Consumer Home Refrigeration Practices: Results of a Web-Based Survey

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ABSTRACT

To reduce bacterial growth and to ensure the quality and safety of food products, the U.S. Department of Agriculture and the U.S. Food and Drug Administration advise consumers to clean their refrigerators regularly, use a refrigerator thermometer, and keep refrigerator temperatures at 40°F (4.4°C) or below. We conducted a nationally representative Web-enabled survey (n = 2,060) to collect data on refrigerator thermometer ownership, home refrigerator temperatures, and the frequency of home refrigerator cleaning. We stratified the sample to provide results for pregnant women, older adults (60 years or older), and the remaining population. About half of all respondents had cleaned their refrigerators at least 1 month before the survey. Only 11% of all respondents had a thermometer in their refrigerator before the survey. Older adults (77.5%) were more likely than the remaining population (70.4%) to have their refrigerators at the recommended temperature (P < 0.01). Older adults who were not married and who lived alone were less likely to have refrigerator thermometers and to have their refrigerators at a recommended temperature (P < 0.05). For all respondents, those who had previously owned a refrigerator thermometer were more likely to have their refrigerators at the recommended temperature than were respondents who did not previously own a thermometer (P < 0.01). Food safety educators can use the survey findings and results of previous research to target educational materials and help consumers, especially those at risk for listeriosis, to safely store refrigerated foods at home.

At least once each week, 92% of consumers eat meals they prepare at home (11); however, consumers are spending less time in the kitchen preparing these meals. For all main meals eaten at home, meal preparation time on average is 30 minutes or less (22). Rather than preparing home-cooked meals from scratch, consumers are increasingly relying on foods that are convenient, quick, and easy (9). This popularity of convenience foods has led to increased consumption of refrigerated ready-to-eat (RTE) foods, such as bagged salads, precut fresh fruits and vegetables, and processed meat and poultry products (e.g., deli meats and deli salads) (11). In 2005, 60% of consumers purchased fresh food deli items from supermarkets on a monthly basis (11). Refrigerated RTE foods appeal to consumers because they are convenient and usually can be consumed without reheating.

Refrigerated RTE foods can become contaminated with foodborne pathogens in processing plants, retail stores, or consumers’ homes through improper handling (e.g., cross-contamination). A foodborne pathogen of particular concern is Listeria monocytogenes, which can cause listeriosis, a potentially fatal disease (29). In the United States, listeriosis is the second most common cause of death among foodborne illnesses (7). L. monocytogenes causes mild illness among the general population but can cause serious illness in individuals at risk (2), including pregnant women, unborn fetuses and neonates (the perinatal population), older adults, and immunocompromised individuals (25). Approximately 2,500 individuals in the United States contract listeriosis each year and become seriously ill, resulting in about 300 deaths per year (20).

Many refrigerated RTE foods, such as frankfurters, deli meats, and soft cheeses, are known to support the growth of L. monocytogenes (14, 26, 28). If a refrigerated RTE food supports such growth and is contaminated with L. monocytogenes at the time of purchase, the pathogen can grow rapidly if the food is not stored at a safe temperature (27). Based on findings from a quantitative risk assessment for foodborne L. monocytogenes among selected categories of RTE foods, the U.S. Department of Agriculture (USDA) and the U.S. Food and Drug Administration (FDA) have recommended that consumers keep refrigerated foods at 40°F (4.4°C) or below and consume RTE foods as soon as possible to reduce the risk of illness from L. monocytogenes (36). The USDA and FDA also have recommended that consumers use a thermometer to make sure their refrigerators are at 40°F or below and that they clean their refrigerators regularly (36).

Despite these recommendations, consumers do not always maintain refrigerated RTE foods at the proper temperature. In a study conducted by the American Dietetic Association and the ConAgra Foods Foundation (4), 67% of consumers did not own a refrigerator thermometer, and 60% did not know the recommended safe refrigerator temperature. Similarly, only about one-third of consumers sur-
A recent review of consumer food handling studies revealed that information on consumer home refrigeration practices is limited (24). Therefore, a national survey was conducted to collect data on refrigerator thermometer ownership, home refrigerator temperatures, and the frequency of cleaning for home refrigerators. The sample was stratified to provide results for pregnant women, older adults, and the remaining population. The demographic characteristics of consumers who do and do not follow government-recommended refrigerator practices also were assessed. The survey data are available on the “Exclusives” page of the Joint Institute for Food Safety and Applied Nutrition Web site at http://www.foodrisk.org.

