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## Retail Deli Slicer Inspection Practices: An EHS-Net Study

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### Abstract

The Centers for Disease Control and Prevention (CDC) estimates that 3,000 people die in the United States each year from foodborne illness, and *Listeria monocytogenes* causes the third highest number of deaths. Risk assessment data indicate that *L. monocytogenes* contamination of particularly delicatessen meats sliced at retail is a significant contributor to human listeriosis. Mechanical deli slicers are a major source of *L. monocytogenes* cross-contamination and growth. In an attempt to prevent pathogen cross-contamination and growth, the U.S. Food and Drug Administration (FDA) created guidance to promote good slicer cleaning and inspection practices. The CDC's Environmental Health Specialists Network conducted a study to learn more about retail deli practices concerning these prevention strategies. The present article includes data from this study on the frequency with which retail delis met the FDA recommendation that slicers should be inspected each time they are properly cleaned (defined as disassembling, cleaning, and sanitizing the slicer every 4 h). Data from food worker interviews in 197 randomly selected delis indicate that only 26.9% of workers ( $n = 53$ ) cleaned and inspected their slicers at this frequency. Chain delis and delis that serve more than 300 customers on their busiest day were more likely to have properly cleaned and inspected slicers. Data also were collected on the frequency with which delis met the FDA Food Code provision that slicers should be undamaged. Data from observations of 685 slicers in 298 delis indicate that only 37.9% of delis ( $n = 113$ ) had slicers that were undamaged. Chain delis and delis that provide worker training were more likely to have slicers with no damage. To improve slicer practices, food safety programs and the retail food industry may wish to focus on worker training and to focus interventions on independent and smaller delis, given that these delis were less likely to properly inspect their slicers and to have undamaged slicers.

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## Keywords

Food safety; *Listeria monocytogenes*; Retail deli; Slicer; U.S. Food and Drug Administration Food Code

Estimates by the Centers for Disease Control and Prevention (CDC) indicate that foodborne illnesses kill 3,000 people in the United States each year. The pathogens most responsible for these deaths are *Salmonella* (nontyphoidal), *Toxoplasma gondii*, *Listeria monocytogenes*, norovirus, and *Campylobacter* spp. (4). Each of these pathogens is unique with specific characteristics and routes of transmission; however, they all have been associated with a delicatessen-related foodborne illness (1).

*L. monocytogenes* in particular has been associated with deli meat. In a 2003 risk assessment of 23 categories of ready-to-eat foods, deli meats posed the highest risk, both per serving and per year, of causing human listeriosis (24). A majority of deli meat-related illnesses result from meat that is packaged at retail (6, 17).

Mechanical slicers pose cross-contamination risks in delis and are an important source of *L. monocytogenes* cross-contamination and growth (7, 11, 12, 14, 15). This pathogen can adhere to stainless steel, making deli slicers a suitable environment for pathogen contamination and growth (13). The complex structure of most slicers may further contribute to *L. monocytogenes* contamination. Multiple components (e.g., blade guards and slicer handles) are connected by seams and sealed with sealants. With frequent use, these seals can become worn and damaged, allowing debris to become trapped in hard-to-reach areas and creating ideal growth conditions for *L. monocytogenes* (16).

To prevent pathogen (e.g., *L. monocytogenes*) cross-contamination and growth, the U.S. Food and Drug Administration (FDA) has created guidance to promote good slicer cleaning and inspection practices. The FDA Food Code (21, 23), which provides the basis for local and state codes that regulate retail food service in the United States, contains provisions (4–602.11(C) and 4–202.11(A)(5)) recommending that food contact surfaces and utensils, such as slicers, be disassembled, cleaned, and sanitized every 4 h when in use. Recommendations such as these are further advocated by guidance documents such as the “Best Practices Guidance for Controlling *Listeria monocytogenes* (*Lm*) in Retail Delicatessen” from the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) (20).

To further prevent bacterial growth, the FDA created a guidance document recommending that slicers and their seams and seals be routinely inspected before being disassembled for each cleaning, and the FDA Food Code (21–23) contains provisions (4–202.11(A)(5) and 4–202.11(A)(2)) recommending that food contact surfaces and equipment components be free of damage. Although these recommendations are important for reducing *L. monocytogenes* contamination, little information is available on actual slicer cleaning and inspection practices in retail delis.

To fill this knowledge gap, the CDC’s Environmental Health Specialists Network (EHS-Net) conducted a study focusing on retail deli food safety policies and practices associated with

the prevention of *L. monocytogenes* cross-contamination and growth. A secondary purpose of this study was to identify deli, manager, and worker characteristics related to these policies and practices.

