HHS Public Access

Author manuscript

J Food Prot. Author manuscript; available in PMC 2021 September 01.

Published in final edited form as:

J Food Prot. 2020 September 01; 83(9): 1607–1618. doi:10.4315/JFP-20-102.

Restaurant Policies and Practices Related to Norovirus Outbreak Size and Duration

E. RICKAMER HOOVER[1,*], **NICOLE HEDEEN**[2], **AMY FREELAND**[1], **ANITA KAMBHAMPATI**[3], **DANIEL DEWEY-MATTIA**[4], **KRISTI-WARREN SCOTT**[1], **ARON HALL**[3], **LAURA BROWN**[1]

[1]Centers for Disease Control and Prevention, National Center for Environmental Health, Atlanta, Georgia 30341, USA

[2]Minnesota Department of Health, St. Paul, Minnesota 55155, USA;

[3]Centers for Disease Control and Prevention, National Center for Infectious and Respiratory Diseases, Atlanta, Georgia 30333, USA;

[4]Centers for Disease Control and Prevention, National Center for Emerging Zoonotic Infectious Diseases, Atlanta, Georgia 30333, USA

Abstract

Norovirus is the leading cause of foodborne illness outbreaks in the United States, and restaurants are the most common setting of foodborne norovirus outbreaks. Therefore, prevention and control of restaurant-related foodborne norovirus outbreaks is critical to lowering the burden of foodborne illness in the United States. Data for 124 norovirus outbreaks and outbreak restaurants were obtained from Centers for Disease Control and Prevention surveillance systems and analyzed to identify relationships between restaurant characteristics and outbreak size and duration. Findings showed that restaurant characteristics, policies, and practices were linked with both outbreak size and outbreak duration. Compared with their counterparts, restaurants that had smaller outbreaks had the following characteristics: managers received food safety certification, managers and workers received food safety training, food workers wore gloves, and restaurants had cleaning policies. In addition, restaurants that provided food safety training to managers, served food items requiring less complex food preparation, and had fewer managers had shorter outbreaks compared with their counterparts. These findings suggest that restaurant characteristics play a role in norovirus outbreak prevention and intervention; therefore, implementing food safety training, policies, and practices likely reduces norovirus transmission, leading to smaller or shorter outbreaks.

Keywords

Foodborne outbreaks; Food safety certification; Food safety policies and practices; Food safety training; Norovirus outbreaks; Outbreak prevention

[*]Author for correspondence. Tel: 770-488-4332; Fax: 770-488-7310; xmo2@cdc.gov.

Norovirus is the leading cause of foodborne illness outbreaks in the United States. From 2009 to 2015, norovirus was the most common cause of single-etiology foodborne outbreaks (38%) and outbreak-associated illnesses (41%) (11). Restaurants are the most common settings of foodborne norovirus outbreaks (81%) (15) and almost half (46%) of restaurant-related foodborne outbreaks are caused by norovirus (1). These data indicate that prevention and control of restaurant-related foodborne norovirus outbreaks are critical to lowering the burden of foodborne illness in the United States.

Infected food workers are the most frequent source of food contamination in foodborne norovirus outbreaks (70%) (15). Food workers' barehand contact with ready-to-eat food (food that requires no further preparation) is frequently the cause of contamination (15). Consequently, in addition to preventing ill or infectious staff from working, proper hand hygiene (appropriate hand washing and using gloves or utensils to prevent barehand contact with ready-to-eat foods) is key to preventing norovirus outbreaks and illness (15). Cleaning and sanitizing surfaces that come into contact with food are also important to reduce norovirus transmission in food service settings, because norovirus can persist on surfaces for long periods and be transferred to foods prepared on those surfaces (12).

The U.S. Food and Drug Administration (FDA) Food Code, a model set of science-based, comprehensive food safety guidelines, provides the basis for state and local food codes that regulate retail food service in the United States. The FDA Food Code contains guidelines aimed at preventing foodborne illness in food establishments and is revised periodically (25). Food Code provisions prohibit food workers from handling ready-to-eat foods with their bare hands (and suggest using barriers such as gloves), prohibit ill food workers from working or from handling food, and specify when and how food contact surfaces should be cleaned and sanitized.

The purpose of this article is to examine relationships between restaurant food safety policies and practices and norovirus outbreak characteristics. More specifically, we examine associations between policies and practices, particularly those associated with norovirus prevention, and outbreak size and duration in restaurants in which a norovirus outbreak occurred. In particular, we focus on policies and practices related to glove use, ill workers, and cleaning and sanitizing processes. We also examine additional restaurant characteristics that have been hypothesized or found to be associated with restaurant food safety. The results of these analyses will contribute to identifying and understanding restaurant characteristics that may mitigate norovirus outbreaks.

MATERIALS AND METHODS

We obtained data for this study from the two Centers for Disease Control and Prevention (CDC) foodborne outbreak reporting systems: the National Environmental Assessment Reporting System (NEARS) and the Foodborne Disease Outbreak Surveillance System (FDOSS). The study data set included only outbreaks that were reported in both systems. For both systems, a foodborne outbreak is defined as two or more cases of a similar illness linked to a common exposure (e.g., a setting or a food).

NEARS: outbreak establishment characteristics.

We obtained data on characteristics of food establishments that experienced a foodborne outbreak from the NEARS. NEARS is a voluntary reporting system through which environmental health programs in state and local health departments report data to CDC from the environmental health component of their investigations of food establishment outbreaks (10). This component is designed to describe the environment in which the outbreak occurred and identify the factors and antecedents contributing to outbreaks. In a typical environmental assessment, an environmental health investigator visits the outbreak establishment and interviews the manager about establishment characteristics, such as food safety policies and practices and worker practices that may have contributed to the outbreak. The assessment also typically involves observing worker food preparation practices, specifically preparation of food items suspected to be linked to the outbreak. At the end of their investigation, participating health departments report selected data points from their environmental assessment through the NEARS Web-based reporting system.

Table 1 lists the variables extracted from NEARS and included in this study, along with data collection methods for the variables. They include establishment characteristics hypothesized or found to be associated with food safety at retail food establishments, such as staff food safety training and certification and establishment ownership (2, 3, 5, 8, 16, 20, 23, 24). They also include establishment policies and practices designed to prevent contamination of food, focusing on hand hygiene (e.g., glove-use policy), preventing ill workers from working (e.g., policy requiring workers to inform their manager when they are ill), and cleaning and sanitizing (e.g., cleaning policy for food prep tables). Policies were coded as verbal (the policy is verbally conveyed to workers but is not written) or written.