MATERIALS AND METHODS

A national survey of U.S. adults was conducted using a Web-enabled panel survey approach. RTI International’s Committee for the Protection of Human Subjects, which serves as RTI’s institutional review board, reviewed and approved the study protocol.

Sample. Samples of the following U.S. subpopulations were surveyed: pregnant women between the ages of 18 and 40 years, older adults 60 years or older, and the remaining population (i.e., men ages 18 to 59 years, nonpregnant women ages 18 to 40 years, and women ages 41 to 59 years). Our sample was selected from a Web-enabled panel developed and maintained by Knowledge Networks (Menlo Park, Calif.), a survey research firm. The Web-enabled panel is designed to be representative of the U.S. population (8) and is based on a list-assisted, random-digit-dial sample drawn from all 10-digit telephone numbers in the United States. Households that do not have telephones (approximately 2.4% of U.S. households) are not included in the sample (33). As part of a household’s agreement to participate in the panel, they are provided with free hardware (an Internet appliance that connects to their television) and free Internet access. All new panel members are sent an initial survey that collects information on a wide variety of demographic characteristics to create member profiles.

At the time of sample selection, approximately 28,000 panel members were actively participating in the Web-enabled panel. An e-mail was sent to the 5,074 female panel members between the ages of 18 and 40 years to collect information on whether they were currently pregnant, and census information was collected from the 296 women who reported they were pregnant. Another 1,059 older adults and 1,073 adults from the remaining population were randomly selected, for a total sample size of 2,428 adults.

Questionnaire. The questionnaire collected information on a wide range of home storage and handling practices. For brevity, only the following information is presented: (i) refrigerator thermometer ownership before the survey, (ii) home refrigerator temperatures at the time of the survey, and (iii) the last time respondents cleaned the inside of their home refrigerators. Figure 1 exhibits the questions presented in the survey and used in the analysis. Information on the last time respondents cleaned the inside of their home refrigerators was collected from only half of the older adult respondents and half of the respondents from the remaining population. Prior to survey administration, the survey instrument was evaluated with 12 adults from the target population using cognitive interviewing techniques (39). Pretest respondents had to meet the following eligibility criteria: (i) shop for groceries for their households at least once per week, (ii) prepare and eat evening meals at home at least three times per week, and

FIGURE 1. Survey questions.

1. Please record your refrigerator’s internal temperature 24 hours after placing the thermometer inside your refrigerator. (Select a number.)
   ____ degrees Fahrenheit
   1. More than 60  7. 48  13. 36  19. 24
   2. 58  8. 46  14. 34  20. 22
   3. 56  9. 44  15. 32  21. 20
   4. 54  10. 42  16. 30  22. Less than 20
   5. 52  11. 40  17. 28
   6. 50  12. 38  18. 26

2. Prior to receiving the refrigerator thermometer we sent you, did you have a thermometer in your refrigerator? Do not include the thermostat that regulates the refrigerator’s temperature. (Select one.)
   1. Yes
   2. No