The focus of the present article is retail deli slicer inspection practices and slicer conditions. We present data on the frequency with which deli workers inspect slicers and the observed conditions of slicers in the delis included in the CDC study. We also examine the relationships between these two outcome variables and specific deli, manager, and worker characteristics.

## MATERIALS AND METHODS

This study was designed and conducted by the EHS-Net, a collaborative program of the CDC, FDA, FSIS, and state and local health departments. The EHS-Net focuses on the investigation of environmental factors contributing to foodborne illness. Six state and local health departments were funded by the CDC to participate in the EHS-Net at the time of the study: California, Minnesota, New York State, New York City, Rhode Island, and Tennessee. Four of the six sites had adopted the FDA Food Code provision recommending that food contact surfaces and utensils, such as slicers, be disassembled, cleaned, and sanitized every 4 h when in use. All six sites had adopted the FDA Food Code provision recommending that food contact surfaces and equipment components be free of damage. Adoption of the FDA guidance document recommendation that slicers be routinely inspected before each cleaning is unknown because this issue is not included in the Food Code.

### Sample.

The study sample consisted of randomly selected retail delis located in each of the six EHS-Net sites. A deli was defined as an establishment that prepares or serves ready-to-eat foods to customers; typically, the food is taken elsewhere to be eaten. This delay in consumption has a public health significance because it may allow for the growth and survival of pathogens such as *L. monocytogenes* on contaminated foods.

In each of the six EHS-Net sites, EHS-Net personnel chose an area based on convenience (reasonable travel distance) in their jurisdiction to recruit delis for study participation through telephone calls. SAS version 9.3 software (SAS Institute, Cary, NC) was used to select a random sample of delis from population lists of delis in those areas. The deli population list for each jurisdiction was obtained from the 2008 to 2009 Homeland Security Infrastructure Project's database of retail establishments (Department of Homeland Security, Washington, DC).

In each site, EHS-Net data collectors collected data in approximately 50 delis. Because of limited resources, delis with non-English-speaking managers were excluded from the study.

### Data collection.

Data were collected from January 2012 to September 2012. Data collectors telephoned delis in each EHS-Net site to request study participation and arrange for a data collection visit at the deli during normal hours of operation. At the deli, data collectors conducted a manager

(defined as the person who had authority over the deli) interview and survey, a food worker interview, and a structured observation of the environment.

The manager interview consisted of questions about the deli manager's personal characteristics (e.g., food safety certification), the deli's characteristics (e.g., chain or independent ownership), and the deli's policies and practices (e.g., presence of a written slicer cleaning policy). The manager survey consisted of eight multiple-choice food safety knowledge questions, assessing topics such as hand washing and bacterial growth in food.

Data collectors also interviewed a food worker. To limit the burden on the establishment and to increase cooperation, data collectors asked managers to choose the worker to be interviewed. Similar to the manager interview, the worker interview contained questions about the worker's personal characteristics (e.g., length of time working at the deli) and about slicer cleaning and inspection. Workers were asked "How often do you break down, clean, then sanitize this slicer?" for up to five slicers in the deli. They were also asked "How often do you inspect seams and seals on the slicers?," "When you do inspect seams and seals, which ones do you inspect?," and "When you do inspect a seal, what do you look for?" The food worker interview also contained five true-or-false food safety knowledge questions, assessing topics such as hand washing and bacterial growth in food.

For the structured observation, data collectors observed up to five slicers in each deli, assessing the physical condition of the slicers and noting any damage on the slicers (e.g., chips, cracks, or missing parts).

The study protocol was cleared by the appropriate institutional review boards in the EHS-Net sites. The study protocol and data collection instruments can be found on the CDC Web site (5). All data collectors participated in training designed to increase data collection consistency. We did not collect data that could identify individual delis, managers, or workers.

### **Data analysis.**

We conducted univariate analyses with SAS version 9.3 to obtain descriptive statistics on deli, manager, and worker characteristics; deli workers' slicer inspection practices; and observed slicer damage. We also constructed two sets of simple and multiple logistic regression models to examine potential associations between explanatory variables (deli, manager, and worker characteristics) and the outcome variables of (i) slicer inspection frequency (whether food workers said they inspected slicers at the FDA recommendation of during each full cleaning, defined by the FDA Food Code as disassembling, cleaning, and sanitizing the slicer at least every 4 h) and (ii) slicer condition (whether the data collector observed slicer damage, such as chips, cracks, or missing parts, on any slicers in the deli). Delis were coded as properly inspecting their slicers when the interviewed food workers said they inspected their slicers every time they fully cleaned and sanitized them and that they fully cleaned (disassemble, clean, and sanitize) all slicers at the FDA-recommended frequency of every 4 h (3). Delis were coded as having no damaged slicers when the data collectors reported no damage on any slicer in the deli. Delis were coded as having damaged slicers when data collectors reported that at least one slicer had "chips, cracks, and/or

scratches,” “cracked seals and seams,” “loose parts,” “missing parts,” “missing seams,” or “other defects.”