FDOSS: outbreak characteristics.

We obtained data on foodborne outbreak characteristics from the FDOSS (Table 1). Outbreaks are voluntarily reported to FDOSS through the National Outbreak Reporting System, a Web-based platform used by state and local health departments to report epidemiologic and laboratory data from their foodborne outbreak investigations to CDC. Typically, epidemiology or communicable disease control programs within health departments collect and report these data, which include outbreak characteristics such as confirmed or suspected etiologies, implicated food, outbreak settings, and reported illnesses, hospitalizations, and deaths associated with the outbreak. We extracted data from FDOSS on outbreak size (number of suspected and confirmed primary illness cases associated with the outbreak), outbreak duration in days (date of last reported illness onset minus date of first reported illness onset), and cohort or case-control studies conducted as part of the outbreak investigation.

Final data set.

From 1 January 2014 through 31 December 2016, 16 state and local health departments reported 404 foodborne illness outbreaks to NEARS. We matched 341 (84.4%) of the 404 NEARS outbreak records with FDOSS outbreak records; matches were based on outbreak identification numbers reported in the systems and manual review of pertinent outbreak characteristics (e.g., mode of transmission, location, etiology, and dates). Of the 341

matched outbreaks, 95.6% (326) of those had exposure that took place at a single location. To limit variability, we chose to include only outbreaks associated with restaurants and exclude other food establishments from our analyses (hereafter, we use the term "restaurant"). Of the 326 single-setting outbreaks, 270 (82.8%) were associated with a restaurant. Outbreak etiologies for both outbreak reporting systems were classified as confirmed if they were confirmed according to CDC laboratory and clinical guidelines (9); otherwise, they were classified as suspected. Among the 270 restaurant outbreaks, norovirus was reported as the sole etiology in 135 (50.0%). Eleven outbreaks were excluded from analysis because restaurant manager interviews were not conducted. The final data set contained 124 norovirus outbreaks associated with a restaurant. These outbreaks occurred in Connecticut, Minnesota, New York City, New York State (excluding New York City), Rhode Island, Tennessee, Washington, and Wisconsin.

Potential control variables.

Two potential control variables were included in the multiple-variable models. The first was whether a cohort or case-control study was conducted as part of the investigation. Such epidemiologic studies can help implicate specific foods and can potentially identify more cases or be used in outbreaks with a larger number of cases. Therefore, we corrected for the influence of epidemiologic studies to test the unique relationships between restaurant characteristics and outbreak size and duration. The second potential control variable was whether the restaurant was part of a chain or was independently owned. Previous research has shown a consistent relationship between ownership and food safety (2, 3, 6, 14, 17, 20). Again, we corrected for the influence of ownership to test the unique relationships between restaurant characteristics and outbreak size and duration. We also considered controlling for the number of meals the restaurant served daily, assuming this variable would be linked with outbreak size. However, no evidence supported this assumption, so we did not control for number of meals served in the analyses.

Regressions.

We first calculated descriptive statistics on all continuous restaurant characteristic variables (e.g., number of critical violations) and dichotomized them using approximate median splits. Next, we calculated the frequency and mean size and duration of each characteristic option (Table 2). We then conducted truncated simple negative binomial regression models to examine the relationships of each of the 22 characteristics with outbreak size and duration (Tables 3 and 4). Finally, we conducted multiple-variable, truncated, negative binomial regression models examining the relationship between each of the characteristic variables and each of the two outcomes, controlling for ownership type and investigation methods (Tables 3 and 4). The outcome distributions are negative binomial, because they are positively skewed, made up of count data, and have variances greater than their means (i.e., overdispersion). Both outcomes are truncated, because their minimum values must be greater than zero. An outbreak, by definition, must involve at least two people (outbreak size ≥ 2) and must last for a minimum of 1 day (outbreak duration ≥ 1).

Results are presented in terms of predicted values, predicted value ratios (i.e.,e^{β_i}), and the nonstandardized beta weight P values. The results and discussion focus on the multiple-

variable models, but we included the single-variable models to put effects into context. Characteristics significant at $P < 0.05$ are discussed below. All analyses were conducted with SAS 9.4 with advance modeling using PROC NLMIXED.

RESULTS

Outbreak characteristics.

The median outbreak size was 11.5 ill people (Q1 = 7.0, Q3 = 23.5, min = 2, max = 112). The mean outbreak size was 18.7 ill people (variance = 375.0, skewness = 2.5, $n = 124$). The median outbreak duration was 3.0 days (Q1 = 2.0, Q3 = 4.0, min 1, max = 13). The mean outbreak duration was 3.5 days (variance = 5.9, skewness = 2.0, $n = 124$). Outbreak size and duration were moderately positively correlated ($r = 0.63$, $P < 0.001$).

Investigators identified at least one contributing factor in 92 outbreaks (74.2%). Outbreaks can have more than one contributing factor, and 112 were identified altogether, all related to contamination. The most frequent contributing factor was barehand contact by a food worker suspected to be infectious (44.6%, 41 of 92), followed by contamination (other than by hands) by a food worker suspected to be infectious (32.6%, 30) and gloved-hand contact by a food worker suspected to be infectious (16.3%, 15). Altogether, 93.5% of outbreaks (86) had one of these three infectious food worker contributing factors. Other contributing factors were contamination by a nonfood worker suspected to be infectious (3.3%, 3), contaminated raw product (1.1%, 1), storage in a contaminated environment (1.1%, 1), and other source of contamination (2.1%, 2).

Restaurant characteristics.

Most restaurants reporting norovirus outbreaks were independently owned (73.4%), had complex food preparation processes (processes requiring a kill step, which include holding beyond same-day service or a combination of holding, cooling, reheating, and freezing) (87.9%), and served 200 or fewer meals a day (52.1%) (Table 4). Most restaurants had at least one food safety–certified kitchen manager (84.6%) and provided food safety training to managers (95.2%) and food workers (92.7%). The largest category of training provided to managers was both on-the-job and classroom training (47.6%), whereas the largest category of training provided to food workers was on the job (49.6%). Investigators observed food workers wearing gloves while handling food in most restaurants (85.5%) but observed food workers handling ready-to-eat foods with their bare hands in almost a third of restaurants (27.4%). Most restaurants (91.1%) had a verbal or written disposable glove-use policy, but less than a third (30.9%) had a written policy. Most restaurants (93.4%) had a verbal or written policy requiring workers to tell managers when they were ill; about 60% (59.3%) had a written policy. Most restaurants (>92.7%) had a verbal or written cleaning policies for the kitchen floor, cutting boards, and food prep tables, but less than half of restaurants (<47.6%) had written cleaning policies. Table 4 contains data on additional characteristics.

