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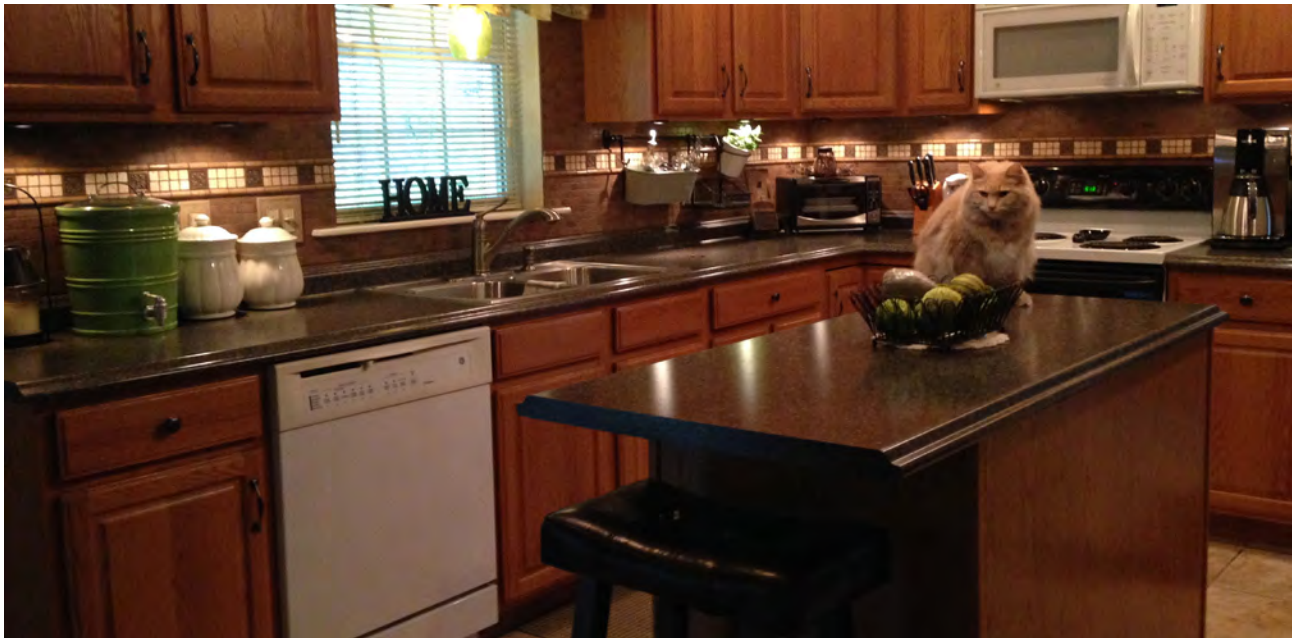

Visual Audit of Food Safety Hazards Present in Homes in an Urban Environment

ABSTRACT

Research utilizing both survey and observational techniques has found that consumers do not accurately report their own food handling behaviors. The goal of this study was to objectively observe conditions related to food safety risks and sanitation in domestic kitchens in an urban environment. Subjects (n = 100) were recruited from Philadelphia, PA. Homes were visited over a one-year period by two trained researchers using a previously developed audit tool to document conditions related to sanitation, refrigeration, and food storage. Potential food safety risks identified included evidence of pest infestation (65%), perishable food stored at room temperature (16%), storage of raw meat above ready-to-eat foods (97% of homes where raw meat was present), and a lack of hot running water in the kitchen (3%). Compliance with correct refrigeration practices was also low, with 43% of refrigerator temperatures ≥ 41°F, and only 4% of refrigerators containing a thermometer. Consumers of minority race/ethnicity were more likely to have evidence of pest infestation in the home, lack a dishwasher and lack a cutting board in the kitchen, while Caucasian consumers were more likely to have an animal present in the kitchen during the audit visit.

INTRODUCTION

Consumer food-handling behavior in the home is considered the final defense against foodborne illness *(9, 35)*. The total number of infections caused by food prepared in the domestic environment is not known; however, evidence supports the assertion that consumers play a critical role in the prevention of foodborne illness. Data from the Centers for Disease Control (CDC) report private homes as the second most common location associated with outbreaks of foodborne illness *(22)*. Pathogens may be introduced to the domestic environment via naturally contaminated raw foods, transfer from the environment (carried by animals or insects), or transfer from another person (fecal-oral contamination and aerosolization). The presence of microbial contamination in consumer homes has been well documented, emphasizing the need for safe food handling practices *(18, 25, 37, 40)*.