3. When was the last time you or someone else in your household cleaned the inside of your refrigerator using soap and warm water or another cleaning product? (Select one.)
   1. More than 8 weeks ago
   2. 5 to 8 weeks ago
   3. 3 to 4 weeks ago
   4. 1 to 2 weeks ago
   5. Less than 1 week ago
   6. Do not clean the inside of the refrigerator
**TABLE 1. Demographic characteristics of respondents**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pregnant women (n = 249)</th>
<th>Older adults (n = 946)</th>
<th>Remaining population (n = 865)</th>
<th>All respondents (n = 2,060)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0</td>
<td>420 44.4</td>
<td>405 50.2</td>
<td>825 48.3</td>
</tr>
<tr>
<td>Female</td>
<td>249 100.0</td>
<td>526 55.6</td>
<td>460 49.8</td>
<td>1,235 51.7</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>118 62.8</td>
<td>221 27.2</td>
<td>339 21.7</td>
<td></td>
</tr>
<tr>
<td>30–44</td>
<td>131 37.2</td>
<td>231 37.4</td>
<td>445 29.2</td>
<td></td>
</tr>
<tr>
<td>45–59</td>
<td></td>
<td>330 35.4</td>
<td>330 27.1</td>
<td></td>
</tr>
<tr>
<td>60–69</td>
<td></td>
<td>546 57.7</td>
<td>546 10.8</td>
<td></td>
</tr>
<tr>
<td>70+</td>
<td></td>
<td>400 42.3</td>
<td>400 11.2</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school (HS)</td>
<td>15 14.7</td>
<td>167 22.7</td>
<td>103 14.9</td>
<td>285 16.6</td>
</tr>
<tr>
<td>HS graduate or GED</td>
<td>34 27.2</td>
<td>357 36.3</td>
<td>269 29.8</td>
<td>660 31.2</td>
</tr>
<tr>
<td>Some college</td>
<td>87 29.1</td>
<td>216 19.5</td>
<td>238 28.8</td>
<td>541 26.8</td>
</tr>
<tr>
<td>Bachelor's degree or higher</td>
<td>113 28.9</td>
<td>206 21.4</td>
<td>255 26.4</td>
<td>574 25.4</td>
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<tr>
<td>Marital status</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>43 30.1</td>
<td>39 4.5</td>
<td>255 33.1</td>
<td>337 26.7</td>
</tr>
<tr>
<td>Married</td>
<td>199 68.2</td>
<td>627 59.7</td>
<td>476 50.7</td>
<td>1,302 52.9</td>
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<tr>
<td>Divorced</td>
<td>6 1.6</td>
<td>121 12.6</td>
<td>98 12.6</td>
<td>225 12.4</td>
</tr>
<tr>
<td>Widowed</td>
<td>0</td>
<td>147 20.9</td>
<td>17 1.4</td>
<td>164 5.7</td>
</tr>
<tr>
<td>Separated</td>
<td>1 0.2</td>
<td>12 2.3</td>
<td>19 2.3</td>
<td>32 2.3</td>
</tr>
<tr>
<td>No. in household (HH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>22 10.6</td>
<td>227 27.8</td>
<td>151 18.6</td>
<td>400 20.6</td>
</tr>
<tr>
<td>Two</td>
<td>88 29.8</td>
<td>598 58.9</td>
<td>270 28.7</td>
<td>956 35.4</td>
</tr>
<tr>
<td>Three or four</td>
<td>104 46.0</td>
<td>108 11.3</td>
<td>346 40.1</td>
<td>558 33.8</td>
</tr>
<tr>
<td>Five or more</td>
<td>35 13.7</td>
<td>13 2.0</td>
<td>98 12.6</td>
<td>146 10.3</td>
</tr>
<tr>
<td>Race or ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>199 61.6</td>
<td>818 80.5</td>
<td>608 66.8</td>
<td>1,625 69.7</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>13 7.6</td>
<td>63 8.7</td>
<td>78 11.6</td>
<td>154 11.0</td>
</tr>
<tr>
<td>Other, non-Hispanic</td>
<td>8 3.6</td>
<td>14 2.0</td>
<td>35 3.2</td>
<td>57 3.0</td>
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<tr>
<td>Hispanic</td>
<td>24 23.6</td>
<td>29 6.4</td>
<td>110 14.6</td>
<td>163 12.9</td>
</tr>
<tr>
<td>Multiracial, non-Hispanic</td>
<td>5 3.5</td>
<td>22 2.4</td>
<td>34 3.8</td>
<td>61 3.5</td>
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<tr>
<td>HH income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $15,000</td>
<td>27 21.0</td>
<td>135 16.7</td>
<td>145 20.0</td>
<td>307 19.3</td>
</tr>
<tr>
<td>$15,000–$34,999</td>
<td>46 21.2</td>
<td>298 32.1</td>
<td>179 22.5</td>
<td>523 24.7</td>
</tr>
<tr>
<td>$35,000–$74,999</td>
<td>110 43.0</td>
<td>379 38.3</td>
<td>355 39.3</td>
<td>844 39.1</td>
</tr>
<tr>
<td>$75,000+</td>
<td>66 14.6</td>
<td>134 12.9</td>
<td>186 18.2</td>
<td>386 17.0</td>
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<tr>
<td>Metropolitan status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetropolitan</td>
<td>28 11.2</td>
<td>193 21.1</td>
<td>151 16.5</td>
<td>372 17.4</td>
</tr>
<tr>
<td>Metropolitan</td>
<td>221 88.8</td>
<td>753 78.9</td>
<td>714 83.5</td>
<td>1,688 82.6</td>
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<tr>
<td>Region</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>33 13.8</td>
<td>189 20.1</td>
<td>170 18.4</td>
<td>392 18.7</td>
</tr>
<tr>
<td>Midwest</td>
<td>78 20.5</td>
<td>222 22.6</td>
<td>193 22.3</td>
<td>493.0 22.3</td>
</tr>
<tr>
<td>South</td>
<td>81 42.6</td>
<td>336 36.4</td>
<td>309 35.9</td>
<td>726.0 36.1</td>
</tr>
<tr>
<td>West</td>
<td>57 23.1</td>
<td>199 20.9</td>
<td>193 23.4</td>
<td>449.0 22.8</td>
</tr>
<tr>
<td>At-risk individual in HH</td>
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<td></td>
</tr>
<tr>
<td>60 years or older</td>
<td>3 2.2</td>
<td>946 100.0</td>
<td>73 8.6</td>
<td>1,022 28.8</td>
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<tr>
<td>Pregnant</td>
<td>249 100.0</td>
<td>2 0.2</td>
<td>9 1.4</td>
<td>260 2.4</td>
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<tr>
<td>Diagnosed with diabetes or kidney disease</td>
<td>16 6.1</td>
<td>195 21.6</td>
<td>94 11.9</td>
<td>305 14.0</td>
</tr>
<tr>
<td>Diagnosed with condition that weakens the immune system</td>
<td>4 1.4</td>
<td>54 5.0</td>
<td>22 2.6</td>
<td>80 3.1</td>
</tr>
</tbody>
</table>
TABLE 2. Respondents’ ownership of refrigerator thermometers before the survey

