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Research Note

Restaurant and Staff Characteristics Related to Practices that Could Contribute to Cross-Contamination

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ABSTRACT

Foodborne illness is a persistent public health concern in the U.S.; over 800 foodborne illness outbreaks are reported to the Centers for Disease Control and Prevention (CDC) annually. Most of these outbreaks (60%) are linked with restaurants. Contamination of food with foodborne pathogens during preparation and storage is a significant contributing factor to many of these outbreaks. The CDC's Environmental Health Specialists Network (EHS-Net) collected data to identify restaurant characteristics, policies, and practices associated with contamination prevention practices. Data collectors interviewed managers and conducted kitchen observations in 312 restaurants across six EHS-Net sites in five states. Data collectors observed at least one food worker action that could lead to contamination in 63.1% of restaurants. The most frequently observed action that could lead to contamination was bare-hand or dirty glove contact with ready-to-eat food (35.9%). The estimated mean number of observed potential contamination actions was greater in restaurants that were independently owned (does not share a name and operations with other restaurants), did not require managers to be certified in food safety, did not have workers trained in food safety, did not have a handwashing policy, did not have a policy minimizing bare-hand contact with ready-to-eat foods, and had a manager with more than two years of experience at their current restaurant. These results suggest that to improve contamination prevention, the foodservice industry and food safety officials can consider supporting and encouraging strong food safety training and policies, particularly concerning hand hygiene, and targeting interventions to independent restaurants.

Approximately 860 foodborne illness outbreaks are reported to the Centers for Disease Control and Prevention (CDC) each year (Centers for Disease Control and Prevention, 2019). Most of these outbreaks (60%) are linked with restaurants. Contamination of food with foodborne pathogens during preparation and storage is a significant contributing factor to outbreaks occurring in restaurants (Angelo et al., 2017). Indeed, infectious food workers contaminating food with foodborne pathogens during its preparation contributed to a third of restaurant outbreaks occurring from 1998 to 2013 (among outbreaks with identified contributing factors) (Angelo et al., 2017). Cross-contamination of pathogens from raw animal products to other foods during preparation (e.g., raw poultry cut on a cutting board contaminates salad vegetables cut on the same unwashed board) contributed to another quarter of restaurant outbreaks during this same period (Angelo et al., 2017).

The U.S. Food and Drug Administration (FDA) Food Code, which provides the basis for local and state food regulatory codes in the U.S., contains science-based food safety guidelines aimed at preventing foodborne illness in retail food establishments (e.g., restaurants) (U.S. Food and Drug Administration, 2017). Its recommendations specifically aimed at reducing contamination of food with pathogens include (but are not limited to): ensuring – through handwashing – that food workers have clean hands when they prepare food; prohibiting food workers from handling ready-to-eat foods with their bare hands; cleaning and sanitizing food contact surfaces and utensils; and separating raw animal products from other foods.

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Despite these guidelines, outbreaks related to pathogen contamination continue to occur. Information about restaurant characteristics, policies, and practices related to contamination prevention practices is key to improving those practices. Thus, the CDC's Environmental Health Specialists Network (EHS-Net), a CDC-funded collaborative network of federal, state, and local health agencies focused on understanding and preventing factors that contribute to foodborne illness (Centers for Disease Control and Prevention, 2022), examined the relationships between restaurant characteristics, policies, and practices and contamination prevention practices. This paper presents data on the frequency with which restaurant food workers engaged in practices that could lead to contamination of food with foodborne pathogens and on the relationships between the occurrence of these practices and restaurant characteristics, policies, and practices.

Methods

Staff in the six EHS-Net jurisdictions experienced in restaurant food safety designed the study and collected the data for this study. CDC funded six health departments to conduct this study – California, Minnesota, New York City, New York state (excluding New York City), Rhode Island, and Tennessee.

Sample. The sample consisted of restaurants randomly selected from restaurant population lists located in predefined geographical areas in each of the six EHS-Net health departments' jurisdictions (i.e., sites). Specifically, in each jurisdiction, EHS-Net staff chose a geographical area, based on reasonable travel distance from their office, in which to recruit restaurants and collect data for the study. Restaurants were defined as establishments that prepare and serve food or beverages to customers; we excluded institutions, food carts, mobile food units, temporary food stands, supermarkets, restaurants in supermarkets, and caterers. Only restaurants with managers who spoke English well enough to be interviewed in English were included in the study. English proficiency was determined by EHS-Net data collectors during their recruiting calls – if the data collector could not conduct a conversation in English with a manager of the restaurant, the restaurant was excluded from the sample.