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A variety of methods have been used to evaluate characteristics of the home and behaviors of consumers in the home that may be relevant to food safety hazards. The majority of studies utilize surveys to collect self-reported data on consumer perceptions, knowledge, and behavior *(16)*. Although this method is the most common form of evaluation, the results may lack accuracy and reliability *(15)*. Comparison of self-reported and observed behaviors within a group of subjects often indicates poor agreement between results obtained by the two methods *(14, 24)*.

Direct observation is widely considered the more accurate method to evaluate behavior and has been used frequently to assess consumer food handling skills *(5, 6, 12, 17)*. Although possibly more accurate, observational studies have several drawbacks. Because any type of observation has the potential to alter a subject's behavior, the research design must ensure that the participant performs his or her "usual" behavior, as opposed to a perceived "correct" behavior *(19)*. This phenomenon, known as the Hawthorne Effect, has been well documented *(26)*. It is also difficult to observe intricate, multi-step behaviors, such as meal preparation, in a systematic and objective way *(51)*. Although the same basic method may be used, small differences in design (such as type of meal prepared, use of a model kitchen vs. an actual home, and objectivity of the observer) add to the complexity of these studies, making it difficult to compare results between studies and form overall conclusions about consumer food handling behavior.

There is a need for better understanding of what is really going on in consumers' homes that may increase the risk of foodborne illness. A visual assessment using an audit tool has the ability to objectively and systematically document the presence of potential food safety hazards in consumer homes.

Although ubiquitously used to evaluate the safety of foodservice facilities *(23, 47, 49)*, audit instruments have been utilized much less often in consumer food safety research. While some studies have used rating techniques such as a 1–5 Likert scale to evaluate cleanliness of surfaces and have described the studies as "audits," actual audits are more complex and involve systematic observation and measurement of specific, pre-determined characteristics that are necessary for the desired outcomes (in this case, safe food handling in the home) *(34)*. This type of visual inspection is especially useful in studying consumer households because, unlike survey questionnaires and behavior observation, it allows the recording of the presence of conditions that are physically tangible and clearly evident without room for interpretation. While a visual audit may represent an ideal method to evaluate consumer homes, to date only a few studies have used this methodology *(4, 7, 10, 30)*.

One instrument developed for such studies was utilized by Byrd-Bredbenner et al. to evaluate food safety risks in the homes of young adults *(7)*. Results from these observations were combined and presented as total composite scores for each section of the audit tool. This method therefore gives the reader a general idea of food safety risks present in the homes evaluated but does not describe the prevalence of specific hazards. Another instrument, developed by Larson et al., focused on one specific behavior (cleaning/sanitation), and therefore cannot be used to describe a wide range of potential food safety hazards *(30)*. An audit tool described by Daniels et al., may be useful for describing a wide range of conditions; however, the study was published by an international auditing company whose materials are not available to the public *(10)*. Also, no data are available regarding the reliability and validity of this tool, a crucial aspect of a measurement instrument.

Research has resulted in development of an audit tool that has been pilot tested for reliability and functionality *(3, 4)*. The tool, based on the FDA's Food Code and restaurant inspection reports, contains 34 items related to four areas of the home: general kitchen, kitchen sink, refrigerator/freezer, and bathroom *(3)*. A set of guidelines is provided with the tool to describe how auditors should evaluate certain criteria, such as what conditions are necessary to consider a food preparation area clean or dirty *(3)*. The tool is used to record observations related to potential food safety hazards in the domestic environment in an objective and standardized manner. Following development, the audit tool was pilot-tested in 22 homes, modified to improve functionality and reliability, and reduced in length before the final version was published *(4)*. The purpose of the research reported here was to utilize this previously developed tool to detect potential unsafe food handling conditions present in the homes of 100 consumers in an urban setting.

MATERIALS & METHODS

All materials and methods used in this study were approved by Drexel University's Institutional Review Board (IRB). Informed consent was obtained from all participants before participation.

Sample size

This study was part of a larger research project that included collection and analysis of microbiological samples from consumer homes in addition to the visual inspection described here. The study spanned 12 months, during which homes were visited at a relatively constant pace. Because of the seasonality of pathogens associated with foodborne illness *(32)*, eight or nine homes were visited each month. The goal for enrollment was set at 100 homes.

Recruitment and eligibility

A representative sample of residents from Philadelphia, PA was recruited to participate in a study to describe characteristics of domestic kitchens in an urban community. Targeted sampling techniques were used to characterize a

target population, utilizing pre-existing information and ethnographic data to form a clear depiction of the group *(27)*. The most recent census data available for race/ethnicity and household income in Philadelphia County served as a goal for the sample population *(44)*. Based on these census data, an enrollment plan with quotas for racial/ethnic and income characteristics was developed.

