APC) by locations in home kitchens

APC (log CFU)/Sample Locations (N)	< 1.0 %	1.0–2.9 %	3.0–4.9 %	5.0–6.9 %	> 7.0 %
Sink Bottom (150)	0	0	22.0	60.7	17.3
Faucet Handle (150)	0	0	18.0	62.0	20.0
Countertop (150)	0	6.7	50.7	42.6	0
Refrigerator Handle (150)	0	0	48.0	46.7	5.3
Refrigerator Meat Drawer (147)	2.0	15.6	50.4	32.0	0
Sponge (32)	3.1	0	6.2	18.8	71.9
Dish Pad (19)	21.0	5.3	10.5	15.8	47.4
Dishcloth (49)	2.1	0	6.1	24.5	67.3

TABLE 4. Percentage distribution of *Enterobacteriaceae* count (EBC) by locations in home kitchens

EBC (log CFU)/Sample Locations (N)	< 1.0 %	1.0–2.9 %	3.0–4.9 %	5.0–6.9 %	> 7.0 %
Sink Bottom (150)	16.7	5.3	38.0	36.0	4.0
Faucet Handle (150)	20.7	5.3	42.7	28.0	3.3
Countertop (150)	37.4	20.0	27.3	15.3	0
Refrigerator Handle (150)	56.7	10.0	25.3	7.3	0.7
Refrigerator Meat Drawer (147)	48.3	25.9	17.0	8.8	0
Sponge (32)	21.9	3.1	9.4	12.5	53.1
Dish Pad (19)	42.1	5.3	5.3	26.3	21.0
Dishcloth (49)	10.2	0	8.1	22.5	59.2

tested using an independent sample *t* test or General Linear Model. Significance thresholds for all tests were set at $P = 0.05$.

RESULTS

Kitchen cleaning practices

A total of 150 participants completed the in-home survey. The demographic data of the respondents are summarized in Table 1. The majority of the respondents were female (76%) and African American (74%) and had a household income of less than $35,000. Participants were asked about the frequencies and methods of cleaning kitchen countertops, sinks and refrigerators, as well as the tools used for cleaning. The survey questions and responses are summarized in Table 2.

Most of the respondents (72%) indicated that they cleaned the kitchen countertop at least once a day. A dishcloth was the item most often used for cleaning the countertop, followed by paper towels, sponges and dish pads. Only a small proportion of the respondents indicated washing the dishcloths (29%) and sponges (45%) after each use, and most just rinsed these items with hot water. About half (56%) of the respondents indicated cleaning faucet handles at least once a day, and most of the respondents (88%) incorporated sanitizing agents such as bleach, anti-bacterial cleaners or powder cleaners in their cleaning schemes.

One-fourth of the respondents reported that they had cut up raw poultry on the countertop at some time. Most of them (79%) said they always washed the

TABLE 5. Percentage distribution of *Staphylococcus aureus* count (SAC) by locations in home ktchens

Locations (N)	SAC (log CFU)/Sample < 1.0 %	1.0–2.9 %	3.0–4.9 %	> 5.0 %
Sink Bottom (85)	41.7	18.7	38.4	1.2
Faucet Handle (85)	35.3	22.4	37.6	4.7
Countertop (86)	27.9	52.3	19.8	0
Refrigerator Handle (85)	38.8	23.5	37.7	0
Refrigerator Meat Drawer (83)	44.6	39.8	15.6	0
Sponge (17)	35.3	5.9	47	11.8
Dish Pad (18)	44.5	22.2	33.3	0
Dishcloth (27)	22.2	7.4	55.6	14.8

countertop with warm soapy water after cutting up the poultry. About one-half (55%) of the respondents sanitized the countertop after washing. Similarly, most of the respondents (85%) always washed the kitchen sink with warm, soapy water and sanitized the sinks after washing poultry in it. Most of the respondents (85%) regularly discarded outdated or old foods from the refrigerators. Refrigerator handles were cleaned less often than other surfaces in the kitchen. While most of the respondents (83%) think they are doing all they can to keep food safe at home, about half (52%) of the respondents worried about the safety of the food they eat at home.

Microbial contamination levels in kitchens

A total of 747 samples of kitchen surfaces and 100 samples of kitchen cleaning tools were analyzed. The Aerobic Plate Count (APC), *Enterobacteriaceae* Count (EBC), and *Staphylococcus aureus* Count (SAC) of various samples are presented in Tables 3, 4, and 5, respectively.