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Pregnant women (n = 249)</th>
<th>Older adults (n = 946)</th>
<th>Remaining population (n = 865)</th>
<th>Total population (n = 2,060)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Owners</td>
<td>15</td>
<td>8.8</td>
<td>151</td>
<td>15.4</td>
</tr>
<tr>
<td>Nonowners</td>
<td>234</td>
<td>91.2</td>
<td>789</td>
<td>83.8</td>
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<tr>
<td>No response</td>
<td>0</td>
<td>0.8</td>
<td>6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

TABLE 3. Respondents who owned and those who did not own a refrigerator thermometer before the survey

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>% of pregnant women (n = 249)</th>
<th>% of older adults (n = 940)</th>
<th>% of remaining population (n = 864)</th>
<th>% of all respondents (n = 2,053)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owners</td>
<td>Non-owners</td>
<td>P value (b)</td>
<td>Owners</td>
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<tr>
<td>Gender</td>
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<td>Age (yr)</td>
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<td>18–29</td>
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<td>30–44</td>
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<td>45–59</td>
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<td>60–69</td>
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<td>70+</td>
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<td>Education</td>
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<tr>
<td>High school graduate or less</td>
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<tr>
<td>Some college or college degree</td>
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<tr>
<td>Marital status</td>
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<td>Not married</td>
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<tr>
<td>No. in household (HH)</td>
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<tr>
<td>One</td>
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<tr>
<td>Two or more</td>
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<td>Race or ethnicity</td>
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<td>Other race or ethnicity</td>
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</tr>
<tr>
<td>HH income</td>
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<tr>
<td>Less than $32,500</td>
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<td>$32,500+</td>
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<td>Nonmetropolitan</td>
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</tr>
<tr>
<td>Metropolitan</td>
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<tr>
<td>Individual in HH with diabetes, kidney disease, or other conditions that weaken the immune system</td>
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<td>Yes</td>
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<tr>
<td>No</td>
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</tbody>
</table>

\(a\) Analysis did not include respondents who did not answer the question on refrigerator ownership (n = 5).

\(b\) \(\chi^2\) test.
thermometer inside the refrigerator at least 24 h before completing the survey. The survey was e-mailed to the selected panel members, and two e-mail reminders were sent to nonrespondents to encourage participation. Because of the limited number of respondents, pregnant women were sent a $10 honorarium for completing the survey. Data were collected over a 21-day field period, and a total of 2,060 completed surveys were received for an 85% completion rate.

Weighting procedures. Respondents from the three subpopulations were combined, and the data were weighted to reflect the selection probabilities of sampled units and to compensate for differential nonresponse and undercoverage (18). The weights were based on the inverses of the overall selection probabilities with adjustments for undersampling of telephone numbers for which an address was not available during panel recruiting; households with multiple telephone lines; oversampling of certain geographic areas, African American and Hispanic households, and households with computer and Internet access; and undersampling of households not covered by MSN TV. Using a raking or iterative proportional fitting technique, data on age, gender, race or ethnicity, geographic region, education, Internet access, and metropolitan status were used in a poststratification weighting adjustment to make the sample reflect population benchmarks, controlling for the demographics within the three subpopulations and the proportions of the three subpopulations. The benchmarks of pregnant and nonpregnant women and the proportion of pregnant and nonpregnant women among women 18 to 40 years of age came from the e-mail screener. The benchmarks and proportions of the other subpopulations came from the December 2002 Current Population Survey (32). The final weights were trimmed and scaled to sum to the total U.S. population 18 years or older so that the weighted survey results were representative of the U.S. adult population.