Census data were used to identify sections of Philadelphia that either had high representation of a single characteristic (i.e., 90% of the population is Asian) or that closely represented the demographics of Philadelphia county as a whole. Racial/ethnic and income characteristics of participants were monitored throughout the study, and recruitment locations were updated as necessary to meet the quota objectives. Flyers were posted in a total of 34 locations throughout Philadelphia (local businesses, supermarkets, libraries, and community centers). Word of mouth from participants also represented a significant source of advertisement for this study and supplemented these recruitment efforts.

The advertisement poster included a brief description of the eligibility criteria, time commitment, compensation ($50 cash) offered for participating in the study, and instructions for volunteers to contact the researcher if they were interested in participating. Potential subjects who contacted the researcher were told that the purpose of the study was to observe food preparation and storage habits in consumer homes and were discouraged from preparing food or cleaning their homes differently from the way they usually did. Volunteers who were still interested were then screened for eligibility based on the following criteria: 18 years of age or older; lives in Philadelphia county; prepares food at home at least three times per week; and is willing to allow researchers to visit the volunteer's home and collect data. Eligible participants were enrolled in the study and were asked to schedule an appointment for their home visit at this time. Phone calls were made to participants several days before their scheduled visit to remind them about their appointment.

For consistency, significant effort was made to restrict appointments to Mondays, between the hours of 8 a.m. and 8 p.m. The study was advertised and took place over 12 months, from January to December 2013. During this time, a total of 151 individuals initiated contact with researchers about this study. Of these, seven (5%) refused to participate after the study was explained to them, nine (6%) did not meet established eligibility requirements and were excluded, four (3%) were interested and eligible but could not participate because of scheduling conflicts, and 31 (21%) could not be reached by phone to discuss the study. A total of 100 subjects were enrolled and completed the study, which accomplished the pre-determined goal for sample size.

Audit tool and home visits

A previously developed and pilot-tested domestic food safety audit tool was utilized in this research *(4)*. The published instrument contained 34 items (21 main questions and 13 sub-questions) pertaining to four areas of the home: general kitchen, kitchen sink, refrigerator/freezer, and bathroom *(3)*. Most items on the audit tool were closed-ended questions containing only two or three response options. Some open-ended questions were also included to provide additional description when necessary. A section for comments in which researchers were encouraged to clarify their responses and/or record other observations relevant to domestic food safety followed each group of questions.

In addition to documenting unsafe food handling conditions in consumer homes, a second objective of this study was to evaluate the inter-rater reliability of the published audit tool. For this reason, consistency and uniformity were emphasized during the training of raters to conduct the visual assessment. At the beginning of this study a training session was held to discuss and review each aspect of the audit tool, as well as the accompanying guidelines. The audit tool guidelines provided supplementary information to clarify certain terms used throughout the tool, for the purpose of improving consistency between raters *(3)*. Informal training sessions were held periodically throughout the duration of the study to review the guidelines and protocol for using the audit tool.

The same two researchers completed all data collection, using the audit tool to independently record observations in each home. The researchers did not discuss their observations and consulted the audit tool guidelines only to determine how to evaluate the conditions present. The visual inspection took approximately 15 minutes to complete. Following data collection, each participant was compensated $50 for his or her time. Subjects also received a packet of food safety material containing an individualized list of recommendations to improve the safety of their kitchens.

Data management and analysis

Responses to audit tool questions were numerically coded and entered into an Excel spreadsheet. The kappa statistic was calculated to evaluate inter-rater reliability of closed-ended audit tool questions, as described in the pilot study *(4)*. The minimum acceptable level of agreement between raters was set at kappa = 0.5, which provides adequate significance and power ($\alpha = 0.05$, $\beta = 0.20$) for a study this size *(50)*. Comparisons between demographics and observations were evaluated using independent *t*-tests, cross-tabulations, and Pearson's Chi-Square tests. All values were calculated using the Statistical Package for the Social Sciences (SPSS), release 20.0.0, for Windows 7 Home Premium (IBM SPSS Statistics 20, IBM Corporation).

Because both raters completed the visual assessment in all homes, each audit tool criterion was observed 200 individual times. A compositional data model was used to combine individual results into a valid, group-level construct *(48)*. For the sufficiently reliable questions, necessary and exact conditions were defined to specify how to summarize group characteristics *(48)*. For example, if only one rater identified pest infestation in a home, that condition was still considered present in the home. In this example, disagreement is more likely caused by a difference in observation (one rater sees a mouse, the other does not) than by a difference in judgment (one rater thinks mice are pests, the other does not). The prevalence of conditions that are more subjective and/or had high levels of disagreement between raters are considered positive only if both raters agreed. This method was chosen as a conservative estimate of the actual observations.