Restaurant characteristics predictive of outbreak size.

Simple regression analysis identified seven characteristics that significantly predicted ($P <$ 0.05) restaurants' outbreak size (Table 2). The following characteristics predicted smaller

outbreaks: lack of case control or cohort studies, one or more critical violations on the last routine inspection, at least one food safety–certified manager, food safety training for kitchen managers and for food workers, glove-use, and cleaning policies.

Multiple regression models, controlling for ownership and outbreak investigation methods, identified seven characteristics that significantly predicted restaurants' average outbreak size (Table 2). Outbreak size was significantly smaller in restaurants with at least one food safety–certified kitchen manager than in restaurants in which no kitchen managers were certified (ratio [outbreak size for restaurants with at least one certified manager divided by outbreak size for restaurants with no certified managers] = 0.57). Compared with when no food safety training was provided to managers, outbreak size was significantly smaller for restaurants in which manager food safety training was provided in the classroom (ratio = 0.48), on the job (ratio = 0.27), and both in the classroom and on the job (ratio = 0.34). Compared with when only classroom training was provided to managers, outbreak size was also significantly smaller for restaurants in which both classroom and on-the-job training were provided (ratio = 0.72) and when only on-the-job training was provided (ratio = 0.47). The pattern of results differed for food safety training for food workers. Outbreak size was significantly smaller in restaurants that provided classroom and on-the-job training to food workers than in restaurants that provided no training (ratio = 0.43), only classroom training (ratio = 0.50), and only on-the-job training (ratio = 0.61). Outbreak size was significantly smaller for restaurants in which investigators saw food workers wearing gloves while handling food than in restaurants in which glove use was not seen (ratio = 0.56). Restaurants that had a verbal or written cleaning policy for kitchen floors had significantly smaller outbreaks than restaurants that had no cleaning policy for kitchen floors (ratios = 0.31 or 0.29, respectively). Outbreak size was also significantly smaller for restaurants that had a written cleaning policy for cutting boards (ratio = 0.68) and food prep tables (ratio = 0.63) compared with restaurants with verbal policies only. None of the general restaurant characteristics or ill worker characteristics were significantly associated with outbreak size.

Restaurant characteristics predictive of outbreak duration.

Simple regression analysis identified four characteristics that significantly predicted ($P < 0.05$) restaurants' outbreak duration (Table 3). Characteristics that predicted shorter outbreaks included complexity of the food preparation process, number of managers, and food safety training for kitchen managers and for food workers. Multiple regression models, controlling for ownership and outbreak investigation methods, identified three characteristics that significantly predicted restaurants' outbreak duration (Table 3). Outbreak duration was significantly shorter for restaurants for which cook-serve (food items requires a kill step, such as cooking) was their most complex food preparation process compared with restaurants that served foods requiring complex food preparation (food item requires a kill step and holding beyond same-day service or a combination of holding, cooling, reheating, and freezing) (ratio = 0.52) and for restaurants with one or two managers compared with three or more managers (ratio = 0.65). Compared with when no food safety training was provided to managers, outbreak duration was significantly shorter for restaurants in which manager food safety training was provided in the classroom and both in the classroom and on the job (classroom ratio = 0.55, both classroom and on-the-job ratio = 0.47).

DISCUSSION

More than 90% of outbreaks with identified contributing factors in this study involved contamination by ill workers; these data indicate that contamination by ill workers is the most common contributing factor in foodborne norovirus outbreaks associated with restaurants. This finding is consistent with previous analyses of national outbreak data (19). The descriptive data also highlight some gaps in restaurant policies and practices that might play a role in outbreak prevention and mitigation. These include gaps in food safety training for managers and workers, in cleaning and ill worker policies, and in glove use. The regression findings presented here support the contention that these gaps may be related to outbreak size and duration. Compared with their counterparts, restaurants that had smaller outbreaks had food safety–certified managers, provided food safety training to their managers and workers, required food workers to wear gloves, and had cleaning policies. Restaurants had shorter outbreaks if they provided food safety training to managers.

The finding that norovirus outbreaks were smaller in restaurants with food safety–certified managers and restaurants providing food safety training to managers and workers supports a growing body of research showing that food safety training and certification is important to retail food safety. Much of this research has documented links between food safety training and certification and safer retail food preparation practices, such as appropriate hand washing, food storage temperatures, and frequent slicer cleaning (3, 5, 8, 13, 17, 25). The data presented here suggest that this link between training and practices may translate to reduced outbreak size.

Our findings on relationships between food safety training and outbreak size further support the importance of training to food safety. Outbreak size was smaller when food safety training was provided than when it was not; this finding was particularly pronounced for manager training. The findings that outbreak size is smaller for restaurants providing both on-the-job and classroom training than for restaurants providing only one type of training suggests that multiple delivery methods may improve the impact of training. Specifically, this finding suggests that on-the-job training is preferable to classroom training; on-the-job training can provide context and allow real-world application of training principles, likely facilitating understanding and adoption of food safety practices. Alternatively, this finding may simply indicate that more training is better than less training. Recent reviews on the effectiveness of food safety training are inconclusive on these specific issues (21, 27) and more research is needed to explore this relationship.

The finding that norovirus outbreaks were smaller in restaurants that had cleaning policies suggests the potential benefits of such policies in mitigating outbreak size. Proper cleaning and sanitizing are important in preventing norovirus outbreaks, because these practices reduce contamination risk and worker exposure to viruses persistent on surfaces (12). Because norovirus is resistant to many common cleaners, has a low infectious dose, and can persist in the environment for days to weeks (18) the existence of (and though unmeasured in this study, adherence to) specific procedures for cleaning and sanitizing is likely a critical measure to control further spread. A recent study found that delis with slicer cleaning policies cleaned their slicers more frequently than delis without such policies (3).

The finding that outbreak size was significantly smaller in restaurants in which food workers were wearing gloves suggests that glove use may mitigate outbreak size. Although the finding was nonsignificant, the directionality of the glove-use policy finding supports this assertion; greater policy formality was related to smaller outbreaks. That is, outbreaks were largest when there was no glove-use policy and smallest when there was a written glove-use policy.

