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Retail Deli Characteristics Associated with Sanitizing Solution Concentrations

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Abstract

Listeria monocytogenes is commonly found in retail delicatessen environments. Proper types and concentrations of sanitizers must be used to eliminate this pathogen from surfaces and reduce the consumer's risk for infection. In 2012, the Environmental Health Specialists Network of the Centers for Disease Control and Prevention completed a study on practices in retail delis that can help prevent cross-contamination and growth of *L. monocytogenes*. The present study focuses on the sanitizing solution used in delis, given its importance to cleaning and reducing pathogen contamination in retail food environments. We identified deli, manager, and worker characteristics associated with use of improper concentrations of sanitizing solution to wipe down food contact surfaces; 22.8% of sanitizing solutions used for wiping food contact surfaces were at improper concentrations. Independent delis were more likely to use improper concentrations of sanitizing solution, as were delis that sold fewer chubs (plastic tubes of meat) per week. Use of improper sanitizing solution concentrations was associated with required food safety training for managers; additional analyses suggest that this relationship is significant for independent but not chain delis. Cleaning and sanitizing must be emphasized in food safety efforts focused on independent and smaller delis.

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Keywords

Deli; *Listeria monocytogenes*; Retail food; Sanitizing solution; U.S. Food and Drug Administration Food Code

The Centers for Disease Control and Prevention (CDC) estimates that 48 million people become sick and 3,000 people die from foodborne illnesses in the United States each year (7). *Listeria monocytogenes* is the third leading cause of death associated with foodborne illnesses, and infection has a 19% fatality rate (21). *L. monocytogenes* is unique among foodborne pathogens in its ability to survive under conditions of high salt concentrations and low temperatures (3, 9, 12). Delicatessen meats are a source of listeriosis cases, and meats sliced and packaged at retail delis are a major source of listeriosis cases (1, 4).

L. monocytogenes can be found on improperly sanitized deli equipment such as slicers, knives, and cutting boards and can adhere to stainless steel food contact surfaces (13, 15). Bacteria can migrate from hands, sponges, clothes, floors, and utensils to many different food contact surfaces (13). Proper sanitization is crucial in places in which food is prepared, and correct concentrations of sanitizing solution must be used on food contact surfaces to kill pathogens, avoid pathogen cross-contamination, and reduce foodborne illness risk. When used at concentrations that are too low, a sanitizing solution does not kill all pathogen cells, and the surviving population can become resistant to that sanitizing agent (1, 18). However, exposure to high concentrations of sanitizing solution, specifically quaternary ammonium, can be toxic to humans (17).

The U.S. Food and Drug Administration (FDA) Food Code (22) provides science-based food safety recommendations for retail food establishments intended to reduce the incidence of foodborne diseases. Most state food safety regulations are based on this Food Code, which includes recommendations for proper temperature, pH, and concentrations of chlorine, quaternary ammonium, and iodine solutions, which are all common sanitizers in retail establishments. The Food Code recommends that all other chemical sanitizers be used by following the specific instructions published by the U.S. Environmental Protection Agency.

In 2012, the CDC Environmental Health Specialists Network (EHS-Net) completed a study to describe practices in retail delis that can prevent cross-contamination and growth of *L. monocytogenes* and to identify deli, manager, and worker characteristics related to those food safety practices (6). The focus of the present article is the concentration of sanitizing solution used in retail delis to wipe down food contact surfaces, given the importance of these solutions for reducing pathogen contamination in retail food environments. We present data on the percentage of delis in the study that used improper sanitizing solutions. We also examine the relationships between improper sanitizer concentrations and specific deli, manager, and worker characteristics.

MATERIALS AND METHODS

EHS-Net, a collaborative program of the CDC, FDA, U.S. Department of Agriculture Food Safety and Inspection Service (FSIS), and health departments focused on the investigation of

environmental factors that contribute to foodborne illness, designed and conducted this study. A CDC cooperative agreement funded the participation of six health departments (jurisdictions) in California, Minnesota, New York State, New York City, Rhode Island, and Tennessee in EHS-Net and in this study.

Sample.