RESULTS

Participant demographics

A total of 100 subjects from 71 census tracts in Philadelphia, PA completed this study. Participants were mostly female (86%) and represented a wide variety of ages, education levels, economic statuses, and racial/ethnic backgrounds *(Table 1)*. Subjects varied in age from 18 to 84 years old, with the highest proportion (29%) in the 45–54 range. The most commonly reported annual income was below $15,000 (25%), and African American was the most common race/ethnicity (47%). Chi-Square goodness-of-fit tests show no significant differences between the sample and population (Philadelphia, PA) patterns for race/ethnicity ($P = 0.18$). The sample pattern for household income level was significantly different from the population pattern, because of a greater representation of low-income subjects ($P = 0.004$).

Education level was almost evenly split between participants who had completed college (41%) and participants who had completed up to high school/GED (43%). When asked what language was used at home, 8% of subjects reported speaking a language other than English at home at least half of the time. The majority (60%) of participants had experience working in the food service or food industry, from either previous or current employment.

Inter-reater reliability of audit tool

The kappa scores for inter-rater reliability of 27 audit tool questions ranged from 0.219 to 1.000 (fair to near-perfect reliability), and the majority (80%) of questions were considered substantially reliable by common standards (kappa ≥ 0.6) *(42)*. Only four questions scored below the pre-determined goal for moderate reliability (kappa = 0.5).

As expected, questions that required raters to evaluate the cleanliness or condition of food preparation surfaces were the most unreliable *(Table 2)*. These questions are the least objective items on the audit tool and require subjective input from the rater; therefore, the level of agreement is determined by the degree of similarity between the raters' interpretations of the construct. Questions regarding the cleanliness of kitchen sinks, refrigerator exteriors, and counter tops scored below the acceptable level of agreement, while questions regarding the cleanliness of refrigerator interiors and sponges/dishcloths scored almost as low (kappa 0.5 – 0.6).

Lack of resources for proper cleaning

Results from the visual assessment were used to evaluate the participant's compliance with recommended food safety guidelines *(Table 3)*. This method was able to document conditions related to many types of food handling behavior, including a lack of cleaning/ sanitizing tools, failure to separate raw and ready-to-eat (RTE) foods, and improper cooling/storage of perishable foods. The majority (96–98%) of homes had access to soap and hot water in the kitchen at the time of the audit. These items are necessary to wash hands, kitchen utensils, and food preparation surfaces correctly. A larger proportion of homes lacked cleaning materials (12%) or paper towels in the kitchen (29%) or hand towels in the bathroom (15%). The specific type of hand drying material present was recorded to determine differences between paper towels and hand towels. Most homes (61%) had both paper and hand towels present, 9% had neither, an additional 10% had only paper towels, and 20% had only hand towels. These items, which are related to the effectiveness of cleaning and hand washing, and may prevent the survival and/or transfer of microbial contamination.

Cleanliness of surfaces and items in the kitchen

The cleanliness of several food contact surfaces was documented, including kitchen sinks, sponges/dishcloths and refrigerator interiors. These items were considered clean only if both raters agreed in their evaluation of the item. Of these surfaces, kitchen sinks were reported unclean most often (82% of homes), while counter tops were least likely to be identified as unclean (46%). Two additional criteria were indirectly related to the cleanliness and sanitation of surfaces: the presence of animals in the kitchen and evidence of pest infestation. An animal was present in the kitchen or dining area during 27% of inspections, while pet toys, food bowls, and accessories were present in an additional 18% of kitchen/dining areas. Pest infestation was defined as the presence of any of the following: insects or rodents (besides pets), either living or dead; material created by pests (droppings, nests, webs); items used to eliminate or repel pests (mouse/insect traps, poison treatments). Evidence of pest infestation was observed in 65% of homes, including the presence of insects (n = 27, 42%), insect repellent, poison, or traps (n = 35, 54%),

Table 1. Demographics of sample population

	(n = 100)
Race/Ethnicity	
African American	47%
Caucasian (Non-Hispanic)	39%
Hispanic, Latino or Spanish	12%
Other	2%
Total Household Income*	
Below $15,000	27%
$15,000 – $24,999	21%
$25,000 – $49,999	19%
$50,000 – $74,999	23%
$75,000 and above	10%
Age Range	
18–24	10%
25–34	18%
35–44	19%
45–54	29%
55–64	19%
65 and above	5%
Highest Level of School Completed	
Primary, or less	5%
High School/GED	43%
Technical/Vocational Degree	2%
College Graduate (4 years)	41%
Advanced Degree: MD, PhD, etc.	9%

*Household income was calculated as a percent of 91 responses, rather than 100.
Nine participants did not respond to the question.

mouse droppings (n = 6, 9%), and mouse poison/traps (n = 9, 14%). Ants were the pests found most often in consumer homes, but cockroaches, fleas, flies, beetles, mosquitos, and spiders were also observed. The presence of either pets or pests in food preparation areas may increase the likelihood of fecal-oral contamination as well as transfer pathogens from the outside environment into the home.