The slicer inspection frequency outcome of interest lacked variability in two of the six sites; in these sites, few to no slicers were cleaned or inspected at the proper frequency. This lack of variability meant that data from these two sites could not be included in either the univariate or regression analyses for this outcome variable. Thus, we dropped the data from these sites from these analyses.

We used a forward selection method for variable selection and determination of model fit. We included variables significant at  $P = 0.05$  in all models.

## RESULTS

### Deli, manager, and worker characteristics.

Of the 691 managers who were contacted at eligible delis, 298 agreed to have their deli participate in the study, yielding a participation rate of 43.1%. In all participating delis, data collectors interviewed and administered the food safety knowledge survey to a manager and conducted an observation of the deli environment. In 98.7% ( $n = 294$ ) of delis, data collectors were also able to interview a food worker. Thus, data are reported on 298 delis and managers and 294 workers.

According to manager interview data, 55.0% ( $n = 164$ ) of the delis were chains (i.e., the deli shares both its name and operations with at least one other deli), and the remaining 45.0% ( $n = 134$ ) were independently owned (Table 1). Most delis (65.8%,  $n = 196$ ) had more than one manager, and most (64.4%,  $n = 192$ ) had two or more workers per shift (a shift was defined as set time periods: deli opening until 10 a.m., 10 a.m. to 2 p.m., 2 p.m. to 6 p.m., and 6 p.m. until deli closing). Manager food safety training was required in 74.6% ( $n = 220$ ) of the delis, and food safety certification (for which the manager has taken a food safety test and been issued a card with an expiration date) was required in 49.8% ( $n = 145$ ). According to worker interview data, 55.6% ( $n = 163$ ) of the workers had 10 or fewer years of experience in the retail food industry, and 64.6% ( $n = 190$ ) had five or fewer years of experience in their current deli. Additional descriptive data on delis, managers, and workers are listed in Table 1.

### Deli slicer inspections.

Data collectors interviewed food workers about up to five slicers in each deli. In the four sites included in the slicer inspection analysis, interview data were collected on 531 slicers in 197 delis. A majority (82.7%,  $n = 163$ ) of the delis had at least two slicers.

Worker interview data indicated that in 66.0% ( $n = 130$ ) of delis, slicer seams and seals were inspected at any of the four frequency options: (i) each time, when fully cleaning and sanitizing slicers, (ii) occasionally, when fully cleaning and sanitizing slicers, (iii) each time, during wipe down or quick clean of slicers, and (iv) occasionally, during wipe down or quick clean of slicers. However, only 26.9% ( $n = 53$ ) of workers selected the frequency option of

“each time, when fully cleaning and sanitizing slicers.” (Fully cleaning and sanitizing is defined as disassembling, cleaning, and sanitizing the slicer at least every 4 h.)

In the 130 delis in which slicers were inspected, 127 food workers responded to the interview question “When you do inspect seams and seals, which ones do you inspect?” These food workers said they inspected the following slicer parts: specific seams and seals (29.9%,  $n = 38$ ), all seams and seals (27.6%,  $n = 35$ ), specific slicer components (e.g., knobs, handles, blade; 23.6%,  $n = 30$ ), the entire slicer (11.8%,  $n = 15$ ), and other areas (e.g., behind the blade or the edges of the slicer; 8.7%,  $n = 11$ ). Multiple responses were allowed; thus, the total percentage is greater than 100%.

In the 130 delis in which slicers were inspected, 127 food workers responded to the interview question “When you do inspect a seal, what do you look for?” These food workers said they looked for the following things when they inspected a slicer seal: food debris (63.8%,  $n = 81$ ), cracks or breaks (28.3%,  $n = 36$ ), general condition of the slicer (12.6%,  $n = 16$ ), loose parts (9.4%,  $n = 12$ ), cleanliness (7.9%,  $n = 10$ ), “other” issues (e.g., leaks or discoloration; 7.1%,  $n = 9$ ), and missing parts (1.6%,  $n = 2$ ). Multiple responses were allowed; thus, the total percentage is greater than 100%.

#### **Deli, manager, and worker characteristics associated with slicer inspection frequency: simple regression analyses.**

Simple logistic regression analyses identified 10 of 20 characteristics that were significantly associated ( $P < 0.05$ ) with workers reporting that slicers in their deli were inspected each time they were fully cleaned at the FDA-recommended frequency (Table 2). Characteristics associated with higher odds of this outcome included chain ownership, higher average number of workers per shift, more shifts in a typical day, more customers served on the deli’s busiest day, more slicers, more chubs (plastic tubes of meat common in delis) sold weekly, existence of written policy for slicer cleaning and sanitizing, interviewed manager previously food safety certified, interviewed manager currently food safety certified, and interviewed manager’s food safety knowledge.