The study sample consisted of randomly selected delis located in the six EHS-Net jurisdictions. Each EHS-Net jurisdiction chose a geographical area in which to recruit delis for study participation. EHS-Net personnel in each jurisdiction collected data from 50 randomly selected retail delis to create the study sample (6). We defined a deli as an establishment that slices meat or cheese and prepares and serves ready-to-eat foods and where food is taken elsewhere to be eaten. We included in the study only those delis in which managers and food workers spoke English well enough to be interviewed in English.

Data collection.

Prior to study recruitment, data collectors completed a data collection training consisting of a webinar and an interactive video that were developed by the CDC and FSIS. Data collectors recruited delis for study participation through telephone calls and collected all data during a single site visit to each deli between January and June 2012. During the site visit, data collectors interviewed a manager (defined as the person who had authority over the deli) about his or her characteristics (e.g., years of experience in retail food industry). They also asked the manager about the deli's characteristics (e.g., average number of customers per day) and its policies and practices relevant to *L. monocytogenes* prevention (e.g., type of surface sanitizer used). Managers also completed a written eight-item food safety knowledge assessment on topics such as cross-contamination, hand hygiene, and hot and cold holding temperatures. EHS-Net staff developed the food safety knowledge assessment for managers based on existing kitchen manager certification examinations. Data collectors interviewed a food worker (someone who prepared food in the deli) about his or her characteristics (Table 1). The interviewer also assessed worker food safety knowledge through five "yes" or "no" questions developed by EHS-Net staff. To increase manager cooperation and decrease burden on the deli, data collectors asked managers to choose the worker to be interviewed.

Data collectors also conducted a structured observation of the deli kitchen area. As part of this observation, data collectors measured the concentration of sanitizing solution in one randomly chosen sanitizer bucket or bottle in use in the deli for wiping down food contact surfaces. According to the Food Code, sanitizing solution used to wipe down food contact surfaces must be at the proper concentration (22). Each data collector used test kits from their jurisdiction's health department to measure the sanitizer concentration according to the kit manufacturer's instructions. The concentration was classified as improper when it was too high or too low (based on the manufacturer's instructions); otherwise, the concentration was classified as proper.

The study protocol received Institutional Review Board approval in each EHS-Net jurisdiction. The study protocol is available on the CDC Web site (6). We did not collect data that could identify individual delis, managers, or workers.

Data analysis.

We first conducted descriptive statistical analyses on deli, manager, and worker characteristics and the observed sanitizing solution concentration then compared the dichotomized outcome (sanitizing solution concentration), using frequencies and the chi-square test, and potential explanatory variables. We controlled for data collection site in both the single and multiple logistic models to hold constant potential variability between sites, such as differences in local or state regulations, departmental training of data collectors, or regional food preferences.

Zou's (24) modified Poisson approach was used to calculate adjusted prevalence ratios between the outcome (modeled as having improper sanitizing solution concentrations) and explanatory variables (deli, manager, and worker characteristics). Significant single characteristic adjusted prevalence ratios ($P < 0.05$) (Table 2) are discussed below.

The multiple logistic regression model was manually constructed using a forward selection procedure with an inclusion criterion of < 0.10 , and variable selection preference was given to maintaining the maximum number of observations. A backwards selection procedure was also utilized with an exclusion criterion of > 0.10 to assess whether different methods converged on the same variable set. A P value of < 0.05 indicated significant findings (Table 3). All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Deli, manager, and worker characteristics.

Two hundred ninety-eight of the eligible 691 delis agreed to participate in the study, yielding a 43.1% participation rate. Data collectors administered an interview and food safety knowledge survey to managers at all participating delis and conducted an observation of the deli environment. In 294 delis (98.7%), data collectors were able to interview a food worker. We excluded 61 delis from analysis because the data collector had not observed the sanitizing solution concentration. We also excluded 46 delis in the California jurisdiction that lacked data points for improper sanitizing solution concentration, reducing the sample size to 191 delis.