Improper packaging and storage of foods in the home

To prevent the spread of pathogens found on raw meat, fish and poultry, these foods must be separated from ready-to-eat (RTE) items. Secure packaging for both raw and RTE foods is recommended to prevent transfer of contamination from contact with exposed surfaces. RTE foods were packaged incorrectly in 57% of consumer refrigerators. Contact with

Table 2. Reliability between raters (kappa scores) of individual audit tool questions

Question	Kappa
Do food contact surfaces of kitchen sink appear clean?	0.219
Do food contact surfaces of refrigerator exterior appear clean?	0.299
Do food contact surfaces of counter tops appear clean?	0.450
Does refrigerator have a visible and accurate thermometer?	0.487
Do sponges/dishcloths appear clean?	0.516
Do food contact surfaces of refrigerator interior appear clean?	0.566
Are RTE foods packaged to avoid cross-contamination?	0.641
Are sanitizing and/or disinfecting cleaners available?	0.651
Is there evidence of pest infestation?	0.675
Are raw meat/fish/poultry within the use-by dates?	0.688
Are cutting boards worn with deep grooves or cracks in the surface?	0.720
Is soap available near the kitchen sink?	0.795
Is either one-use paper towels or a designated hand towel available near the kitchen sink?	0.796
Do cutting boards appear clean?	0.825
Are raw meat/fish/poultry stored in leak-proof containers?	0.834
Are raw meat/fish/poultry stored below ready-to-eat foods?	0.845
Are cutting boards present?	0.860
Are animals present in areas where food preparation/consumption occurs?	0.882
Are dishes, kitchenware or utensils present in kitchen sink?	0.913
Is any perishable food stored outside of the refrigerator?	0.924
Are raw meat/fish/poultry present in the refrigerator?	0.931
Is either one-use paper towels or a designated hand towel available near the bathroom sink?	0.964
Does the kitchen have a working dishwasher?	0.978
Is soap available near the bathroom sink?	0.981
Are sponges/dishcloths present near kitchen sink?	1.000
Are both hot and cold water available?	1.000
Is refrigerator temp. within recommended range (≤ 40°F)?	1.000

exposed surfaces ranged from minor tears in packaging to direct placement of RTE food on refrigerator shelves. Raw meat/fish/poultry were packaged incorrectly in 55% of homes where raw meat was present, and also ranged in severity of exposure, including storage only in a plastic grocery bag, with no other packaging. Because even correct, secure packaging is vulnerable to rips and tears, raw meat should be stored below RTE foods in the refrigerator. This behavior was the most frequently observed violation, present in 97% of homes with raw meat. Leaking juice from packaged raw meat was observed in two refrigerators, emphasizing the need for correct storage of these items.

Correct storage time and temperature may decrease the rate of growth of pathogens in food and inhibit survival of pathogens on food contact surfaces. Raw meat products were examined to determine if the item was within the recommended use-by date. When present, raw meat was within the use-by date in 42% of homes, while 27% of meats had been kept past the appropriate date and 30% had no date label at all. Although not included as an audit tool question,

Table 3. Food safety hazards and conditions observed in consumer homes

Food Safety Risk	% Homes (n = 100)
No soap available at bathroom sink	2*
No hot water in home	3
No soap available at kitchen sink	4
Lack of towels (paper or cloth) in kitchen	9
Sanitizing and/or disinfecting cleaners not available	12
Lack of paper/hand towels in bathroom	15*
Perishable food stored outside of the refrigerator	16
Cutting boards appear dirty	23*
Animal(s) present in food preparation/consumption area	27
Raw meat/fish/poultry past use-by date	27*
Lack of paper towels in kitchen	29
Raw meat/fish/poultry present in home	33
Refrigerator temperature above 41°F	43
Lack of cutting boards in kitchen	49
Raw meat/fish/poultry packaged incorrectly	55*
Ready-to-eat (RTE) foods packaged incorrectly	57
Evidence of pest infestation	65
Dishes, kitchenware and/or utensils present in kitchen sink	66
Cutting boards are worn with deep grooves/cracks in the surface	76*
Raw meat/fish/poultry stored above RTE foods	97*

*-Frequency calculated as a percentage of the number of homes with the necessary condition (raw meat present in 33 homes, cutting boards present in 50 homes, only bathroom located on same floor as kitchen in 48 homes. Kitchen dishcloths/sponges were evaluated in 96 homes).

the presence of high risk Ready-to-Eat (RTE) foods kept past the use-by date was also recorded, and present in three homes (expired items included unpasteurized cheese, freshly sliced lunch meat, and seafood salad). Raw meat/poultry and Ready-to-Eat foods were stored at room temperature in 16% of homes. RTE foods, including leftovers and pre-cut fruit, were observed to be stored at room temperature in 11 homes, and raw meat or poultry was observed to be stored at room temperature in six homes (one home had both raw and RTE foods present at room temperature).