#### **Deli, manager, and worker characteristics associated with slicer inspection frequency: multiple regression analyses.**

A multiple logistic regression analysis identified two characteristics that were significantly associated ( $P < 0.05$ ) with workers reporting that slicers in their deli were inspected each time they were fully cleaned at the FDA-recommended frequency (Table 3). Chain delis were more likely to meet the slicer inspection frequency recommendation than were independently owned delis. Delis that served more than 300 customers on their busiest day were more likely to meet the slicer inspection frequency recommendation than were delis who served fewer customers on their busiest day.

#### **Deli slicer damage.**

Data collectors collected data on up to five slicers in each deli during their observation time, for a total of 685 slicers in the 298 delis. Slightly more than half (54.5%,  $n = 373$ ) of the slicers had no observed damage, and 45.5% ( $n = 312$ ) had some type of observed damage.

Of the 312 slicers that were damaged, 63.5% ( $n = 198$ ) had one problem, 23.4% ( $n = 73$ ) had two problems, and 13.1% ( $n = 41$ ) had three or more problems. The problems included chips, cracks, and/or scratches (76.6%,  $n = 239$ ), “other” (e.g., rust, exposed screws, or corrosion; 35.9%,  $n = 112$ ) missing seams (15.7%,  $n = 49$ ), cracked seams and seals (14.7%,  $n = 46$ ), missing parts (6.1%,  $n = 19$ ), and loose parts (4.8%,  $n = 15$ ). Multiple responses were allowed; thus, the total percentage is greater than 100%.

In 37.9% ( $n = 113$ ) of the delis, all slicers were free of damage; however, in 62.1% ( $n = 185$ ) of the delis, damage was observed on one or more of the slicers. A majority (76.2%,  $n = 141$ ) of the delis with damaged slicers had at least one slicer with chips, cracks, and/or scratches, 45.1% ( $n = 82$ ) had at least one slicer with “other” (e.g., rust, exposed screws, or corrosion) problems, 19.5% ( $n = 36$ ) had at least one slicer with missing seams, 17.8% ( $n = 33$ ) had at least one slicer with cracked seams and seals, 8.6% ( $n = 16$ ) had at least one slicer with missing parts, and 7.0% ( $n = 13$ ) had at least one slicer with loose parts. Multiple responses were allowed; thus, the total percentage is greater than 100%.

### **Deli, manager, and worker characteristics associated with observed slicer damage: simple regression analyses.**

Simple logistic regression analyses identified 10 of 21 characteristics that were significantly associated ( $P < 0.05$ ) with the observation that all slicers in a deli were free of damage (Table 2). Characteristics associated with higher odds of this outcome were chain ownership, higher average number of workers per shift, more shifts in a typical day, more slicers, more chubs sold weekly, required manager food safety training, existence of written policy for slicer cleaning and sanitizing, interviewed manager previously food safety certified, interviewed manager’s food safety knowledge, and interviewed worker trained in food safety at the deli.

### **Deli, manager, and worker characteristics associated with observed slicer damage: multiple regression analyses.**

A multiple logistic regression analysis identified two characteristics that were significantly associated ( $P < 0.05$ ) with the observation that all slicers in a deli were free of damage (Table 3). Chain delis were more likely to meet the recommendation that slicers be free of damage than were independently owned delis. Delis that provided worker training were more likely to meet the recommendation that slicers should be free of damage than were delis that did not provide worker training.

## **DISCUSSION**

These analyses indicate that many delis have insufficient deli slicer inspection practices; only 26.9% of delis included in our analyses met the FDA-recommended slicer inspection frequency. Most delis also had damaged slicers; only 37.9% of delis included in our analyses had slicers that were undamaged. Given that improperly maintained retail deli slicers have been found to be contributing factors for cross-contamination and growth of *L. monocytogenes*, these results raise concerns (12, 16).



Multiple logistic regression analyses revealed that certain deli characteristics were associated with delis having better slicer inspection practices and slicers that were free of damage. One characteristic in particular, chain ownership, was associated with both positive outcomes. This finding is consistent with other data suggesting that chain establishments may have better food safety practices than independent establishments (2, 3, 8, 9). Compared with independent delis, chain delis may have more resources or more standardized and rigorous processes.

These analyses also revealed that more customers served per day is associated with better slicer inspection practices. This variable is likely a measurement of establishment size or volume. As with chain establishments, larger establishments may have more resources or more standardized and rigorous processes than smaller establishments.