Analysis. Weighted frequencies were first calculated for each survey question. Next, the characteristics of respondents for the following comparisons were assessed: (i) respondents who owned a refrigerator thermometer before the survey compared with those who did not, (ii) respondents whose refrigerators were at the recommended temperature of 40°F or below compared with those whose refrigerators were not, and (iii) respondents who cleaned the inside of their home refrigerators using soap and warm water or another cleaning product at least 1 month before the survey compared with those who did not. For each comparison, the following sociodemographic and other variables were included in the analysis: gender, age, educational background, marital status, household size (single versus two or more individuals), race or ethnicity, household income, and metropolitan status (metropolitan versus nonmetropolitan) based on the metropolitan statistical area for the household. A variable was also included to describe whether the respondent or a member of the household had been diagnosed with diabetes, kidney disease, or another condition that weakens the immune system. A chi-square test was performed for the relationships between the variables of interest and various sociodemographic and other variables. The analysis was conducted with the Stata release 8.2 software package (30).

RESULTS

Table 1 provides the respondents’ demographic characteristics. Of the 2,060 respondents, 52% were women. The majority of respondents were white and non-Hispanic (69.7%). Approximately 50% of respondents had at least some college education. For less than 20% of respondents, an individual in the household had been diagnosed with diabetes, kidney disease, or another condition that weakens the immune system.

Refrigerator thermometer ownership. Table 2 provides the prevalence of refrigerator thermometer ownership before the survey. Almost 11% of all respondents had a thermometer in their refrigerator before the survey. Comparing the three subpopulations, older adults (15.4%) were significantly more likely than the remaining population (9.4%; \( P = 0.0018 \)) but not significantly more likely than pregnant women (8.8%; \( P = 0.1131 \)) to own a refrigerator thermometer.

Table 3 provides the characteristics of respondents who owned a refrigerator thermometer before the survey and those who did not. For all respondents, those with more
TABLE 4. Respondents whose home refrigerators were and those whose refrigerators were not at the recommended temperature of 40°F or belowa

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>% of pregnant women (n = 248)</th>
<th>% of older adults (n = 929)</th>
<th>% of remaining population (n = 860)</th>
<th>% of all respondents (n = 2,037)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40°F or below</td>
<td>Above 40°F</td>
<td>P value</td>
<td>40°F or below</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>81.9</td>
<td>18.1</td>
<td>0.0186</td>
<td>72.8</td>
</tr>
<tr>
<td>Female</td>
<td>73.9</td>
<td>26.1</td>
<td>0.8741</td>
<td>67.7</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>70.4</td>
<td>29.6</td>
<td>0.8741</td>
<td>68.5</td>
</tr>
<tr>
<td>30–44</td>
<td>71.7</td>
<td>28.3</td>
<td>0.0186</td>
<td>70.9</td>
</tr>
<tr>
<td>45–59</td>
<td>70.9</td>
<td>29.1</td>
<td>0.5886</td>
<td>77.5</td>
</tr>
<tr>
<td>60+</td>
<td>77.8</td>
<td>22.2</td>
<td>0.8328</td>
<td>77.1</td>
</tr>
<tr>
<td>Race or ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>72.0</td>
<td>28.0</td>
<td>0.7531</td>
<td>79.3</td>
</tr>
<tr>
<td>Other race or ethnicity</td>
<td>69.1</td>
<td>30.9</td>
<td>0.7531</td>
<td>70.1</td>
</tr>
<tr>
<td>HH income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $32,500</td>
<td>72.1</td>
<td>27.9</td>
<td>0.2414</td>
<td>79.7</td>
</tr>
<tr>
<td>$32,500+</td>
<td>69.9</td>
<td>30.1</td>
<td>0.2414</td>
<td>79.5</td>
</tr>
<tr>
<td>Metropolitan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetropolitan</td>
<td>62.2</td>
<td>37.8</td>
<td>0.2414</td>
<td>79.6</td>
</tr>
<tr>
<td>Metropolitan</td>
<td>72.0</td>
<td>28.0</td>
<td>0.2414</td>
<td>76.9</td>
</tr>
<tr>
<td>Individual in HH with diabetes, kidney disease, or other conditions that weaken the immune system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>47.1</td>
<td>52.9</td>
<td>0.5958</td>
<td>71.5</td>
</tr>
<tr>
<td>No</td>
<td>72.8</td>
<td>27.2</td>
<td>0.5123</td>
<td>76.8</td>
</tr>
</tbody>
</table>

a Analysis did not include respondents who did not answer the question on refrigerator temperature (n = 21).
b \( \chi^2 \) test.