Manager interviews revealed that slightly over half (51.3%, $n = 98$) of delis were part of a chain business (private, franchise, or corporate) and the rest (48.7%, $n = 93$) were independently owned. Most delis (57.6%, $n = 110$) had two or more workers per shift. Manager interviews also revealed that most delis (77.7%, $n = 143$) used a ready-to-use sanitizer (purchased from a vendor and diluted according to instructions); the remaining delis (22.3%, $n = 41$) used a self-prepared sanitizer (prepared from in-house common household-strength products). The most commonly used surface sanitizing solution was quaternary ammonium (50.0%, $n = 87$) followed by chlorine or a chlorine-based sanitizer (44.3%, $n = 77$). In most delis (57.1%, $n = 109$), the solution was changed based on a time

schedule (e.g., every x hours and/or at the beginning or end of each shift), but in some delis (25.1%, $n = 48$) it was changed based on appearance (e.g., on an as-needed basis, when the solution appeared dirty, and/or when the solution changed colors) (Table 1).

Over half of managers (51.3%, $n = 98$) had 20 years of experience working in retail food establishments. Most food workers (72.9%, $n = 137$) had received food safety training (general food safety training conducted by management, owner, supervisor, or co-worker or via computer) at their current deli (Table 1). Descriptive data on additional manager and worker characteristics are given in Table 1.

Sanitizing solution concentration.

Sanitizing solution used to wipe down food contact surfaces was at an improper concentration in 54 delis (22.8%).

Deli, manager, and worker characteristics associated with sanitizing solution concentration.

Simple regression analyses identified 6 of 17 characteristics that were significantly associated ($P < 0.05$) with use of improper concentrations of sanitizing solution. Deli characteristics associated with improper concentrations included independent ownership, a moderate average number of customers per day, fewer chubs (plastic tubes of meat) sold weekly, self-preparation method for sanitizing solution, use of chlorine or chlorine-based sanitizing solution, and use of a time schedule as the criterion for changing sanitizing solution. No manager or worker characteristics were significantly associated with improper sanitizing solution in the simple regression analyses (Table 2).

Multiple regression analysis identified four characteristics associated with improper concentrations of sanitizing solution. Improper concentrations were more prevalent at delis that were independently owned, had a manager with more experience (>20 years), sold fewer chubs on a weekly basis, and required managers to have food safety training (Table 3).

Post hoc analyses.

The finding that delis that required manager food safety training were more likely to have improper sanitizing concentrations than delis that did not require manager training is counterintuitive. Thus, we conducted an analysis to investigate whether this finding could be explained by a confounding variable within the multiple regression model. We conducted a series of simple logistic regressions testing the relationship between sanitizing solution concentration and the interaction term of manager training requirements with each of the other deli, manager, and worker characteristics. Only one interaction was significant: deli ownership and required manager training ($P < 0.001$). To explore this interaction, we conducted separate chi-square tests of independence for independently owned delis and chain-owned delis, examining the relationship between required manager training and sanitizing solution concentration in each group of delis. The chi-square test was significant for independent delis ($\chi^2 = 3.94$, $P = 0.047$) but not for chain delis ($\chi^2 = 0.44$, $P = 0.508$). The prevalence ratios were 1.62 (95% confidence interval [CI]: 1.04, 2.54) for independent delis and 0.97 (95% CI: 0.80, 1.18) for chain delis. In the independent deli group, delis that

required manager training were more likely to have improper concentrations of sanitizing solution (54.2%) than would be expected by chance. In comparison, in the chain deli group, delis that required manager training were less likely to have improper concentrations of sanitizing solution (12.5%) than would be expected by chance.

DISCUSSION

Results from this study indicate that in about one in four delis the sanitizing solution used for wiping food contact surfaces was at an improper concentration. Use of improper sanitizing solution concentrations puts delis at risk for survival and proliferation of foodborne pathogens, including *L. monocytogenes*. Our data suggest that delis need to focus on improving their sanitizing solution practices.

Multiple regression results indicated that independently owned delis were more likely to use improper sanitizing concentrations than were chain delis. This finding supports a growing body of research suggesting that chain restaurants have better food safety practices than do independent restaurants (14) perhaps because of standardized practices and greater availability of resources in chain establishments (3, 11, 14). Independently owned establishments might not have the defined structure of a corporate policy or specific food safety practices such as when to change sanitizing solutions. Delis that sold fewer chubs per week were more likely to be using improper sanitizing solution concentrations. As with the findings concerning ownership, these data are consistent with previous research suggesting that busier establishments may be more likely to have better food safety practices (4, 14).