Another common problem observed in consumer homes was incorrect refrigeration practices. Among the 100 homes assessed in this study, temperatures ranged from below freezing (26°F) to very warm (54°F) *(Fig. 1)*. Almost half (43%) of homes had a refrigerator that was too warm (≥ 41°F). Thirteen homes (13%) had refrigerator temperatures above 45°F.

Differences in consumer behavior associated with demographics

Demographic characteristics of participants were compared to observation data to determine if particular groups were more likely to practice unsafe food handling behavior. Participants were grouped according to race/ethnicity, income level, gender, age, education level, and language spoken at home to determine if differences in food handling behaviors were associated with these characteristics *(Table 4)*.

Several statistically significant differences emerged when food-handling behavior of Caucasian participants were compared with those who identified as part of a minority racial/ethnic group (African American, Hispanic/Latino, and Asian). Overall analyses indicated safe food-handling violations were observed more frequently in homes of non-Caucasian participants, with the exception of animal

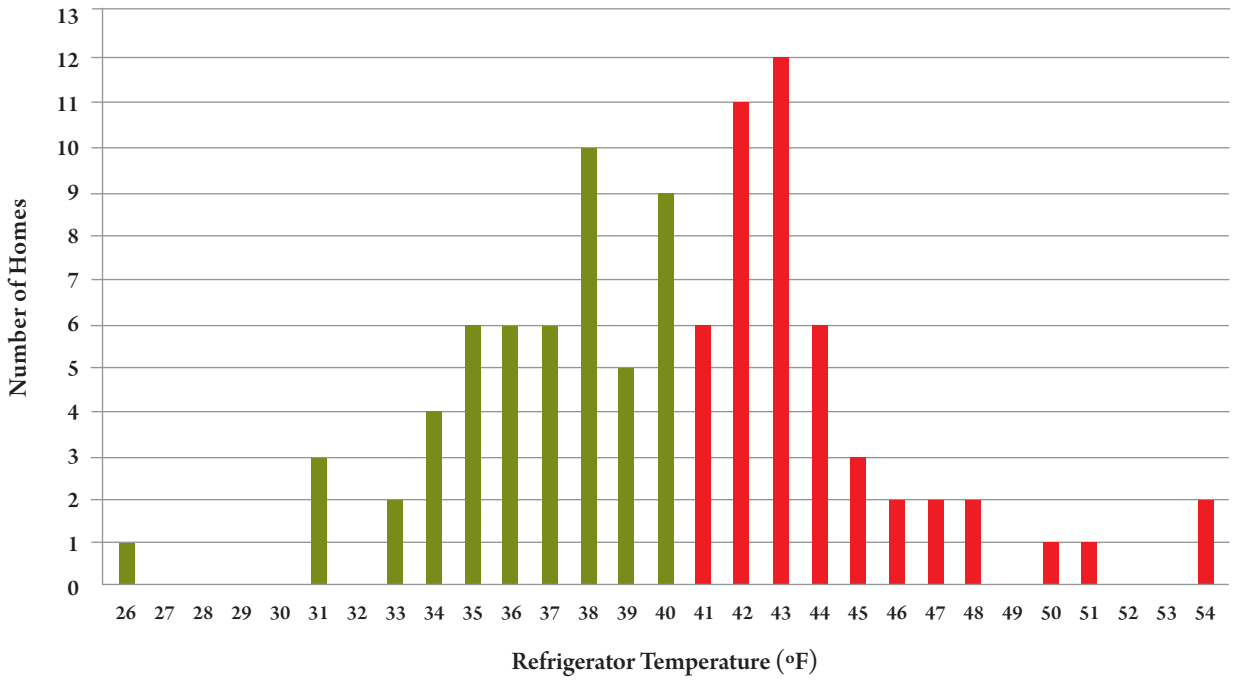

Figure 1. Temperatures of household refrigerators (n = 100)

presence in the kitchen *(Table 4)*. Caucasian participants also had significantly higher mean refrigerator temperatures (41.0°F) than participants from all other racial/ethnic groups (39.0°F) ($P < 0.05$).