Sink bottoms and faucet handles were more contaminated than countertops, refrigerator handles and meat drawers. Average APC and EBC were significantly higher ($P < 0.05$) on sink and faucet handles than on countertops, refrigerator handles, and meat drawers. The average APC and EBC of sink bottoms were 5.9 and 4.1 log CFU/sample, respectively, and the average APC and EBC of faucet handles were 6.0 and 3.8 log CFU/sample. Many homes had APC of more than 7.0 log CFU/sample on the sink bottoms (17%) and faucet handles (20%), as shown in Table 3, and similar levels of EBC were found on the sink bottoms (4%) and faucet handles (3%), as shown in Table 4.

The average APC and EBC of refrigerator handles were lower than those of the countertops ($P < 0.05$) and were similar to those of meat drawers. However, the refrigerator handles of few homes had more than 7.0 log CFU/sample of APC (5% of homes) and EBC (1% of homes). Similar results were observed with SAC; sink bottoms and faucet handles were the most contaminated sites of all kitchen sites assessed (Table 5). The average SAC for sink bottoms and faucet handles were 2.0 and 2.4 log CFU/sample, respectively. The average SAC of faucet handles was significantly higher ($P < 0.05$) than those of countertops and meat drawers, and the average SAC of sink bottoms was significantly higher ($P < 0.05$) than that of countertops.

Tools used for cleaning kitchen surfaces (dishcloths, sponges and dish pads) were more contaminated ($P < 0.05$) than the kitchen surfaces they were used to clean. The average APC for dishcloths and sponges were both at 6.9 log CFU/sample, which was significantly higher ($P < 0.05$) than that of the dish pads (5.1 log CFU/sample). The average EBC for dishcloths and sponges were 6.2 and 5.4 log CFU/sample, respectively, significantly higher ($P < 0.05$) than that of dish pads (3.8 log CFU/sample). About 72% of the sponges and 67% of the dishcloths had APC higher than 7 log CFU/sample, and about 53% and 59% of these items had similar levels of EBC (Tables 3 and 4). The average SAC also suggested that dishcloths and sponges were more contaminated than dish pads (Table 5).

Relationship between cleaning practices and microbial contamination

The APC, EBC, and SAC from the kitchen samples were compared to the reported cleaning practices. No difference in APC or EBC was associated with the frequencies of cleaning countertops. However, samples from kitchens of respondents who cleaned the countertops only once or several times a week had significantly lower SAC ($P < 0.05$) than those of respondents who did so more often (several times a day) as well as those who did so occasionally (once or a few times a month).

There was no relationship between cleaning frequencies and APC or EBC of dishcloths and sponges. Although not significantly different, dishcloths of respondents who used washing machines and bleach for cleaning dishcloths showed consistently lower APC, EBC and SAC.

There was no significant difference of APC, EBC or SAC of kitchen sinks between respondents who reported using sanitizing agents (bleach, anti-bacterial cleaner and powder cleaners) to clean kitchen sinks and those who did not. Refrigerator handles of respondents who never or seldom cleaned refrigerator handles had lower APC and EBC than those of respondents who did clean them regularly ($P < 0.05$). A reverse trend was observed for SAC; samples from respondents who never or less often cleaned refrigerator handles had higher SAC than those from respondents who cleaned regularly, although for the respondents who cleaned routinely, the difference was not statistically significant. The faucet handles of respondents who cleaned these routinely had significantly lower APC, EBC and SAC ($P < 0.05$) than those of respondents who only cleaned "whenever it looks dirty."

Countertops of respondents who never handle raw poultry on their countertops (75%) had significantly lower APC ($P < 0.05$) than those of respondents who did (25%). Similar results were observed for EBC and SAC, although they were not statistically significant. There was no difference in APC, EBC, and SAC of countertops between people who always and sometimes/never sanitized the countertops after handling raw poultry. Similarly, there was no difference in APC, EBC and SAC of sinks between people who always and sometimes/never sanitized the sink area after handling raw poultry.

Respondents who worried about the safety of the foods they eat at home had significantly lower EBC on sink bottoms and lower SAC on faucet handles ($P < 0.05$). In addition, consistently lower averages of APC and EBC were observed in this group at all other kitchen locations, although these differences were not statistically significant. Respondents who think they were doing all they can to keep their food safe at home had meat drawers with significantly higher APC and faucet handles with higher SAC ($P < 0.05$). Consistently, higher averages of APC, EBC and SAC were observed in samples from this group at all other kitchen locations, although these differences were not statistically significant.