Required manager food safety training was associated with improper sanitizing concentration. Previous research has revealed that food safety training and certification is positively associated with food safety (4, 10, 23). Post hoc analyses conducted to investigate this counterintuitive finding revealed that this relationship was significant for independent but not chain delis. These data suggest that the relationship between training and improper sanitizing solution concentration is driven by a difference between chain and independent delis. Other research has revealed differences between chain and independent food establishments in food safety practices (2), and the quality or quantity of training provided may also differ based on deli ownership types; these kinds of differences may explain the counterintuitive finding. Further research is needed to understand disparities between deli ownership types.

Delis with managers with more experience in the retail food industry had a higher prevalence of use of improper sanitizing solution concentrations. Some research has indicated that experience is associated with food safety; Brown et al. (4) found that workers with more experience reported better food slicer cleaning practices. Others have found that experience is associated with negative food safety outcomes (16). Carpenter et al. (5) found that workers with more experience were more likely to work while ill, and Radke et al. (19) found that experienced managers were less receptive to accommodating patrons with food allergies. Food establishment employees tend to experience high levels of stress, accompanied by monotonous activities and nontraditional work hours during nights and weekends (20). Those managers who have worked in retail food establishments longer may

lack motivation and dedication in their current jobs and be more likely to overlook worker performance and food safety practices (8). More research is needed to explore the relationship between work experience and food safety.

This study had several limitations. The interview data may have been affected by social desirability bias, which may have resulted in managers and workers responding with what they thought was the correct answer rather than describing practices they actually follow at the establishment. Because the manager on duty chose the worker to be interviewed, the sample of workers may not have been representative of the full range of workers. Managers and workers chosen for the study were limited to those who spoke English, removing our ability to represent delis without English-speaking staff, and the cross-sectional study design does not allow us to make causal inferences. We assessed only whether the sample sanitizing solution concentration was outside the recommended range; we did not differentiate between solutions that did not have enough sanitizer and those that had too much sanitizer. Although both situations pose a risk, the consequences for each extreme are different.

Our results suggest that some delis need to improve their sanitizing solution practices. *L. monocytogenes* is a concern in the retail deli environment, and its unique characteristics allow this pathogen to grow in many environments and on many surfaces, resulting in outbreaks and deaths. Proper sanitizing practices can reduce this risk for deli customers. Interventions in this area should focus on independent and smaller delis. Given our unexpected findings associating required manager food safety training with improper concentrations of sanitizing solution, the relationship between manager training and food safety practices warrants further research.

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REFERENCES

1. Aase B, Sundheim G, Langsrud S, and Rørvik LM. 2000. Occurrence of and a possible mechanism for resistance to a quaternary ammonium compound in *Listeria monocytogenes*. *Int. J. Food Microbiol* 62:57–63. [PubMed: 11139022]
2. Brown L. 2013. EHS-Net restaurant food safety studies: what have we learned? *J. Environ. Health* 75:44–45.
3. Brown LG, Hoover ER, Faw BV, Hedeem NK, Nicholas D, Wong MR, Shepherd C, Gallagher DL, and Kaase JR. 2018. Food safety practices linked with proper refrigerator temperatures in retail delis. *Foodborne Pathog. Dis* 15:300–307. [PubMed: 29498545]
4. Brown LG, Hoover ER, 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.
5. Carpenter LR, Green AL, Norton DM, Frick R, Tobin-D'Angelo M, Reimann DW, Blade H, Nicholas DC, Egan JS, Everstine K, Brown LG, and Le B. 2013. Food worker experiences with and beliefs about working while ill. *J. Food Prot* 76:2146–2154. [PubMed: 24290694]