Some cleaning and food storage materials were observed less often in households that had a total income below $15,000 than in other homes. Low-income households had a dishwasher 16% of the time, while a dishwasher was present in higher income homes 45% of the time. Low-income homes were also more likely to lack soap and paper/hand towels in the kitchen as well as more likely to store raw and RTE foods incorrectly *(Table 4)*. While these relationships do not meet the criteria for statistical significance ($P < 0.05$), the associations should be further investigated with a larger sample size. It is possible that low-income individuals may lack resources to purchase necessary items, making them more prone to unsafe food handling and more vulnerable to foodborne illness.

To compare behaviors associated with participant education, subgroups of education levels were collapsed into two main groups: High school (HS) education and below; college degree and above *(Table 4)*. Food safety violations related to the absence of cleaning materials (dishwasher, soap, paper/hand towels) were more prevalent among less educated participants, while violations related to cleanliness and maintenance of kitchen surfaces were more prevalent among subjects with at least a college level education *(Table 4)*. Participants who reported previous experience working in the food industry were more likely than others to have items necessary for safe food handling (sanitizing/disinfecting cleaners, cutting board, paper/hand towels) present in the kitchen during the audit (data not shown).

Differences in behavior associated with age were determined by comparing youngest and oldest groups of participants (18–24 years old, 65+ years old) to all other participants to identify if these groups handled food differently. These results indicate no difference in the conditions observed in homes of older participants. Participants age 18–24 were more likely to store RTE food incorrectly and also less likely to have cleaning supplies present in the kitchen *(Table 4)*. Differences in behavior associated with primary language were determined by grouping subjects according to how frequently they reported speaking English at home (more than half the time vs. less than half the time). Participants who speak English at home less than half the time were more likely to have clean sponges in the kitchen, and less likely to have a dishwasher, than participants who speak English at home more frequently *(Table 4)*. Again, while some associations mentioned above are only weakly significant ($P < 0.1$), these relationships should be further explored to identify true behavioral patterns.

DISCUSSION

Lack of compliance with safe food-handling guidelines

The visual inspection described in this research provides a cross sectional study of 100 consumer homes, using a previously developed audit tool to record the presence of

Table 4. Selected differences in food handling risk associated with demographics race/ethnicity

Observation	Caucasian	All Other	Sig.
Evidence of pest infestation	49%	75%	*
Animal in kitchen during inspection	44%	16%	*
No dishwasher in home	44%	79%	*
Lack cutting board in kitchen	31%	61%	*
Kitchen sink dirty	69%	90%	*
Refrigerator exterior dirty	41%	59%	$P = 0.079$
Refrigerator interior dirty	59%	77%	$P = 0.054$
RTE food packaged incorrectly	44%	66%	*
Income Level (Annual/Household)			
Observation	**< $15,000**	**All Other**	**Sig.**
No dishwasher in home	84%	55%	*
Lack soap in kitchen	12%	2%	$P = 0.062$
Lack paper/hand towels in kitchen	20%	6%	$P = 0.061$
Raw meat packaged incorrectly	88%	48%	$P = 0.058$
RTE food packaged incorrectly	72%	53%	$P = 0.10$
Education Level (Highest completed)			
Observation	**≤ HS****	**College +**	**Sig.**
No dishwasher in home	79%	54%	*
Cutting boards dirty	5%	26%	$P = 0.064$
Cutting boards have deep scratches	62%	85%	$P = 0.065$
Lack soap in kitchen	8%	0%	$P = 0.054$
Lack paper/hand towels in kitchen	17%	2%	*
Sponge/dishcloth dirty	73%	90%	*
Age Group			
Observation	**18–24**	**All Other**	**Sig.**
Lack sanitizing/disinfecting cleaners	30%	10%	$P = 0.098$
RTE foods packaged incorrectly	80%	39%	*
English Spoken at Home (≥ 50% of the time)			
Observation	**Yes**	**No**	**Sig.**
No dishwasher in home	62%	100%	*
Sponge/dishcloth dirty	85%	50%	*

*$P < 0.05$
**- HS = High School

unsafe food handling conditions *(4)*. This method has been utilized infrequently to describe hazards present in the domestic environment; therefore, one purpose of this study was to compare our findings with results of similar studies. Direct comparison with observations from other studies was not always possible because of the relatively small number of conditions reported in other studies using this method. Evidence of pest infestation was found in 65% of consumer homes observed during this study. However pest infestation was observed in only one other study, which reported significantly lower prevalence of this condition (present in only 3% of homes) *(10)*. This difference may indicate that pest infestation is a more significant problem in urban environments; however, additional observational data are necessary to describe this relationship.