than one individual living in their households were significantly more likely to own a refrigerator thermometer than were respondents living alone (P = 0.0469). White, non-Hispanic respondents were significantly more likely to own a refrigerator thermometer than were respondents of other races and ethnicities (P = 0.0394), and respondents with annual household incomes less than $32,500 were significantly more likely to own a refrigerator thermometer than were respondents with higher incomes (P = 0.0432). For the subpopulation of pregnant women, respondents 30 to 44 years of age were significantly more likely than respondents 18 to 29 years of age to own a refrigerator thermometer (P = 0.0525). For the subpopulation of older adults, married respondents were significantly more likely than respondents who were not married to own a refrigerator thermometer (P = 0.0345). For the remaining population, respondents with annual household incomes less than $32,500 were significantly more likely to own a refrigerator thermometer than were respondents in households with higher incomes (P = 0.0285).

**Recommended refrigerator temperature.** Figure 2 provides the distribution of refrigerator temperatures that were recorded by respondents using the thermometers provided for the study. Seventy-two percent of all respondents reported that their refrigerators were at the recommended
TABLE 5. Respondents’ refrigerator-cleaning practices at least 1 month before the survey

<table>
<thead>
<tr>
<th>Cleaning practice</th>
<th>Pregnant women (n = 249)</th>
<th>Older adults (n = 466)</th>
<th>Remaining population (n = 429)</th>
<th>All respondents (n = 1,144)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Cleaned at least 1 mo prior</td>
<td>104</td>
<td>48.3</td>
<td>231</td>
<td>49.7</td>
</tr>
<tr>
<td>Did not clean at least 1 mo prior</td>
<td>145</td>
<td>51.7</td>
<td>235</td>
<td>50.3</td>
</tr>
</tbody>
</table>

We collected information on the last time respondents cleaned the inside of their home refrigerators from approximately half the respondents for the older adult and remaining populations.

TABLE 6. Respondents who cleaned and those who did not clean the inside of their refrigerators at least 1 month before the survey

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>% of pregnant women (n = 249)</th>
<th>% of older adults (n = 466)</th>
<th>% of remaining population (n = 429)</th>
<th>% of all respondents (n = 1,144)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Did not clean</td>
<td>P value&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Did not clean</td>
<td>P value</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>41.8</td>
<td>58.2</td>
<td>47.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Female</td>
<td>56.1</td>
<td>43.9</td>
<td>0.0126</td>
<td>49.5</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>49.4</td>
<td>50.6</td>
<td>42.6</td>
<td>57.4</td>
</tr>
<tr>
<td>30–44</td>
<td>46.4</td>
<td>53.6</td>
<td>0.0126</td>
<td>47.5</td>
</tr>
<tr>
<td>45–59</td>
<td>48.1</td>
<td>51.9</td>
<td>0.4343</td>
<td>48.1</td>
</tr>
<tr>
<td>60+</td>
<td>49.6</td>
<td>50.4</td>
<td>0.4343</td>
<td>47.5</td>
</tr>
<tr>
<td>60–69</td>
<td>49.8</td>
<td>50.2</td>
<td>0.4343</td>
<td>47.5</td>
</tr>
<tr>
<td>70+</td>
<td>49.8</td>
<td>50.2</td>
<td>0.4343</td>
<td>47.5</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduate or less</td>
<td>56.0</td>
<td>44.0</td>
<td>51.8</td>
<td>48.2</td>
</tr>
<tr>
<td>Some college or college degree</td>
<td>42.8</td>
<td>57.2</td>
<td>0.0126</td>
<td>46.9</td>
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<tr>
<td>Marital status</td>
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<td></td>
<td></td>
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<tr>
<td>Married</td>
<td>46.4</td>
<td>53.6</td>
<td>50.1</td>
<td>49.9</td>
</tr>
<tr>
<td>Not married</td>
<td>52.3</td>
<td>47.7</td>
<td>0.6078</td>
<td>49.1</td>
</tr>
<tr>
<td>No. in household (HH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>48.8</td>
<td>51.2</td>
<td>20.2</td>
<td>79.8</td>
</tr>
<tr>
<td>Two or more</td>
<td>48.2</td>
<td>51.8</td>
<td>0.0126</td>
<td>50.5</td>
</tr>
<tr>
<td>Race or ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>51.1</td>
<td>48.9</td>
<td>49.2</td>
<td>50.8</td>
</tr>
<tr>
<td>Other race or ethnicity</td>
<td>47.5</td>
<td>52.5</td>
<td>0.0126</td>
<td>50.5</td>
</tr>
<tr>
<td>HH income</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $32,500</td>
<td>45.5</td>
<td>54.5</td>
<td>53.5</td>
<td>46.5</td>
</tr>
<tr>
<td>$32,500+</td>
<td>44.2</td>
<td>55.8</td>
<td>0.0126</td>
<td>46.4</td>
</tr>
<tr>
<td>Metropolitan status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetropolitan</td>
<td>30.2</td>
<td>69.8</td>
<td>54.7</td>
<td>45.3</td>
</tr>
<tr>
<td>Metropolitan</td>
<td>50.6</td>
<td>49.4</td>
<td>0.1016</td>
<td>48.4</td>
</tr>
<tr>
<td>Individual in HH with diabetes, kidney disease, or other conditions that weaken the immune system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>52.6</td>
<td>47.4</td>
<td>54.2</td>
<td>45.8</td>
</tr>
<tr>
<td>No</td>
<td>45.9</td>
<td>54.1</td>
<td>0.0126</td>
<td>47.5</td>
</tr>
</tbody>
</table>