6. Centers for Disease Control and Prevention. 2012. EHS-Net retail deli study protocol Available at: https://www.cdc.gov/nceh/ehs/ehsnet/study_tools/ehs-net-retail-deli-study.pdf. Accessed February 2019.
7. Centers for Disease Control and Prevention. 2018. Burden of foodborne illness: findings. Available at: <https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html>. Accessed 8 November 2018.
8. Clayton ML, Clegg Smith K, Neff RA, Pollack KM, and Ensminger M. 2015. Listening to food workers: factors that impact proper health and hygiene practice in food service. *Int. J. Occup. Environ. Health* 21:314–327. [PubMed: 26243248]
9. de Noordhout CM, Devleeschauwer B, Angulo FJ, Verbeke G, Haagsma J, Kirk M, Havelaar A, and Speybroeck N. 2014. The global burden of listeriosis: a systematic review and meta-analysis. *Lancet Infect. Dis* 14:1073–1082. [PubMed: 25241232]
10. Hedberg CW, Smith SJ, Kirkland E, Radke V, Jones TF, Selman CA, and the EHS-Net Working Group. 2006. Systematic environmental evaluations to identify food safety differences between outbreak and nonoutbreak restaurants. *J. Food Prot* 69:2697–2702. [PubMed: 17133814]
11. Kassa H, Silverman GS, and Baroudi K. 2010. Effect of a manager training and certification program on food safety and hygiene in food service operations. *Environ. Health Insights* 4:13–20. [PubMed: 20523880]
12. Kurpas M, Wieczorek K, and Osek J. 2018. Ready-to-eat meat products as a source of *Listeria monocytogenes*. *J. Vet. Res* 62:49–55. [PubMed: 29978127]
13. Kusumaningrum HD, Riboldi G, Hazeleger WC, and Beumer RR. 2003. Survival of foodborne pathogens on stainless steel surfaces and cross-contamination to foods. *Int. J. Food Microbiol* 85:227–236. [PubMed: 12878381]
14. Lipcsei LE, Brown LG, Hoover ER, Faw BV, Hedeem N, Matis B, Nicholas D, and Ripley D. 2018. Retail deli slicer inspection practices: an EHS-Net study. *J. Food Prot* 81:799–805. [PubMed: 29637808]
15. Lundén 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]
16. McIntyre L, Vallaster L, Wilcott L, Henderson SB, and Kosatsky T. 2013. Evaluation of food safety knowledge, attitudes and self-reported hand washing practices in FOODSAFE trained and untrained food handlers in British Columbia, Canada. *Food Control* 30:150–156.
17. Nagamune H, Maeda T, Ohkura K, Yamamoto K, Nakajima M, and Kourai H. 2000. Evaluation of the cytotoxic effects of bis-quaternary ammonium antimicrobial reagents on human cells. *Toxicol. In Vitro* 14:139–147. [PubMed: 10793292]
18. Ortega Morente E, Fernández-Fuentes MA, Grande Burgos MJ, Abriouel H, Pérez Pulido R, and Gálvez A. 2013. Biocide tolerance in bacteria. *Int. J. Food Microbiol* 162:13–25. [PubMed: 23340387]
19. Radke TJ, Brown LG, Hoover ER, Faw BV, Reimann D, Wong MR, Nicholas D, Barkley J, and Ripley D. 2016. Food allergy knowledge and attitudes of restaurant managers and staff: an EHS-Net study. *J. Food Prot* 79:1588–1598. [PubMed: 28221943]
20. Sahin H. 2012. The level of burnout of kitchen personnel in accommodation facilities. *Int. J. Bus. Social Sci* 3:116–120.
21. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, and Griffin PM. 2011. Foodborne illness acquired in the United States—major pathogens. *Emerg. Infect. Dis* 17:7–15. [PubMed: 21192848]
22. U.S. Food and Drug Administration. 2009. Food Code. U.S. Food and Drug Administration, Silver Spring, MD.
23. Webb M, and Morancie A. 2015. Food safety knowledge of foodservice workers at a university campus by education level, experience, and food safety training. *Food Control* 50:259–264.
24. Zou G. 2004. A modified Poisson regression approach to prospective studies with binary data. *Am. J. Epidemiol* 159:702–706. [PubMed: 15033648]

HIGHLIGHTS

- In 22.8% of delis, improper sanitizing solutions were used to wipe food contact surfaces.
- Food safety programs should perhaps focus on sanitizing education for smaller delis.
- More manager experience was associated with use of improper sanitizing solutions.