Observed worker barehand contact with ready-to-eat food was not related to outbreak size and duration, even though barehand contact by an infectious worker was the most common contributing factor to the outbreaks in this study. Worker barehand contact with ready-to-eat foods may cause outbreaks but may not substantially influence outbreak size or duration. Minimizing barehand contact with ready-to-eat food is an important step in preventing norovirus transmission and outbreaks, and glove use is a common way to prevent that contact in restaurants. Further investigation is warranted to explore these relationships.

One relationship between establishment characteristics and outbreak duration mirrored outbreak size relationships. Outbreaks were shorter in restaurants where managers were provided food safety training. However, two relationships were unique to outbreak duration. Restaurants that only served food items not involving temperature control processes (such as holding and cooling) had shorter outbreaks than restaurants serving food items that did involve these processes. Although possible temperature abuse during these processes does not lead to proliferation of norovirus as it does with bacteria, food items involving complex food preparation may involve more handling and thus may create more risk of cross-contamination. These complex food items may also be stored and served for longer periods than less complex foods, leading to extended exposure. For example, workers may cook a large batch of food, serve some, and then cool it and place it in cold storage overnight before reheating it for service the next day. Finally, restaurants with one or two managers had shorter outbreaks than restaurants with three or more managers. One possibility is that having more managers may lead to inconsistent interventions and messaging with food workers and thus a delay in outbreak resolution. More research is needed to explore this relationship.

These results suggest that establishment characteristics affect the duration of norovirus outbreaks less than they affect the size of outbreaks. Norovirus has a short incubation period (12 to 48 hours), and norovirus outbreaks are often point-source outbreaks, originating with an ill food worker; once the worker is removed, the outbreak typically ends. However, the size of the outbreak is likely affected by several factors, including policies and practices. For example, restaurants with workers who do not touch ready-to-eat food with their bare hands and clean food contact surfaces often and well are likely to reduce food contamination, thereby reducing the number of people who get sick.

No ill worker policy characteristics were significantly related to outbreak size or duration. Several potential explanations may account for this lack of relationship. This study did not measure policy enforcement, only policy existence. Enforcing ill worker policies is possibly more difficult and less effective than enforcing other policies, such as cleaning policies. For example, enforcing ill worker policies requires knowledge about the worker that may not be

observable, unlike enforcing cleaning policies. In addition, appropriately implementing ill worker policies can lead to worker absenteeism, which can negatively affect restaurants (e.g., understaffing) (22). Managers may therefore be less likely to adhere to ill worker policies than to other policies for which adherence has less negative impact. Workers may also be averse to missing work; they may fear negative impacts for themselves (e.g., loss of income or job) or have other concerns (e.g., concerns about leaving their coworkers short staffed) (7); these factors may lead to lack of adherence to these policies. Given the complexity of these interventions, not finding a relationship between them and outbreak characteristics is perhaps not surprising.

This study has several limitations. First, the study collected cross-sectional data, which do not allow causal inferences about the relationships among outbreak establishment characteristics, size, and duration. Characteristics we did not measure, such as restaurant revenue or other food safety policies and practices, may be driving these relationships. Second, restaurant characteristic data were primarily collected through manager interviews; these data might be subject to social desirability bias, in which respondents overreport socially desirable conditions (e.g., the existence of food safety policies). Third, the findings are based on data reported by a limited number of sites and may not represent all U.S. outbreaks. A final limitation is the time frame of data collection. Investigators collected data on restaurant characteristics during outbreak investigations, not before the outbreak. Although investigators try to collect these data as soon as possible after they become aware of a potential outbreak, the data collection timeframe varies depending on circumstances (4). Restaurant managements can change their policies and practices once they become aware of a potential outbreak but before or during data collection and investigation activities. Thus, we cannot assume that the assessed policies and practices in place during the investigation were in place during pathogen transmission. Lack of food safety training, policies, and practices can be environmental antecedents to foodborne outbreaks; for example, lack of glove use can lead to hand contamination of foods, subsequent pathogen transmission, and outbreaks. However, implementing training, policies, and practices once outbreaks are identified (i.e., during outbreak investigations) could also reduce transmission during the outbreaks, leading to smaller or shorter outbreaks. In either case, our findings suggest that these restaurant characteristics likely play a role in outbreak prevention and intervention.

Food safety training and certification and food safety policies are considered important contributors to strong food safety management systems in restaurants; strong food safety management systems are critical to retail food safety (25). The retail industry and food safety officials should support and encourage food safety certification for managers, food safety training for retail food staff, and the development and implementation of strong food safety policies. In addition, states should consider incorporating the most recent version of the FDA Food Code into their food safety regulations, specifically the provisions related to norovirus prevention (e.g., hand hygiene). Finally, research comparing restaurants that have had norovirus outbreaks with restaurants that have not had such outbreaks can contribute significantly to our knowledge about outbreak prevention.

ACKNOWLEDGMENTS

We thank Carol Selman, Vince Radke, and Erik Coleman (CDC) for their long-term and critical work in support of NEARS and the health department staff who collected the outbreak data. This publication is partly based on data collected and provided by the CDC EHS-Net, which is supported by a CDC grant funded under CDC-RFA-EH05-013. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of CDC or the Agency for Toxic Substances and Disease Registry.