<sup>a</sup>χ² test.

Comparing the three subpopulations, older adults (77.5%) were significantly more likely than the remaining population (70.4%; P = 0.0057) but not significantly more likely than pregnant women (70.9%; P = 0.1174) to have their refrigerators at the recommended temperature.

Table 4 provides the characteristics of respondents whose refrigerators were at the recommended temperature and of those whose refrigerators were not. For all respondents, those who were white, non-Hispanic were significantly more likely than respondents of other races and ethnicities to have refrigerators at the recommended temperature (P = 0.0), and respondents living in nonmetropolitan areas were significantly more likely than their urban counterparts.
terparts to have refrigerators at the recommended temperature ($P = 0.0092$). For the subpopulation of older adults, men were significantly more likely than women to have refrigerators at the recommended temperature ($P = 0.0186$); married respondents were significantly more likely than those who were not married to have refrigerators at the recommended temperature ($P = 0.0009$), and respondents with more than one individual living in their households were significantly more likely than respondents living alone to have refrigerators at the recommended temperature ($P = 0.0033$). For the remaining population, white, non-Hispanic respondents were significantly more likely than respondents of other races and ethnicities to have refrigerators at the recommended temperature ($P = 0.0002$), and respondents living in nonmetropolitan areas were significantly more likely than their urban counterparts to have refrigerators at the recommended temperature ($P = 0.0152$). No differences were observed for the subpopulation of pregnant women. For all respondents, previous refrigerator thermometer owners were significantly more likely to have their refrigerators at the recommended temperature than were respondents who did not previously own a thermometer ($P = 0.0$). This same finding was observed in the subpopulation of older adults ($P = 0.0317$) and the remaining population ($P = 0.0008$) but not for pregnant women.

**Refrigerator cleaning practices.** Table 5 provides the percentage of respondents who had cleaned the inside of their home refrigerators at least 1 month before completing the survey. Nearly half of all respondents (47.4%) had cleaned their refrigerators using soap and warm water or another cleaning product at least 1 month before the survey. Differences in cleaning practices were not observed among the three subpopulations.

Table 6 provides the characteristics of respondents who cleaned their refrigerators at least 1 month before the survey and of those who did not. For all respondents, those with a high school education or less were significantly more likely than their collegiate counterparts to have cleaned their refrigerators at least 1 month before the survey ($P = 0.0$). Respondents living in households with two or more individuals were significantly more likely than respondents living alone to have cleaned their refrigerators at least 1 month before the survey ($P = 0.0001$). Respondents of other races and ethnicities were significantly more likely than white, non-Hispanic respondents to have cleaned their refrigerators at least 1 month before the survey ($P = 0.0002$), and respondents of other races and ethnicities were significantly more likely than white, non-Hispanic respondents to have cleaned their refrigerators at least 1 month before the survey ($P = 0.0001$).

**DISCUSSION**

The strengths of the present study include the large sample sizes of older adults and the remaining population and the nationally representative survey design. Although we took a census of all pregnant women participating in the Web-enabled panel, the resulting sample size of pregnant women was relatively small, which may have limited our ability to detect differences in survey estimates among the subpopulations. Our study also used self-reported behaviors that may not always reflect actual practices (24).