Data collection. Data collectors (EHS-Net site staff) telephoned restaurants in each EHS-Net site to request study participation and arrange for an on-site visit to the restaurant. During the visit, data collectors interviewed a kitchen manager about restaurant characteristics such as ownership type and manager and worker certification, and policies or procedures (hereafter referred to as policies) related to contamination prevention (Table 1). Data collectors also administered a written food safety knowledge assessment to the interviewed manager. Additional information concerning the interview and knowledge assessment can be found in Brown et al. (Brown et al., 2014).

Data collectors also conducted an approximately 50-minute-long observation in the restaurant kitchen. They collected data on restaurant characteristics, such as the number of hand sinks and the number of critical violations on the restaurant's last inspection, and food preparation complexity. They also observed food workers preparing food and noted whether they engaged in eight actions that could lead to cross-contamination if the items (e.g., hands, surfaces, food) involved were contaminated with foodborne pathogens. These eight actions were potential cross-contamination: from bare hands to ready-to-eat foods; from dirty gloves to ready-to-eat foods; from dirty bare hands to clean equipment or clean food preparation (prep) surfaces; from dirty gloved hands to clean equipment or clean food prep surfaces; from a wiping cloth (not properly stored in sanitizer) to clean bare or gloved hands; from a wiping cloth (not properly stored in sanitizer) to clean equipment or clean food prep surfaces; from dirty equipment or utensils to ready-to-eat foods; and from raw animal foods stored over or on ready-to-eat foods in a refrigeration unit (Table 2).

The study protocol was cleared by the CDC Institutional Review Board (IRB) and the appropriate IRBs in the EHS-Net sites. All data collectors participated in training designed to increase data collection consistency. Data were collected in 2012 and are anonymous.

Analysis. First, we reviewed the frequency of and relationships between the eight individual potential cross-contamination actions. We collapsed some action categories because of similarity in the cross-contamination mechanism. For example, we combined potential cross-contamination from bare hands to ready-to-eat foods and from dirty gloves to ready-to-eat foods to create one category of potential cross-contamination focused on poor hand hygiene. As a result, the initial eight potential cross-contamination actions were collapsed into five. We then created a variable assessing the number of these actions observed in each restaurant (0–5). We present the simple mean of cross-contamination actions for each restaurant characteristic in Table 1.

We then conducted independent stratified zero-inflated Poisson regressions for each restaurant characteristic to identify relationships between each characteristic and the estimated marginal mean number of observed potential cross-contamination actions. We controlled for collection site to account for differences across sites, such as in local and state regulations and regional food preferences, which could influence food preparation practices.

We also present the ratio of estimated marginal means (REMMs), as a measure of effect size, along with corresponding 95% confidence intervals and levels of significance. The REMM is the ratio of the estimated marginal mean number of cross-contamination behaviors for a characteristic level (e.g., manager certification is required) divided by the estimated marginal mean of a second characteristic level (e.g., manager certification is not required). Denominators vary per regression because of missing data. All analyses were conducted using SAS 9.4.

Although identifying relationships between restaurant characteristics and potential cross-contamination actions was our primary focus, the fact that we had sites with and without regulatory provisions that prohibited bare-hand contact presented a unique opportunity to examine the relationship between regulatory provisions and practices. Thus, we conducted an independent t test to examine the relationship between the existence of a regulatory provision and the overall rate of potential contamination and a chi-square test of independence to examine the relationship between the existence of a regulatory provision and the occurrence of bare-hand contact with ready-to-eat food.

Results

Forty-four percent (399 of 907) of eligible managers agreed to participate in the study. For this analysis, we excluded 82 restaurants that did not cook raw meat products, as one of the cross-contamination actions of interest pertained to raw meat. We also excluded from the analysis five restaurants in which observations did not take place. The final sample contained 312 restaurants. The median number of restaurants per site was 52 restaurants (min = 47, max = 57).

Restaurant characteristics. Managers in this sample were most likely to describe their restaurants as independently owned (64.7%), serving "American" style cuisine (65.9%), serving less than 200 meals on their busiest day (35.9%), having seating capacity of 100 or more (39.6%), and employing 11 or more workers (36.1%). Most also said they required managers to be food safety certified (which requires passing a food safety test and being issued a card or a certificate; 72.0%) and trained managers in food safety (95.2%). In most restaurants, the interviewed manager was previously or currently certified in food safety (80.7%), had been managing at their current restaurant for more than two years (64.3%), and scored at least 80% on the food safety knowledge assessment (56.9%). Managers also reported that most restaurants had at least one worker *trained* in food safety

Table 1
Frequencies for restaurant characteristics and mean and estimated marginal mean number of potential cross-contamination actions, and ratio of estimated marginal mean number of potential cross-contamination actions for restaurant characteristic levels