Samples obtained from kitchens of elderly respondents (age 70+) had consistently higher SAC at all kitchen locations, with samples from sink bottoms, faucet handles, countertops, and meat drawers being significantly higher ($P < 0.05$) than samples from kitchens of the younger groups. The highest income group (> $75,000) was consistently associated with higher EBC at all kitchen locations, with countertops and meat drawers being significantly ($P < 0.05$) more contaminated than those of other income groups. The reverse trend was observed for SAC. The lowest income group (< $15,000) was consistently associated with higher SAC at all kitchen locations, with countertops and refrigerator handles being significantly ($P < 0.05$) more contamined than those of other income groups. There was no relationship between bacterial counts on kitchen surfaces and the number of people in the household or the presence of a pet in the home.

DISCUSSION

The demographic data in this study reflects the population of middle to low income residents in Nashville, Tennessee. It is our intention to develop an effective food safety education program for this target group. It has been reported that kitchen sinks and faucet handles were among the most contaminated in consumers' homes *(16)*. Over more than a decade, the situation has not changed as a recent report *(17)* and our study both indicated. These results highlight the need to improve consumers' cleaning practices at home.

As indicated in the results, respondents who reported regularly cleaning their kitchen had kitchens with less microbial contamination. However, frequency of cleaning was not a reliable predictor for cleanliness of kitchen surfaces, as most respondents who reported very frequent cleaning did not have cleaner kitchens, judging from bacterial populations recovered from these surfaces. This indicates that, in addition to cleaning frequencies, cleaning tools and methods are critical for effective cleaning, and consumers need to learn correct cleaning procedures. Infrequent or improper use of antimicrobial agents is unlikely to reduce the levels of bacterial contaminants *(8)*.

Raw poultry, as well as raw meats, raw eggs and produce, has been identified as a source of contamination of kitchen surfaces *(5, 15)*. Our results showed that respondents who never handle raw poultry on their countertops had cleaner countertops. Respondents who always sanitized the surfaces after handing raw poultry did not have cleaner surfaces. This could be an indication of ineffective sanitizing practices. The importance of effective procedures to sanitize kitchens surfaces, utensils and hands after handling raw meats and poultry has been emphasized by researchers in previous studies *(5, 13, 15, 16)*.

Our survey results indicate that kitchen cleaning tools (sponges and dishcloths) are heavily contaminated, which is consistent with several published reports *(3, 6, 10, 17)*. Consumers need to be educated about cleaning these kitchen tools and replacing them more frequently. Our results have shown that cleaning with bleach and a washing machine is more effective than just rinsing with hot water, and a dedicated dishcloth often cleans better. In other studies, researchers have recommended microwaving or dishwashing as a fast and effective method of disinfecting kitchen sponges *(18)*.

Respondents who are conscious about food safety were more likely than others to have clean kitchens. In contrast, respondents who think they have done all they can to keep food safe were less likely than others to have clean kitchens. Awareness seems to have an active role in consumers' food safety and cleaning practices. In addition, socioeconomic status may have a crucial impact on consumers' cleaning patterns. The elderly are generally regarded as a high-risk group for foodborne illnesses because of their weakened immune system. Limited mobility could also be a risk factor. As their mobility deteriorates, so may the cleanliness of their kitchen environment worsen; therefore, the elderly may need special assistance in cleaning their kitchens.

Several practices and socioeconomic characteristics have been identified, that may account for the high microbiological contamination of home kitchens. In addition, consumers' consciousness of food safety tends to lead to a clean kitchen environment. It is possible that being overconfident and having a busy lifestyle may decrease awareness of the importance of cleanliness of kitchens. Consumers need

to learn effective cleaning methods and to be reminded of the importance of a routine cleaning schedule. It is crucial that educational and outreach programs direct efforts toward improving the effectiveness of microbiological control measures in home kitchens.

ACKNOWLEDGMENTS

This research project was financially supported by a grant from USDA-CSREES (TENX-2005-03675). The authors thank Fisseha Tegegne and Richard Stone for reviewing the manuscript and the following individuals for their participation in this project: Lou Pearson, Associate Investigator; Bhargavi Sheshachala, Research Assistant; Cindy Thompson, Research Assistant; Natalie Nelson, Research Associate; Emily Rotich, Graduate Assistant; and Candice Smith, Undergraduate Assistant.