REFERENCES

1. Angelo K, Nisler A, Hall A, Brown L, and Gould L. 2017. Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998–2013. Epidemiol. Infect 145:523–534. 10.1017/S0950268816002314 [PubMed: 27751201]
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. 10.4315/0362-028X.JFP-13-126 [PubMed: 24290692]
3. Brown L, Hoover E, Ripley D, Matis B, Nicholas D, Hedeen N, and Faw B. 2016. Retail deli slicer cleaning frequency—six selected sites, United States, 2012. Morb. Mortal. Wkly. Rep 65:306–310. 10.15585/mmwr.mm6512a2
4. Brown L, Hoover E, Selman C, Coleman E, and Schurz Rogers H. 2017. Outbreak characteristics associated with identification of contributing factors to foodborne illness outbreaks. Epidemiol. Infect 145:2254–2262. [PubMed: 28689510]
5. Brown L, Hoover ER, Faw B, Hedeen N, Nicholas D, Wong M, Shepherd C, Gallagher D, and Kause J. 2018. Food safety practices linked with proper refrigerator temperatures in retail delis. Foodborne Pathog. Dis 15:1–9. [PubMed: 29337606]
6. Brown L, Le B, Wong M, Reimann D, Nicholas D, Faw B, Davis E, and Selman C. 2014. Restaurant manager and worker food safety certification and knowledge. Foodborne Pathog. Dis 11(11):1–9. [PubMed: 24134667]
7. Carpenter L, Green A, Norton D, 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. 10.4315/0362-028X.JFP-13-128 [PubMed: 24290694]
8. Cates S, Muth M, Karns S, Penne M, Stone C, Harrison J, and Radke V. 2009. Certified kitchen managers: do they improve restaurant inspection outcomes? J. Food Prot 72:384–391. [PubMed: 19350984]
9. Centers for Disease Control and Prevention. 2017. Guide to confirming an etiology in foodborne disease outbreaks. U.S. Department of Health and Human Services, CDC, Atlanta. Available at: https://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/confirming_diagnosis.html
10. Centers for Disease Control and Prevention. 2017. National environmental assessment reporting system (NEARS). U.S. Department of Health and Human Services, CDC, Atlanta. Available at: https://www.cdc.gov/nceh/ehs/nears
11. Dewey-Mattia D, Manikonda K, Hall A, Wise M, and Crowe S. 2018. Surveillance for foodborne disease outbreaks—United States, 2009–2015. MMWR Surveill. Summ 67:SS–10. 10.15585/mmwr.ss6710a1
12. Escudero B, Rawsthorne H, Gensel C, and Jaykus L. 2012. Persistence and transferability of noroviruses on and between common surfaces and foods. J. Food Prot 75:927–935. [PubMed: 22564943]
13. Green L, Radke V, Mason R, Bushnell L, Reimann D, Mack J, Motsinger M, Stigger T, and Selman C. 2007. Factors related to food worker hand hygiene practices. J. Food Prot 70:661–666. [PubMed: 17388056]
14. Green L, Selman C, Banerjee A, Marcus R, Medus C, Angulo F, 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]
15. Hall A, Wikswo M, Pringle K, Gould L, and Parashar U. 2014. Vital signs: foodborne norovirus outbreaks—United States, 2009–2012. Morb. Mortal. Wkly. Rep 63:491–495.

16. Hedberg C, Smith S, Kirkland E, Radke V, Jones T, Selman C, and 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]

17. Lipcsei L, Brown L, Hoover E, Faw BV, Hedeen N, Matis B, Nicholas D, and Ripley D. 2018. Retail deli slicer inspection practices—an EHS-Net study. J. Food Prot 81:799–805. 10.4315/0362-028X.JFP-17-407 [PubMed: 29637808]

18. Lopman B, Gastanaduy P, Park G, Hall A, Parashar U, and Vinje J. 2012. Environmental transmission of norovirus gastroenteritis. Curr. Opin. Virol 2(1):96–102. [PubMed: 22440972]

19. Marsh Z, Shah M, Wikswo M, Barclay L, Kisselburgh H, Kambhampati A, L Cannon J, Parashar UD, Vinjé J, and Hall AJ. 2018. Epidemiology of foodborne norovirus outbreaks—United States, 2009–2015. Food Saf. 6(2):58–66. 10.14252/foodsafetyfscj.2017028

20. Masters M, Brown L, and Hoover R. 8 2018. Restaurant characteristics as predictors of cross-contamination behavior. Poster Annu. Meet. IAFP 2018, Salt Lake City, UT, 8–11 July, 2018.

21. McFarland P, Sielaff A, Rasco B, and Smith S. 2019. Efficacy of food safety training in commercial food service. J. Food Sci 84:1239–1246. [PubMed: 31066914]

22. Norton D, Brown L, Frick R, Carpenter LR, Green A, Tobin D'Angelo M, Reimann D, Blade H, Nicholas D, Egan J, and Everstine K. 2015. Managerial practices regarding workers working while ill. J. Food Prot 78:187–195. doi:10.4315/0362-028X.JFP-14-134 [PubMed: 25581195]

23. Reed K, Ripley D, Hedeen N, Nicholas D, Faw B, Bushnell L, Nair P, Wickam T, and Brown L. Restaurant characteristics associated with the use of specific food cooling methods. J. Environ. Health, in press.

24. 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 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]

25. U.S. Food and Drug Administration. 2017. Food Code. U.S. Department of Health and Human Services, U.S. Public Health Service, U.S. FDA, Washington, DC. Available at: https://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/UCM595140.pdf.

26. U.S. Food and Drug Administration. 2018. FDA report on the occurrence of foodborne illness risk factors in fast food and full-service restaurants, 2013–2014. Available at: https://www.fda.gov/media/117509/download.

27. Young I, Greig J, Wilhelm B, and Waddell L. 2019. Effectiveness of food handler training and education interventions: a systematic review and meta-analysis. J. Food Prot 82:1714–1728. 10.4315/0362-028X.JFP-19-108 [PubMed: 31536416]

HIGHLIGHTS

- Restaurant policies and practices are related to smaller and shorter norovirus outbreaks.
- Outbreaks were smaller and shorter in restaurants with staff food safety training.
- Outbreaks were smaller in restaurants with cleaning policies.
- Outbreaks were smaller in restaurants in which workers were observed wearing gloves.

TABLE 1.

Source of study data

Study variable	Source[a]
Outbreak characteristics	
Contributing factor	NEARS investigator determination
Outbreak size (no. of ill people)	FDOSS
Outbreak duration (no. of days)	FDOSS
Control variables	
Investigation methods (case-control or cohort study conducted vs not conducted)	FDOSS
Restaurant ownership—independent or chain (restaurant shares name and operations with at least one other restaurant)	NEARS manager interview
General restaurant characteristics	
Preparation complexity—most complex food preparation process • Complex—food item requires a kill step (a process, like cooking, that reduces or eliminates pathogens) and holding beyond same-day service or a kill step and some combination of holding, cooling, reheating, and freezing • Cook-serve—food item is prepared for same-day service; at least one involves a kill step such as cooking • Prep-serve—food item is prepared and served without a kill step	NEARS investigator determination
No. of critical violations on last inspection (violations of regulations that help eliminate or reduce foodborne illness hazards, also called priority or priority foundation items)	NEARS investigator determination
Type of food served	NEARS investigator determination
Approximate no. of meals served daily	NEARS manager interview
No. of workers	NEARS manager interview
No. of managers	NEARS manager interview
Training and certification	NEARS manager interview
Any kitchen managers food safety certified	NEARS manager interview
Type of food safety training managers receive	NEARS manager interview
Type of food safety training food workers receive	NEARS manager interview
Hand hygiene	
Food workers observed using gloves while handling food	NEARS kitchen observation
Food workers observed handling ready-to-eat food with bare hands	NEARS kitchen observation
Policy about disposable glove use	NEARS manager interview
Ill workers	NEARS manager interview

Study variable	Source[a]
Policy requiring food workers to tell a manager when they are ill	NEARS manager interview
Policy requiring ill workers to tell managers their symptoms	NEARS manager interview
Policy specifying symptoms that would prompt excluding or restricting ill workers	NEARS manager interview
Any kitchen managers get paid when they miss work because they are ill	NEARS manager interview
Any food workers get paid when they miss work because they are ill	NEARS manager interview
Cleaning	
Cleaning policy for kitchen floor	NEARS manager interview
Cleaning policy for cutting boards	NEARS manager interview
Cleaning policy for food prep tables	NEARS manager interview

[a]NEARS, National Environmental Assessment Reporting System. FDOSS, Foodborne Disease Outbreak Surveillance System.