TABLE 1.

Deli, manager, and worker characteristics^a

Characteristic	Total no. (%)	No. (%) with improper sanitizing solution concn
Deli		
Ownership type (<i>N</i> = 191)		
Chain	98 (51.3)	13 (24.1)
Independent	93 (48.7)	41 (75.9)
Avg no. of customers/day (<i>N</i> = 180)		
99	75 (41.7)	31 (57.4)
100–299	73 (40.5)	16 (29.6)
300	32 (17.8)	7 (13.0)
No. of managers (<i>N</i> = 191)		
1	77 (40.3)	24 (44.4)
2	78 (40.8)	21 (38.9)
3	36 (18.9)	9 (16.7)
Avg no. of workers/shift (<i>N</i> = 191)		
<2	81 (42.4)	30 (55.6)
2	110 (57.6)	24 (44.4)
No. of chubs (plastic tubes of meat) sold/wk (<i>N</i> = 178)		
30	98 (55.1)	41 (77.4)
>30	80 (44.9)	12 (22.6)
Manager food safety training required by deli (<i>N</i> = 188) ^b		
Yes	136 (72.3)	37 (69.8)
No	52 (27.7)	16 (30.2)
Manager food safety certification required by deli (<i>N</i> = 185) ^c		
Yes	103 (55.7)	30 (55.6)
No	82 (44.3)	24 (44.4)
Written policy for cleaning and sanitizing (<i>N</i> = 190)		
Yes	124 (65.3)	35 (64.8)
No	66 (24.7)	19 (35.2)
Method for sanitizing solution preparation (<i>N</i> = 184) ^{d, e}		
Ready to use	143 (77.7)	35 (67.3)
Self-prepared	41 (22.3)	17 (32.7)
Surface sanitizer type (<i>N</i> = 174) ^e		
Quaternary ammonia	87 (50.0)	13 (25.5)
Chlorine or chlorine based	77 (44.3)	35 (68.6)
Mixed	10 (5.7)	3 (5.9)
Criterion for changing sanitizing solution (<i>N</i> = 191) ^{e, f}		
Time schedule	109 (57.1)	24 (44.4)
Appearance	48 (25.1)	21 (38.9)

Characteristic	Total no. (%)	No. (%) with improper sanitizing solution concn
Time and appearance	34 (17.8)	9 (16.7)
Manager		
Years of experience in retail food industry (<i>N</i> = 191)		
<10	30 (15.7)	6 (11.1)
10–20	63 (33.0)	16 (29.6)
>20	98 (51.3)	32 (59.3)
Food safety certified (<i>N</i> = 190) ^c		
Yes	132 (69.5)	33 (62.3)
No	58 (30.5)	20 (37.7)
Food safety knowledge assessment score (<i>N</i> = 191)		
75%	58 (30.4)	25 (46.3)
>75%	133 (69.6)	29 (53.7)
Worker		
Years of experience in retail food industry (<i>N</i> = 188)		
<10	94 (50.0)	32 (60.4)
10	94 (50.0)	21 (39.6)
Food safety knowledge assessment score (<i>N</i> = 189)		
<100%	93 (49.2)	33 (62.3)
100%	96 (50.8)	20 (37.7)
Received food safety training at current deli (<i>N</i> = 188) ^b		
Yes	137 (72.9)	31 (58.5)
No	51 (27.1)	22 (41.5)

^aSample sizes differ because of missing data.

^bFood safety trainings could be formal or informational.

^cCertification was defined as having passed a food safety test and been issued a certificate.

^dSelf-prepared, prepared from in-house common household-strength products; ready to use, purchased from a vendor and diluted according to instructions or used without dilution.

^eSanitizer used to wipe down food contact surfaces.

^fAppearance, solution was changed when it appeared dirty, changed color, and/or “as needed”; time, solution was changed according to a specified time schedule and/or at the beginning or end of each shift.

TABLE 2.