REFERENCES

1. Barker, J., M. Naeeni, and S. F. Bloomfield. 2003. The effects of cleaning and disinfection in reducing *Salmonella* contamination in a laboratory model kitchen. *J. Appl. Microbiol.* 95:1351–1360.
2. Cogan, T. A., S. F. Bloomfield, and T. J. Humphrey. 1999. The effectiveness of hygiene procedures for prevention of cross-contamination from chicken carcasses in the domestic kitchen. *Lett. Appl. Microbiol.* 29:354–358.
3. Cogan, T. A., J. Slader, S. F. Bloomfied, and T. J. Humphrey. 2002. Achieving hygiene in the domestic kitchen: the effectiveness of commonly used cleaning procedures. *J. Appl. Microbiol.* 92:885–892.
4. de Jong, A. E., L. Verhoeff-Bakkenes, M. J. Nauta, and R. de Jonge. 2008. Cross-contamination in the kitchen: effect of hygiene measures. *J. Appl. Microbiol.* 105:615–624.
5. Gorman, R., S. Bloomfield, and C.C. Adley. 2002. A study of cross-contamination of foodborne pathogens in the domestic kitchen in the Republic of Ireland. *Int. J. Food Microbiol.* 76:143–150.
6. Hilton, A. C., and E. Austin. 2000. The kitchen dishcloth as a source of and vehicle for foodborne pathogens in a domestic setting. *Int. J. Environ. Health Res.* 10:257–261.
7. Jay, L., D. Comar, and L. D. Govenlock. 1999. A video study of Australian domestic food-handling practices. *J. Food Prot.* 62:1285–1296.
8. Josephson, K. L., J. R. Rubino, and I. L. Pepper. 1997. Characterization and quantification of bacterial pathogens and indicator organisms in household kitchens with and without the use of a disinfectant cleaner. *J. Appl. Microbiol.* 83:737–750.
9. Kagan, L. J., A. E. Aiello, and E. Larson. 2002. The role of the home environment in the transmission of infectious diseases. *J. Community Health*, 27:247–267.
10. Kennedy, J., V. Jackson, I. S. Blair, D. A. McDowell, C. Cowan, and D. J. Bolton. 2005. Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *J. Food Prot.* 68:1421–1430.
11. Kohl, K. S., K. Rietberg, S. Wilson, and T. A. Farley. 2002. Relationship between home food-handling practices and sporadic salmonellosis in adults in Louisiana, United States. *Epidemiol. Infect.* 129:267–276.
12. Lagendijk, E., A. Asséré, E. Derens, and B. Carpentier. 2008. Domestic refrigeration practices with emphasis on hygiene: analysis of a survey and consumer recommendations. *J. Food Prot.* 71:1898–1904.
13. Mattick, K., K. Durhman, G. Dominigue, F. Jorgensen, M. Sen, D. W. Schaffner, and T. Humphrey. 2003. The survival of foodborne pathogens during domestic washing up and subsequent transfer onto washing-up sponges, kitchen surfaces, and food. *Int. J. Food Microbiol.* 85:213–226.
14. Mead, P. S., L. Slutsker, V. Dietz, L. F. McCaig, J. S. Bresee, C. Shapiro, P. M. Griffin, and R. V. Tauxe. 1999. Food-related illness and death in the United States. *Emerg. Infect. Dis.* 5:607-625.
15. Parry, S. M., S. R. Palmer, J. Slader, and T. Humphrey. 2002. Risk factors for *Salmonella* food poisoning in the domestic kitchen—a case control study. *Epidemiol. Infect.* 129:277–285.
16. Scott, E. 1996. Foodborne diseases and other hygiene issues in the home. *J. Appl. Bacteriol.* 80:5–9.
17. Scott, E., S. Duty, and K. McCue. 2009. A critical evaluation of methicillin-resistant *Staphylococcus aureus* and other bacteria of medical interest on commonly touched household surfaces in relation to household demographics. *Am. J. Infect. Control.* 37:447–453.
18. Sharma, M., J. Eastridge, and C. Mudd. 2009. Effective household disinfection methods of kitchen sponges. *Food Control.* 20:310–313.
19. Wenrich, T., K. Cason, N. Lv, and C. Kassab. 2003. Food safety knowledge and practices of low income adults in Pennsylvania. *Food Prot. Trends*, 23:326–335.