TABLE 2.

Frequencies for outbreak restaurant characteristics

Characteristic	*n*	%	Mean outbreak size (no. of ill people)	Mean outbreak duration (days)
Control variables				
Investigation methods[a] ([N][b] = 124)				
Case-control or cohort study was not conducted	26	21.0	10.4	2.9
Case-control or cohort study was conducted	98	79.0	20.9	3.6
Restaurant ownership[c] (*N* = 124)				
Chain	33	26.6	23.1	4.1
Independent	91	73.4	17.2	3.3
General restaurant characteristics				
Preparation complexity type[d] (*N* = 124)				
Prep-serve	4	3.2	20.5	3.8
Cook-serve	11	8.9	14.5	2.2
Complex	109	87.9	19.1	3.6
No. of critical violations on last inspection[d] (*N* = 124)				
0	37	29.8	23.5	3.6
1 or more	87	70.2	16.7	3.4
Type of food served[d] (*N* = 124)				
American	50	40.3	20.7	3.4
Other	74	59.7	17.4	3.5
Approximate no. of meals served daily[c] (*N* = 119)				
200 or less	62	52.1	17.2	3.3
More than 200	57	47.9	19.2	3.6
No. of workers[c] (*N* = 123)				
14 or less	66	53.7	16.3	3.3
More than 14	57	46.3	21.7	3.7
No. of managers[c] (*N* = 123)				
1 or 2	62	50.4	17.8	2.9

Characteristic	*n*	%	Mean outbreak size (no. of ill people)	Mean outbreak duration (days)
3 or more	61	49.6	20.0	4.1
Training and certification				
Any kitchen managers are food safety certified[c] (*N* = 123)				
No	19	15.5	26.6	3.8
Yes	104	84.6	17.2	3.4
Type of food safety training managers receive[c] (*N* = 124)				
No training	6	4.8	38.5	5.3
Classroom training only	53	42.7	18.9	3.3
On-the-job training only	6	4.8	10.3	2.3
Both on-the-job and classroom training	59	47.6	17.4	3.5
Type of food safety training food workers receive[c] (*N* = 123)				
No training	9	7.3	27.8	3.5
Classroom training only	14	11.4	20.4	3.1
On-the-job training only	61	49.6	22.1	4.0
Both on-the-job and classroom training	39	31.7	11.2	2.9
Hand hygiene				
Food workers observed using gloves while handling food[e] (*N* = 124)				
No	18	14.5	28.4	3.9
Yes	106	85.5	17.1	3.4
Food workers observed handling ready-to-eat foods with bare hands[e] (*N* = 124)				
No	90	72.6	19.5	3.5
Yes	34	27.4	16.8	3.3
Policy about disposable glove use[c] (*N* = 123)				
No	11	8.9	27.1	4.1
Yes verbal (manager said there was a policy and it was not written)	74	60.2	18.9	3.2
Yes written (manager said there was a policy and it was written)	38	30.9	16.3	3.9
Ill workers				
Policy requiring food workers to tell a manager when they are ill[c] (*N* = 123)				
No	8	6.5	29.8	3.6

Characteristic	*n*	%	Mean outbreak size (no. of ill people)	Mean outbreak duration (days)
Yes verbal (manager said there was a policy and it was not written)	42	34.1	15.6	3.0
Yes written (manager said there was a policy and it was written)	73	59.3	19.4	3.7
Policy requiring ill workers to tell managers their symptoms[C] (*N* = 116)				
No	26	22.4	22.0	3.5
Yes	90	77.6	17.5	3.4
Policy specifying symptoms that would prompt excluding or restricting ill workers[C] (*N* = 117)				
No	40	34.2	15.3	3.3
Yes	77	65.8	20.0	3.6
Any kitchen managers get paid when they miss work because they are ill[C] (*N* = 99)				
No	21	21.2	13.0	2.9
Yes	78	78.8	19.7	3.6
Any food workers get paid when they miss work because they are ill[C] (*N* = 93)				
No	60	64.5	19.9	3.4
Yes	33	35.5	18.2	3.8
Cleaning				
Cleaning policy for kitchen floor[C] (*N* = 124)				
No	2	1.6	58.5	6.0
Yes verbal	63	50.8	18.5	3.3
Yes written	59	47.6	17.6	3.6
Cleaning policy for cutting boards[C] (*N* = 123)				
No	9	7.3	16.9	3.0
Yes verbal	81	65.9	20.0	3.3
Yes written	33	26.8	16.5	4.1
Cleaning policy for food prep tables[C] (*N* = 123)				
No	4	3.3	16.5	3.5
Yes verbal	79	64.2	20.6	3.4
Yes written	40	32.5	15.7	3.7

[a] FDOSS.

[b] *N*, number of restaurants with data for this variable.

[c]NEARS manager interview.

[d]NEARS investigator determination.

[e]NEARS kitchen observation.

TABLE 3.