These analyses also revealed that delis that provide worker food safety training were more likely to have damage-free slicers. This finding is consistent with those of other studies in which worker training was associated with good food safety practices (9, 10, 19). This consistency of findings suggests that worker food safety training is important for food safety. Retail delis should consider ensuring that all workers receive food safety training.

Simple logistic regression analyses revealed other characteristics associated with slicer inspection practices and slicer conditions. A higher average number of workers per shift, a higher number of shifts per day, a higher number of slicers, and a higher number of chubs sold weekly were all associated with better slicer inspection practices and with slicers that were free of damage. As with the characteristic of number of customers served daily, these characteristics are likely measures of deli size and are consistent with other findings suggesting that larger establishments tend to have better food safety practices than smaller establishments (3). Delis with written slicer cleaning policies and delis with managers who had been food safety certified and who had a high level of food safety knowledge were also associated with both positive outcomes. As with the characteristic of providing worker food safety training, these characteristics emphasize the importance of workplace policies and well-qualified managers.

Our slicer cleaning and physical condition criteria were derived from the FDA Food Code. However, the slicer inspection criterion was derived from an FDA guidance document because no language in the Food Code specifically addresses slicer inspection practices. Because guidance concerning slicer cleaning and physical condition is separate from guidance concerning slicer inspection practices, some retail delis may not be aware of the important connections between these practices, i.e., that slicer cleaning and inspection should happen at the same frequency (every 4 h as described in the Food Code). To improve public knowledge of this important food safety practice, the FDA should consider incorporating slicer inspection guidance in the Food Code.

This study had several limitations. First, the response rate of 43.1%, although consistent with other similar recent studies, may have resulted in selection bias, e.g., an overrepresentation of delis with better food safety practices(18). Second, because we used interviews to collect data from the workers and managers, the data may have been affected



by desirability bias. This type of bias may result in the overreporting of socially desirable practices by the individuals who were interviewed. Third, the worker data may not represent the full range of the deli's workers because the interviewed worker was chosen by the manager. Fourth, because we collected data from English-speaking managers and workers only, our data may not be fully representative of delis with non-English-speaking staff. The design of this study also did not allow us to make causal inferences about the associations we found between our explanatory and outcome variables. Further research is needed to determine the causal nature of those relationships.

The analyses reported here revealed food safety gaps: some delis are not inspecting slicers according to FDA recommendations, and some delis have damaged slicers. They also revealed deli characteristics linked with better slicer practices, including written slicer policies, worker food safety training, manager certification, and manager food safety knowledge. Regulatory food safety programs and the retail industry should consider ensuring that delis have trained and knowledgeable staff, food safety certified managers, and written slicer policies. Interventions should consider focusing on independent and smaller delis, because these delis were less likely to properly inspect their slicers and to have slicers that were free of damage.

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## REFERENCES

1. Batz MB, Hoffmann S, and Morris JG, Jr. 2012 Ranking the disease burden of 14 pathogens in food sources in the United States using attribution data from outbreak investigations and expert elicitation. *J. Food Prot* 75:1278–1291. [PubMed: 22980012]
2. Bogard A, Fuller C, Radke V, Selman C, and Smith K. 2013 Ground beef handling and cooking practices in restaurants in eight states. *J. Food Prot* 76:2132–2140. [PubMed: 24290692]
3. Brown LG, Hoover R, Ripley D, Matis B, Nicholas D, Hedeem N, and Faw B. 2016 Retail deli slicer cleaning frequency—six selected sites, United States, 2012. *Morb. Mortal. Wkly. Rep* 65:306–310.
4. Centers for Disease Control and Prevention. 2011 Estimates of foodborne illness in the United States. Available at: <http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html>. Accessed 21 April 2017.
5. Centers for Disease Control and Prevention. 2017 EHS-Net retail deli study protocol. Available at: [https://www.cdc.gov/nceh/ehs/ehsnet/study\\_tools/ehs-net-retail-deli-study.pdf](https://www.cdc.gov/nceh/ehs/ehsnet/study_tools/ehs-net-retail-deli-study.pdf). Accessed 29 June 2017.
6. Endrikat S, Gallagher D, Pouillot R, Quesenberry HH, LaBarre D, Schroeder CM, and Kause JA. 2010 A comparative risk assessment for *Listeria monocytogenes* in prepackaged versus retail-sliced deli meat. *J. Food Prot* 73:612–619. [PubMed: 20377948]
7. Gallagher D, Pouillot R, Hoelzer K, Tang J, Dennis SB, and Kause JR. 2016 *Listeria monocytogenes* in retail delicatessens: an interagency risk assessment—risk mitigations. *J. Food Prot* 79:1076–1088. [PubMed: 27357026]
8. Green L, Selman C, Banerjee A, Marcus R, Medus C, Angulo FJ, Radke V, Buchanan S, and EHS-Net Working Group. 2005 Food service workers' self-reported food preparation practices: an EHS-Net study. *Int. J. Hyg. Environ. Health* 208:27–35. [PubMed: 15881976]