Several research groups have concluded that many consumers do not know the recommended refrigerator temperature of 40°F or below (1, 4, 5, 12, 16, 19, 21, 37, 38). In an extensive literature review, Redmond and Griffith (24) found that 45 to 60% of consumers lack knowledge about proper refrigerator temperatures. In a recent survey, however, 91% of respondents reported that it is important that refrigerators are at the proper temperature (4), but in another national survey, only 30% of respondents had heard that they should use a thermometer to check whether their home refrigerators are at a safe temperature (35).

Only refrigerator thermometers can safely monitor whether the home refrigerator is at a safe temperature (10). We found that only 11% of respondents previously owned a refrigerator thermometer, and more than one fourth of respondents had refrigerator temperatures above 40°F. These findings are consistent with those from other surveys and from observational studies, in which many consumers did not own refrigerator thermometers and did not keep refrigerator temperatures at the recommended temperature of 40°F or below (6, 15, 16). Other surveys have revealed higher rates of refrigerator thermometer ownership, ranging from 15 to 33% (1, 4, 31). According to a national survey, about one third of respondents mistakenly rely on refrigerator thermostats (dials) to gauge whether food is stored at a safe temperature (4); thus, by sending respondents a refrigerator thermometer, we were more likely to determine actual refrigerator thermometer ownership. The refrigerator thermometers we sent to participants indicated a “safe” zone between 0 and 40°F. We do not know the extent to which the safe zone affected participants’ responses; however, 28% of the respondents reported their refrigerator temperatures were above the recommended temperature of 40°F.

The survey findings provide evidence of the need to educate consumers on the recommended refrigerator tem-
perature of 40°F or below and the importance of using a thermometer to monitor refrigerator temperature. Because storage time for refrigerated foods and refrigerator temperature are both important for reducing the risk of listeriosis, the need to educate consumers about recommended storage times for various refrigerated RTE foods is also critical.

To reduce bacterial growth and to ensure the quality and safety of food products, the USDA and FDA recommend consumers clean the inside of their refrigerators regularly (36). A recent study found that visual assessment of the cleanliness of the inside of a home refrigerator may not be a reliable indicator of microbial contamination; thus, consumers should regularly clean their refrigerators, regardless of visible soiling (13). Nearly half of all respondents (47.4%) reported that they cleaned the inside of their refrigerators using soap and warm water or another cleaning product at least 1 month before our survey. Although it is not known how respondents interpreted the word “cleaning” (i.e., cleaning whole refrigerator versus wiping a spill on a refrigerator shelf), our results are consistent with a recent survey in which 50% of respondents cleaned their refrigerators at least once per month and respondents with a high school education or less and respondents with lower incomes were more likely to clean their refrigerators at least once per month (17). Li-Cohen and Bruhn (17) found that although consumers clean the inside of their refrigerators, few consumers sanitize, suggesting consumers need information on safe and effective disinfecting solutions.

We found that respondents with relatively lower incomes were more likely to own refrigerator thermometers, and respondents living in nonmetropolitan areas were more likely to have their refrigerators at the recommended temperature. We also found that respondents with a high school education or less, those that were of an ethnicity other than white non-Hispanic, and those with relatively lower incomes were more likely to have cleaned their refrigerators at least 1 month before the survey. These findings are consistent with those of other researchers, who found that the prevalence of risky food handling and food consumption practices generally increases with education and income and is higher among individuals living in metropolitan areas (3, 23).

Individuals with relatively less education and lower incomes and those living in rural areas are typically a part of the target audiences of the USDA Cooperative State Research Education and Extension Services (CSREES) Expanded Food and Nutrition Education Program (EFNEP) (34) and Food and Nutrition Service nutrition assistance programs (i.e., Food Stamp Nutrition Education Program, Women, Infants, and Children). These programs typically offer information on basic food safety practices as part of the services they provide to eligible participants. For example, EFNEP offers adult program participants two lessons on food safety through local county extension offices. In the most recent EFNEP annual report, 67% of the 94,215 participants improved in one or more food safety practices (34). Our survey findings and those from the EFNEP annual report suggest that the USDA nutrition programs are successful in providing information on food safety practices (e.g., safe refrigerator temperatures and refrigerator cleaning practices) to individuals with relatively less education and lower incomes and those living in rural areas.

Our survey findings suggest that individuals with relatively higher incomes and more education need more information about safe food handling practices. Another segment of the population that would benefit from information on safe refrigeration practices is older adults, an at-risk population for listeriosis. Specifically, older adults who were not married and those who lived alone were less likely to have refrigerator thermometers and to have their refrigerators at the recommended temperature.

We found that consumers could benefit from information on how to keep refrigerated foods at a safe temperature. Food safety educators can use our study findings to develop and deliver targeted educational programs concerning safe refrigerator practices.

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