Predicted values, ratios, and P *values of the truncated negative binomial regression analyses on outbreak restaurant characteristics associated with outbreak size in number of ill people, simple and multiple models*[a]

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak sizes (no. of ill people)	Ratio[c]	Sig.	Ratio	Sig.
Control variables					
Investigation methods[d]					
Case-control or cohort study was not conducted/case-control or cohort study was conducted (n[e] = 124)	**9.9/20.6**	**0.48**	**<0.001**		
Restaurant ownership[f]					
Independent/chain (n = 124)	16.7/22.6	0.74	0.09		
General restaurant characteristics					
Preparation complexity type[g]					
Complex/prep-serve (n = 113)	18.6/20.0	0.93	0.872	0.80	0.617
Cook-serve/complex (n = 120)	13.9/18.6	0.75	0.318	0.77	0.332
Cook-serve/prep-serve (n = 15)	14.0/20.1	0.70	0.475	0.58	0.598
No. of critical violations on last inspection[g]					
1 or more/0 (n = 124)	**16.2/23.1**	**0.70**	**0.043**	0.74	0.069
Type of food served[g]					
Other/American (n = 124)	16.9/20.2	0.84	0.285	0.82	0.179
Approximate no. of meals served daily[f]					
200 or less/more than 200 (n = 119)	16.7/18.7	0.89	0.488	1.02	0.887
No. of workers[f]					
14 or less/more than 14 (n = 123)	15.9/21.3	0.74	0.068	0.84	0.292
No. of managers[f]					
1 or 2/3 or more (n = 123)	17.3/19.5	0.89	0.455	0.93	0.647
Training and certification					
Any kitchen managers are food safety certified[f]					
Yes/no (n = 123)	**16.7/26.2**	**0.64**	**0.043**	**0.57**	**0.006**

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak sizes (no. of ill people)	Ratio[c]	Sig.	Ratio	Sig.
Type of food safety training managers receive[f]					
Classroom only/no training (*n* = 59)	18.4/38.2	0.48	0.055	**0.48**	**0.032**
On-the-job only/no training (*n* = 12)	**10.2/38.5**	**0.27**	**0.002**	**0.27**	**0.004**
Classroom and on-the-job/no training (*n* = 65)	**17.0/38.2**	**0.45**	**0.030**	**0.34**	**<0.001**
Classroom and on-the-job/classroom only (*n* = 112)	16.9/18.4	0.92	0.619	**0.72**	**0.041**
Classroom and on-the-job/on-the-job only (*n* = 65)	17.0/9.8	1.73	0.153	1.54	0.207
On-the-job only/classroom only (*n* = 59)	9.8/18.5	0.53	0.105	**0.47**	**0.047**
Type of food safety training food workers receive[f]					
In class only/no training (*n* = 23)	20.1/27.6	0.73	0.364	0.96	0.886
On-the-job only/no training (*n* = 70)	21.7/27.5	0.79	0.438	0.71	0.242
Classroom and on-the-job/no training (*n* = 48)	**11.0/27.7**	**0.40**	**<0.001**	**0.43**	**<0.001**
Classroom and on-the-job/classroom only (*n* = 53)	**10.8/20.1**	**0.54**	**0.016**	**0.50**	**0.002**
Classroom and on-the-job/on-the-job only (*n* = 100)	**10.7/21.8**	**0.49**	**<0.001**	**0.61**	**0.007**
On-the-job only/classroom only (*n* = 75)	21.6/19.8	1.09	0.754	0.76	0.339
Hand hygiene					
Food workers observed using gloves while handling food[g]					
Yes/no (*n* = 124)	**16.6/28.0**	**0.59**	**0.020**	**0.56**	**0.005**
Food workers observed handling ready-to-eat foods with bare hands[g]					
Yes/no (*n* = 124)	16.3/19.0	0.86	0.400	0.87	0.406
Policy about disposable glove use[f]					
Yes verbal/none (*n* = 85)	18.4/26.6	0.70	0.210	0.81	0.419
Yes written/none (*n* = 49)	15.8/26.7	0.59	0.087	0.63	0.108
Yes written/yes verbal (*n* = 112)	15.8/18.5	0.85	0.365	0.76	0.106
Ill workers					
Policy requiring food workers to tell a manager when they are ill[f]					
Yes verbal/none (*n* = 50)	15.1/29.4	0.52	0.054	0.56	0.073
Yes written/none (*n* = 81)	18.8/29.2	0.64	0.198	0.64	0.180
Yes written/yes verbal (*n* = 115)	19.0/15.2	1.25	0.185	1.06	0.712

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak sizes (no. of ill people)	Ratio[c]	Sig.	Ratio	Sig.
Policy requiring ill workers to tell managers their symptoms[f]					
Yes/no (*n* = 116)	17.1/21.7	0.79	0.219	0.76	0.120
Policy specifying symptoms that would prompt excluding or restricting ill workers[f]					
Yes/no (*n* = 117)	19.6/14.9	1.32	0.103	1.28	0.120
Any kitchen managers get paid when they miss work because they are ill[f]					
Yes/no (*n* = 99)	19.2/12.5	1.54	0.053	1.41	0.099
Any food workers get paid when they miss work because they are ill[f]					
Yes/no (*n* = 93)	17.7/19.4	0.91	0.636	0.89	0.525
Cleaning					
Cleaning policy for kitchen floor[f]					
Yes verbal/none (*n* = 65)	**18.2/58.3**	**0.31**	**0.045**	**0.31**	**0.020**
Yes written/none (*n* = 61)	17.0/58.0	0.29	0.063	**0.29**	**0.044**
Yes written/yes verbal (*n* = 122)	17.2/18.0	0.95	0.762	0.81	0.164
Cleaning policy for cutting boards[f]					
Yes verbal/none (*n* = 90)	19.4/16.3	1.19	0.590	1.23	0.489
Yes written/none (*n* = 42)	16.3/16.7	0.98	0.937	0.81	0.459
Yes written/yes verbal (*n* = 114)	15.9/19.4	0.82	0.300	**0.68**	**0.037**
Cleaning policy for food prep tables[f]					
Yes verbal/none (*n* = 83)	20.0/15.9	1.26	0.630	1.30	0.547
Yes written/none (*n* = 44)	15.4/16.2	0.95	0.896	0.73	0.431
Yes written/yes verbal (*n* = 119)	15.1/20.0	0.75	0.110	**0.63**	**0.007**

[a] Ratios significant at $P < 0.05$ are shown in boldface.

[b] Multiple models were conducted for each characteristic variable, controlling for ownership and investigation methods. Sig., significance probability.

[c] Ratio, first predicted outbreak size listed in the simple regression column/second predicted outbreak size listed.

[d] Data obtained from FDOSS.

[d] *n* = number of restaurants included in this comparison.

[e]Data obtained from NEARS manager interview.

[f]Data obtained from NEARS investigator determination.

[g]Data obtained from NEARS kitchen observation.

TABLE 4.