Simple logistic regression models of deli, manager, and worker characteristics associated with improper sanitizing concentration^a

Characteristic	Comparison	PR (95% CI) ^b	P value ^c
Deli			
Ownership type (N = 191)	Independent vs chain	2.76 (1.44, 5.30)	0.002*
Avg no. of customers/day (N = 180) (P = 0.044)	100–299 vs 0–99	0.54 (0.33, 0.90)	0.019*
	300 vs 0–99	0.65 (0.31, 1.35)	0.246
No. of managers (N = 191) (P = 0.785)	2 vs 1	0.85 (0.53, 1.37)	0.510
Avg no. of workers/shift (N = 191)	3 vs 1	0.98 (0.47, 2.05)	0.960
	2 vs <2	0.77 (0.48, 1.26)	0.307
No of chubs (plastic tube of meat) sold/wk (N = 178)	30 vs >30	2.32 (1.23, 4.35)	0.009*
Manager food safety training required by deli (N = 188) ^d	Yes vs no	1.42 (0.82, 2.45)	0.208
Manager food safety certification required by deli (N = 185) ^e	Yes vs no	1.15 (0.72, 1.81)	0.554
Written policy for preparing sanitizing solution (N = 190)	Yes vs no	0.87 (0.50, 1.52)	0.624
Method for preparing sanitizing solution (N = 184) ^f	Self-prepared vs ready to use	1.73 (1.00, 3.02)	0.052*
Surface sanitizer used at deli (N = 174) (P = 0.036)	Chlorine or chlorine based vs quaternary ammonia	2.68 (1.12, 6.38)	0.026*
	Mixed vs quaternary ammonia	1.93 (0.64, 5.81)	0.243
Criterion for changing sanitizing solution (N = 191) (P = 0.026) ^g	Time vs appearance	0.53 (0.33, 0.86)	0.010*
	Time and appearance vs appearance	0.82 (0.44, 1.54)	0.537
Manager			
Years of experience in retail food industry (N = 191) (P = 0.323)	10–20 vs <10	1.36 (0.61, 3.00)	0.451
	>20 vs <10	1.65 (0.77, 3.53)	0.196
Food safety certified (N = 190) ^e	Yes vs no	0.76 (0.47, 1.21)	0.250
Food safety knowledge assessment score (N = 191)	>75% vs 75%	0.80 (0.44, 1.43)	0.446
Worker			
Years of experience in retail food industry (N = 188)	10 vs <10	0.80 (0.50, 1.28)	0.351
Food safety knowledge assessment score (N = 189)	100% vs <100%	0.81 (0.50, 1.32)	0.404
Received food safety training at current deli (N = 188) ^d	No vs yes	1.35 (0.85, 2.15)	0.202

^aModels adjusted for site. Sample sizes differ because of missing data. Sanitizer was used to wipe down food contact surfaces.

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^bPR, prevalence ratio; CI, confidence interval.

^cAsterisks indicate significant values ($P < 0.05$).

^dFood safety trainings could be formal or informational.

^eCertification defined as having taken or passed a food safety test and been issued a certification.

^fSelf-prepared, prepared from in-house common household-strength products; ready to use, purchased from a vendor and diluted according to instructions or used without dilution.

^gAppearance, water appeared dirty, changed color, and/or “as needed”; time, an hourly rate and/or at the beginning or end of each shift.

TABLE 3.

Multiple logistic regression model of deli, manager, and worker characteristics associated with improper sanitizing concentrations^a

Characteristic	Comparison	PR (95% CI) ^b	P value ^c
Deli ownership type	Independent vs chain	2.07 (1.02, 4.19)	<0.001*
Manager years of experience in retail food industry ($P=0.050$)	10–20 vs <10	1.70 (0.81, 3.59)	0.162
	>20 vs <10	2.15 (1.04, 4.48)	0.040*
No. of chubs (plastic tubes of meat) sold/wk	30 vs >30	2.24 (1.12, 4.51)	0.033*
Manger food safety training required by deli ^d	Yes vs no	1.95 (1.17, 3.25)	0.032*

^a $N=173$. Models adjusted for site. Sanitizer was used to wipe down food contact surfaces.

^b PR, prevalence ratio; CI, confidence interval.

^c Asterisks indicate significant values ($P=0.05$).

^d Food safety trainings could be formal or informational.