9. Green LR, Radke V, Mason R, Bushnell L, Reimann DW, Mack J, Motsinger MD, Stigger T, and Selman C. 2007 Factors related to food worker hand hygiene practices. *J. Food Prot* 70:661–666. [PubMed: 17388056]
10. Green LR, and Selman C. 2005 Factors impacting food workers' and managers' safe food preparation practices: a qualitative study. *Food Prot. Trends* 25:981–990.
11. Keskinen LA, Todd ECD, and Ryser ET. 2008 Impact of bacterial stress and biofilm-forming ability on transfer of surface-dried *Listeria monocytogenes* during slicing of delicatessen meats. *Int. J. Food Microbiol* 127:298–304. [PubMed: 18755520]
12. Lin CM, Takeuchi K, Zhang L, Dohm CB, Meyer JD, Hall PA, and Doyle MP. 2006 Cross-contamination between processing equipment and deli meats by *Listeria monocytogenes*. *J. Food Prot* 69:71–79. [PubMed: 16416903]
13. Lunden JM, Autio TJ, and Korkeala HJ. 2002 Transfer of persistent *Listeria monocytogenes* contamination between food-processing plants associated with a dicing machine. *J. Food Prot* 65:1129–1133. [PubMed: 12117246]
14. Maitland J, Boyer R, Gallagher D, Duncan S, Bauer N, Kause J, and Eifert J. 2013 Tracking cross-contamination transfer dynamics at a mock retail deli market using GloGerm. *J. Food Prot* 76:272–282. [PubMed: 23433375]
15. Pouillot R, Gallagher D, Tang J, Hoelzer K, Kause J, and Dennis S. 2015 *Listeria monocytogenes* in retail delicatessens: an interagency risk assessment—model and baseline results. *J. Food Prot* 78:134–145. [PubMed: 25581188]
16. Powell DA, Jacob CJ, and Chapman BJ. 2011 Enhancing food safety culture to reduce rates of foodborne illness. *Food Control* 22:817–822.
17. Pradhan AK, Ivanek R, Grohn YT, Bukowski R, Geornaras I, Sofos JN, and Wiedmann M. 2010 Quantitative risk assessment of listeriosis-associated deaths due to *Listeria monocytogenes* contamination of deli meats originating from manufacture and retail. *J. Food Prot* 73:620–630. [PubMed: 20377949]
18. Radke TJ, Brown LG, Faw B, Hedeem N, Matis B, Perez P, Viveiros B, and Ripley D. 2017 Restaurant food allergy practices—six selected sites, United States, 2014. *Morb. Mortal. Wkly. Rep* 66:404–407.
19. Sumner S, Brown LG, Frick R, Stone C, Carpenter LR, Bushnell L, Nicholas D, Mack J, Blade H, Tobin-D'Angelo M, Everstine K, and the Environmental Health Specialists Network Working Group. 2011 Factors associated with food workers working while experiencing vomiting or diarrhea. *J. Food Prot* 74:215–220. [PubMed: 21333140]
20. Department of Agriculture US, Food Safety and Inspection Service. 2015 Best practices guidance for controlling *Listeria monocytogenes* (Lm) in retail delicatessens. Available at: <https://www.fsis.usda.gov/wps/wcm/connect/29d51258-0651-469b-99b8-e986baee8a54/Controlling-LM-Delicatessens.pdf?MOD=AJPERES>. Accessed 21 April 2017.
21. U.S. Food and Drug Administration. 2009 Equipment, utensils, and linens, chap. 4. In *Food Code* 2009. Available at: <https://www.fda.gov/food/guidanceregulation/retailfoodprotection/foodcode/ucm2019396.htm>. Accessed 13 October 2015.
22. U.S. Food and Drug Administration. 2011 Keep commercial deli slicers safe. Available at: <http://www.fda.gov/food/guidanceregulation/retailfoodprotection/industryandregulatoryassistanceandtrainingresources/ucm240666.htm>. Accessed 13 October 2015.
23. U.S. Food and Drug Administration. 2013 Equipment, utensils, and linens, chap. 4. In *Food Code* 2013. Available at: <https://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/ucm374275.htm>. Accessed 13 October 2015.
24. U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition; and U.S. Department of Agriculture, Food Safety and Inspection Service. 2003 Quantitative assessment of the relative risk to public health from foodborne *Listeria monocytogenes* among selected categories of ready-to-eat foods. Available at: <http://www.fda.gov/downloads/Food/FoodScienceResearch/UCM197330.pdf>. Accessed 21 April 2017.