The cleanliness of several food contact surfaces was documented, including cutting boards, sponges/dishcloths and refrigerator interiors. Of these surfaces, refrigerator exteriors and kitchen sinks were reported unclean most often (70% and 82% of homes, respectively), while cutting boards were reported dirty much less often (23% of homes where cutting boards were present). It is difficult to make comparisons between these findings and reports from other studies, because of the use of a wide variety of tools and techniques to describe cleanliness. One study that included a large inner-city population reported that 85% of all food preparation areas were visibly clean *(29)*, while other studies report that 48–78% refrigerator surfaces *(8, 21)* and 62% of kitchen sponges *(7)* were clean. Only two of these four studies report specific details regarding the validity and reliability of their methods, despite recommendations to rigorously evaluate measurement tools *(24, 29)*. Improved standards of measurement in consumer studies are needed, especially for topics that are difficult to describe quantitatively.

Compliance with recommended guidelines for proper cooling and storage of foods was also evaluated. Refrigerators were found operating above the recommended temperature (41.0°F) in almost half (43%) of consumer homes. These observations are consistent with reports from several other studies, which found between 25–61% of domestic refrigerators tested were too warm *(12, 20, 25, 33)*. Raw meat or poultry at room temperature was observed in only 6% of homes, which is a much lower figure than expected based on observational research. Three studies report 65–72% of participants incorrectly thaw frozen raw meat or poultry at room temperature *(1, 6, 14)*. These studies, however, reported conditions present during meal preparation and required the subject to handle meat or poultry at some point during the observations. Although a standardized checklist was used in each study to record observations, unsafe conditions are more likely while meal preparation is occurring. This difference in methodology may account for the greater compliance among consumers observed during this study, which was not centered around meal preparation

Lack of access to necessary resources/items in consumer homes

Certain items are generally accepted as necessary to achieve adequate cleaning and sanitation in the domestic kitchen, such as hot water and soap *(11, 45, 46)*. During this study, these items were present in almost all kitchens evaluated (97% and 96%, respectively), yet the implications of their absence in even a few homes must be considered. The high prevalence of dish soap in the domestic kitchen has been reported in one other study, which found it present in 92% of homes observed *(7)*. Lack of access to hot water (43°C/109°F) in homes in a developed country has not been reported elsewhere, and represents a potentially alarming food safety risk. Although absent from only 3% of homes in this sample, the effect on the true population must be considered. A lack of hot water among the same proportion (3%) of homes in Philadelphia would affect almost 500,000 people, representing a serious public health risk. Further research is necessary to identify the actual prevalence of this condition among the general population and to identify alternative cleaning and sanitation strategies for consumers who regularly lack access to hot water.

Following proper cleaning and sanitation, kitchen surfaces and hands should be dried appropriately to reduce the survival and spread of microorganisms *(36)*. For this reason, paper and/or hand towels in the kitchen and bathroom are necessary to ensure safe food handling in the home. The tendency of reusable cloth towels to harbor and spread microbial contamination between kitchen surfaces has been well documented, making disposable paper towels the preferred option for proper sanitation *(2, 28, 31, 39, 41)*. The presence of paper towels in the kitchen was observed less often during this study (71% of homes) than has been reported by others using similar audit tools (83–94% of homes) *(7, 10)*.

While the overall presence of dish soap and paper/hand towels observed in homes during this study is encouraging, results indicate certain consumers were more likely than others to lack these items in their kitchen — specifically, those who are low-income (below $15,000/year). Two other violations observed during this study are related to the presence of particular factors in the home — incorrect storage of raw meat/fish/poultry and incorrect storage of ready-to-eat (RTE) foods. To store opened food items correctly in the refrigerator, items must be thoroughly and securely wrapped to prevent exposure and cross-contamination. For this reason, food storage materials such as plastic wrap, aluminum foil and plastic bags may be considered necessary for safe food handling. Results from this study indicate low-income and minority participants were more likely to store RTE foods incorrectly, while low-

income individuals were also more likely to store raw meat/fish/poultry incorrectly.

These relationships suggest that the presence of certain risks may be due to a lack of resources, on the part of some consumers, rather than a lack of knowledge or motivation to follow safe food handling guidelines. Similar studies report that low-income individuals may lack access to other items necessary for safe food handling, such as meat thermometers *(38)* and sanitation materials *(13)*. Although not related to food safety, the burden on low-income families to afford items that are necessary but expensive (diapers) has been described by Smith et al. *(43)*. Low-income individuals may be unable to follow guidelines that depend on purchasing items such as paper towels and plastic wrap and may therefore be at greater risk for foodborne illness. Outreach programs that provide financial assistance or increase access to items necessary for proper sanitation may be more beneficial than educational materials to these vulnerable populations.

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