Predicted values, ratios, and P *values of the truncated negative binomial regression analyses on outbreak restaurant characteristics associated with outbreak duration in days, simple and multiple models*[a]

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak durations (days)	Ratio[c]	Sig.	Ratio	Sig.
Control variables					
Investigation methods[d]					
Case-control or cohort study was not conducted/case-control or cohort study was conducted (n[e] = 124)	2.5/3.3	0.75	0.125		
Restaurant ownership[f]					
Independent/chain (n = 124)	2.9/3.8	0.76	0.086		
General restaurant characteristics					
Preparation complexity type[g]					
Complex/prep-serve (n = 113)	3.2/3.4	0.95	0.892	1.06	0.891
Cook-serve/complex (n = 120)	**1.6/3.3**	0.50	**0.032**	**0.52**	**0.041**
Cook-serve/prep-serve (n = 15)	1.8/3.7	0.49	0.083	0.63	0.496
No. of critical violations on last inspection[g]					
1 or more/0 (n = 124)	3.0/3.3	0.93	0.624	0.97	0.826
Type of food served[f]					
Other/American (n = 124)	3.2/3.0	1.04	0.784	1.04	0.804
Approximate no. of meals served daily[f]					
200 or less/more than 200 (n = 119)	2.9/3.2	0.89	0.458	0.99	0.941
No. of workers[f]					
14 or less/more than 14 (n = 123)	2.9/3.3	0.88	0.396	1.00	0.998
No. of managers[f]					
1 or 2/3 or more (n = 123)	**2.5/3.8**	**0.64**	**0.002**	**0.65**	**0.004**
Training and certification					
Any kitchen managers are food safety certified[f]					

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak durations (days)	Ratio[c]	Sig.	Ratio	Sig.
Yes/no (*n* = 123)	3.0/3.5	0.88	0.516	0.82	0.304
Type of food safety training managers receive[f]					
In class only/no training (*n* = 59)	3.0/5.1	0.58	0.072	**0.55**	**0.050**
On-the-job only/no training (*n* = 12)	**1.9/5.2**	0.36	**0.046**	0.62	0.096
Classroom and on-the-job/no training (*n* = 65)	3.1/5.1	0.61	0.121	**0.47**	**0.019**
Classroom and on-the-job/classroom only (*n* = 112)	3.2/3.0	1.06	0.686	0.92	0.566
Classroom and on-the-job/on-the-job only (*n* = 65)	3.2/1.8	1.75	0.180	1.80	0.129
On-the-job only/classroom only (*n* = 59)	1.9/3.0	0.61	0.222	0.57	0.168
Type of food safety training food workers receive[f]					
Classroom only/no training (*n* = 23)	2.9/3.4	0.84	0.369	—[h]	—
On-the-job only/no training (*n* = 70)	3.7/3.2	1.13	0.646	1.05	0.868
Classroom and on-the-job/no training (*n* = 48)	2.5/3.3	0.76	0.344	0.75	0.340
Classroom and on-the-job/classroom only (*n* = 53)	2.4/2.7	0.91	0.737	0.88	0.627
Classroom and on-the-job/on-the-job only (*n* = 100)	**2.4/3.6**	**0.66**	**0.025**	0.73	0.104
On-the-job only/classroom only (*n* = 75)	3.7/2.7	1.37	0.207	1.08	0.768
Hand hygiene					
Food workers observed using gloves while handling food[i]					
Yes/no (*n* = 124)	3.0/3.6	0.83	0.348	0.81	0.283
Food workers observed handling ready-to-eat foods with bare hands[i]					
Yes/no (*n* = 124)	2.9/3.2	0.90	0.534	0.91	0.566
Policy about disposable glove use[f]					
Yes verbal/none (*n* = 85)	2.9/3.9	0.74	0.182	0.77	0.216
Yes written/none (*n* = 49)	3.4/3.6	0.94	0.844	0.92	0.800
Yes written/yes verbal (*n* = 112)	3.6/2.8	1.28	0.107	1.23	0.192
Ill workers					
Policy requiring food workers to tell a manager when they are ill[f]					
Yes verbal/none (*n* = 50)	2.7/3.4	0.80	0.415	0.80	0.407

Characteristic	Simple regression			Multiple regression[b]	
	Predicted outbreak durations (days)	Ratio[c]	Sig.	Ratio	Sig.
Yes written/none (n = 81)	3.3/3.2	1.03	0.925	0.98	0.954
Yes written/yes verbal (n = 115)	3.4/2.6	1.30	0.113	1.16	0.395
Policy requiring ill workers to tell managers their symptoms[f]					
Yes/no (n = 116)	3.1/3.1	0.99	0.954	0.92	0.642
Policy specifying symptoms that would prompt excluding or restricting ill workers[f]					
Yes/no (n = 117)	3.2/2.9	1.10	0.535	1.05	0.756
Any kitchen managers get paid when they miss work because they are ill[f]					
Yes/no (n = 99)	3.3/2.5	1.35	0.146	1.32	0.171
Any food workers get paid when they miss work because they are ill[f]					
Yes/no (n = 93)	3.5/3.0	1.15	0.432	1.14	0.452
Cleaning					
Cleaning policy for kitchen floor[f]					
Yes verbal/none (n = 65)	3.0/5.9	0.51	0.104	0.50	0.067
Yes written/none (n = 61)	3.2/5.7	0.55	0.274	0.54	0.266
Yes written/yes verbal (n = 122)	3.2/2.9	1.13	0.425	1.03	0.838
Cleaning policy for cutting boards[f]					
Yes verbal/none (n = 90)	3.0/2.7	1.12	0.675	1.13	0.654
Yes written/none (n = 42)	3.7/2.5	1.48	0.251	1.38	0.384
Yes written/yes verbal (n = 114)	3.8/2.9	1.31	0.105	1.22	0.229
Cleaning policy for food prep tables[f]					
Yes verbal/none (n = 83)	3.1/3.2	0.96	0.912	0.98	0.964
Yes written/none (n = 44)	3.3/3.1	1.06	0.893	0.93	0.882
Yes written/yes verbal (n = 119)	3.3/3.0	1.11	0.512	1.02	0.903

[a] Ratios significant at $P < 0.05$ are shown in boldface.

[b] Multiple models were conducted for each characteristic variable, controlling for ownership and investigation methods. Sig. = significance probability.

[c] Ratio, first predicted outbreak duration listed in the simple regression column/second predicted outbreak duration listed.

[d] Data obtained from FDOSS.

[e] *n* = number of restaurants included in this comparison.

[f] Data obtained from NEARS manager interview.

[g] Data obtained from NEARS investigator determination.

[h] *n* is insufficient to estimate.

[i] Data obtained from NEARS kitchen observation.