**TABLE 1.**

Deli, manager, and food worker characteristics, obtained from manager interviews and surveys and worker interviews<sup>a</sup>

Characteristic	<i>n</i>	%
Deli		
Ownership type ( <i>N</i> = 298)		
Chain	164	55.0
Independent	134	45.0
No. of managers ( <i>N</i> = 298)		
1	102	34.2
>1	196	65.8
Average no. of workers per shift ( <i>N</i> = 298)		
<2	106	35.6
2	192	64.4
No. of shifts in typical day ( <i>N</i> = 298)		
1 or 2	150	50.3
3	148	49.7
No. of hours in typical shift ( <i>N</i> = 298)		
<8	91	30.5
8	207	69.5
No. of customers on busiest day ( <i>N</i> = 262)		
0–300	203	77.5
301	59	22.5
No. of slicers ( <i>N</i> = 298)		
1 or 2	171	57.4
3	127	42.6
No. of chubs sold weekly ( <i>N</i> = 274)		
<30	134	48.9
30	140	51.1
Manager food safety training required by deli ( <i>N</i> = 295)		
Yes	220	74.6
No	75	25.4
Manager food safety certification required by deli <sup>b</sup> ( <i>N</i> = 291)		
Yes	145	49.8
No	146	50.2
Written policy for cleaning and sanitizing slicers ( <i>N</i> = 296)		
Yes	194	65.5
No	102	34.5
Worker-rated difficulty of slicer Leaning ( <i>N</i> = 293)		
Easy	216	73.7
More difficult <sup>c</sup>	77	26.3

Characteristic	<i>n</i>	%
Manager		
Experience in retail food industry ( <i>N</i> = 298)		
10 yr	77	25.8
>10–15 yr	50	16.8
>15 yr	171	57.4
Experience as manager in current deli ( <i>N</i> = 298)		
5 yr	156	52.3
>5 yr	142	47.7
Ever food safety certified <sup>b</sup> ( <i>N</i> = 297)		
Yes	203	68.4
No	94	31.6
Currently food safety certified ( <i>N</i> = 297)		
Yes	164	55.2
No	133	44.8
Food safety knowledge assessment (TV = 298)		
75% correct	97	32.6
>75% correct	201	67.4
Worker		
Experience in retail food industry ( <i>N</i> = 293)		
10yr	163	55.6
>10–15 yr	57	19.5
>15 yr	73	24.9
Experience in current deli ( <i>N</i> = 294)		
5 yr	190	64.6
>5 yr	104	35.4
Received food safety training at current deli ( <i>N</i> = 293)		
Yes	220	75.1
No	73	24.9
Food safety knowledge assessment ( <i>N</i> = 294)		
<100% correct	157	53.4
100% correct	137	46.6

<sup>a</sup> Sample sizes (*N*) differ because of missing data.

<sup>b</sup> Certification defined as having taken and passed a food safety test and been issued a certificate.

<sup>c</sup> Somewhat easy, neither easy nor difficult, somewhat difficult, or difficult to clean.

TABLE 2.

Simple logistic regression analyses of deli, manager, and worker characteristics associated with workers reporting that slicers in their delis were inspected each time slicers were fully cleaned and with all slicers in the deli observed as free of damage<sup>a</sup>

Characteristic	Comparison <sup>b</sup>	Workers said slicers inspected each time, when fully cleaning slicers <sup>c</sup>			All slicers in deli free of damage		
		N	OR (95% CI)	P value	N	OR (95% CI)	P value
Deli							
Ownership type	Chain vs independent	186	7.96 (2.35, 26.98)	<0.001	298	3.55 (2.14, 5.91)	<0.001
No. of managers	>1 vs 1	186	1.63 (0.80, 3.29)	0.177	298	1.11 (0.68, 1.83)	0.673
Avg no. of workers per shift	2 vs <2	186	2.80 (1.02, 7.65)	0.045	298	2.55 (1.51, 4.31)	<0.001
No. of shifts in typical day	3 vs 1 or 2	186	3.83 (1.61, 9.15)	0.003	298	2.37 (1.47, 3.83)	<0.001
No. of hours in typical shift	<8 vs >8	186	0.97 (0.51, 1.88)	0.939	298	0.74 (0.44, 1.23)	0.244
No. of customers on busiest day	301 vs 0–300	156	6.56 (3.07, 13.99)	<0.001	262	1.09 (0.60, 1.98)	0.776
No. of slicers	3 vs 1 or 2	186	3.99 (1.85, 8.59)	<0.001	298	3.03 (1.87, 4.93)	<0.001
No. of chubs sold weekly	30 vs <30	170	2.29 (1.04, 5.03)	0.039	274	2.46 (1.49, 4.05)	<0.001
Manager food safety training required by deli	Yes vs no	184	1.35 (0.42, 4.34)	0.615	295	2.59 (1.42, 4.74)	0.002
Manager food safety certification required by deli <sup>d</sup>	Yes vs no	180	1.99 (0.98, 4.04)	0.058	291	0.95 (0.59, 1.53)	0.843
Written policy for sheer cleaning and sanitizing	Yes vs no	185	6.78 (1.99, 23.05)	0.002	296	2.17 (1.28, 3.66)	0.004
Worker-rated difficulty of slicer cleaning	Easy vs more difficult <sup>e</sup>	185	0.91 (0.46, 1.78)	0.778	293	0.70 (0.41, 1.19)	0.187
Manager							
Experience in retail food industry <sup>f</sup>	10–15 vs 10 yr	80	1.05 (0.40, 2.74)	0.922	127	1.48 (0.72, 3.04)	0.281
	15 vs 10 yr	150	0.90 (0.41, 1.95)	0.786	248	0.74 (0.43, 1.29)	0.292
Experience as manager in current deli	>5 vs 5 yr	186	1.57 (0.83, 2.98)	0.169	298	0.80 (0.50, 1.28)	0.358
Ever food safety certified <sup>d</sup>	Yes vs no	186	2.92 (1.07, 7.97)	0.037	297	1.82 (1.08, 3.09)	0.025
Currently food safety certified <sup>d</sup>	Yes vs no	186	2.53 (1.20, 5.35)	0.015	297	1.16 (0.73, 1.87)	0.532
Food safety knowledge assessment	>75% vs 75% correct	186	3.12 (1.04, 9.40)	0.043	298	1.68 (1.00, 2.82)	0.048
Worker							
Experience in retail food industry <sup>g</sup>	10–15 vs 10 yr	136	0.81 (0.35, 1.88)	0.628	220	1.40 (0.76, 2.58)	0.277
	>15 vs 10 yr	143	1.26 (0.60, 2.66)	0.546	236	0.82 (0.46, 1.47)	0.502
Experience in current deli	>5 vs 5 yr	185	1.77 (0.92, 3.41)	0.086	294	1.27 (0.78, 2.07)	0.348

Characteristic	Workers said slicers inspected each time, when fully cleaning slicers <sup>c</sup>			All slicers in deli free of damage		
	Comparison <sup>b</sup>	N	OR (95% CI)	P value	N	P value
Received food safety training at deli	Yes vs no	185	NI <sup>h</sup>	NI	293	<0.001
Food safety knowledge assessment	100% vs <100% correct	185	1.39 (0.73, 2.66)	0.318	294	0.303

<sup>a</sup>Sample sizes (N) differ because of missing data. OR, odds ratio; CI, confidence interval.

<sup>b</sup>Reference level is the second category listed. Thus, the OR is for the first category listed compared with the second category.

<sup>c</sup>Disassembled, cleaned, and sanitized at least every 4 h.

<sup>d</sup>Certification defined as having taken and passed a food safety test and been issued a certificate.

<sup>e</sup>Somewhat easy, neither easy nor difficult, somewhat difficult, or difficult to clean.

<sup>f</sup>For the overall ORs,  $P = 0.920$  and  $0.094$  for the two models.

<sup>g</sup>For the overall ORs,  $P = 0.647$  and  $0.329$  for the two models.

<sup>h</sup>NI, not included in the simple logistic regression because of a value of 0 in the  $2 \times 2$  table.



**TABLE 3.**

Multiple logistic regression analyses of deli, manager, and worker characteristics associated with workers reporting that slicers in their delis were inspected each time slicers were fully cleaned and with all slicers in the deli observed to be free of damage<sup>a</sup>

Characteristic	Comparison <sup>b</sup>	Workers said slicers inspected each time when fully cleaning slicers <sup>c</sup>		All slicers in deli free of damage	
		OR (95% CI)	P value	OR (95% CI)	P value
Ownership type	Chain vs independent	16.96 (2.20, 130.74)	0.007	3.11 (1.81, 5.33)	<0.001
No. of customers on busiest day	301 vs 0–300	4.64 (2.11, 10.24)	<0.001	NS <sup>d</sup>	NS
Worker training provided by deli	Yes vs no	NS	NS	2.04 (1.05, 3.97)	0.036

<sup>a</sup>OR, odds ratio; CI, confidence interval.

<sup>b</sup>Reference level is the second category listed. Thus, the OR is for the first category listed compared with the second category.

<sup>c</sup>Disassembled, cleaned, and sanitized at least every 4 h.

<sup>d</sup>NS, not significantly associated with the outcome variable.