Restaurant characteristics	% (n)	Number of potential cross-contamination actions			p value
		Mean (SD)	Estimated marginal mean (95% CI) [a]	Ratio of estimated marginal means (95% CI) [b]	
Ownership type (N = 312) [a]					**<.001**
Chain (shares a name and operations with another restaurant)	35.3 (110)	0.94 (1.02)	1.01 (0.81, 1.27)	–	
Independent	64.7 (202)	1.48 (1.42)	1.64 (1.41, 1.90)	1.62 (1.26, 2.07)	
Menu type (N = 311) [a]					.473
American	65.9 (202)	1.21 (1.27)	1.38 (1.18, 1.61)	–	
International	35.1 (109)	1.44 (1.38)	1.50 (1.23, 1.83)	1.09 (0.86, 1.37)	
Seating capacity [a] (N = 288)					.296
0–49	31.3 (90)	1.36 (1.38)	1.43 (1.15, 1.78)	0.95 (0.73, 1.25)	
50–99	29.2 (84)	1.13 (1.20)	1.21 (0.95, 1.53)	0.80 (0.60, 1.07)	
100 +	39.6 (114)	1.30 (1.28)	1.50 (1.24, 1.83)	–	
Number of meals served on busiest day [a] (N = 312)					.266
1–199	35.9 (112)	1.41 (1.37)	1.59 (1.31, 1.92)	1.17 (0.90, 1.53)	
200–400	33.0 (103)	1.24 (1.25)	1.30 (1.06, 1.59)	0.96 (0.73, 1.26)	
401 +	31.1 (97)	1.20 (1.33)	1.35 (1.09, 1.69)	–	
Number of workers [a] (N = 305)					.157
1–4	33.1 (101)	1.44 (1.30)	1.51 (1.25, 1.84)	1.26 (0.95, 1.66)	
5–10	30.8 (94)	1.46 (1.32)	1.54 (1.26, 1.88)	1.28 (0.97, 1.68)	
11 +	36.1 (110)	1.06 (1.30)	1.20 (0.96, 1.50)	–	
Interviewed manager's food safety certification status [a] (N = 311)					.255
Previously or currently certified	80.7 (251)	1.35 (1.35)	1.36 (1.17, 1.59)	–	
Never certified	19.3 (60)	1.07 (1.16)	1.67 (1.24, 2.26)	1.23 (0.86, 1.74)	
Manager food safety certification is required [a] (N = 304)					**.011**
Yes	72.0 (219)	1.23 (1.27)	1.22 (1.02, 1.45)	–	
No	28.0 (85)	1.34 (1.31)	1.75 (1.40, 2.17)	1.44 (1.09, 1.89)	
Interviewed manager received training in food safety [a] (N = 312)					.292
Yes	95.2 (297)	1.29 (1.32)	1.39 (1.21, 1.60)	–	
No	4.8 (15)	1.27 (1.22)	1.84 (1.14, 2.96)	1.32 (0.80, 2.17)	
Interviewed manager's tenure in restaurant [a] (N = 311)					**.027**
2 years or less	35.7 (111)	1.13 (1.19)	1.20 (0.98, 1.47)	–	
More than 2 years	64.3 (200)	1.39 (1.37)	1.56 (1.34, 1.82)	1.30 (1.03, 1.64)	
Interviewed manager's food safety knowledge assessment score [c] (N = 311)					.095
≥ 80%	56.9 (177)	1.14 (1.27)	1.28 (1.07, 1.53)	–	
< 80%	43.1 (134)	1.46 (1.34)	1.54 (1.31, 1.82)	1.21 (0.97, 1.50)	
Any workers food safety trained [a] (N = 305)					**.043**
Yes	94.4 (288)	1.27 (1.31)	1.38 (1.20, 1.59)	–	
No	5.6 (17)	1.47 (1.59)	2.38 (1.44, 3.94)	1.73 (1.03, 2.89)	
Any workers food safety certified [a] (N = 283)					.308
Yes	43.8 (124)	1.40 (1.42)	1.51 (1.23, 1.86)	1.14 (0.88, 1.48)	
No	56.2 (159)	1.18 (1.21)	1.33 (1.11, 1.58)	–	
Food prep complexity [b] (N = 312)					.185
Prep-serve: all food items are prepared without a kill step	1.9 (6)	0.50 (0.55)	0.54 (0.17, 1.77)	–	
Cook-serve: ≥1 food item is prepared for same day service and involves a kill step	37.2 (116)	1.27 (1.35)	1.46 (1.19, 1.79)	2.70 (0.82, 8.88)	
Complex: ≥1 food item requires a kill step and holding beyond same day service or a combination of complex processes (e.g., reheating)	60.9 (190)	1.33 (1.31)	1.42 (1.21, 1.67)	2.62 (0.80, 8.61)	
Number of critical violations on last inspection [b] (N = 312)					.100
1 +	52.9 (165)	1.46 (1.35)	1.53 (1.30, 1.80)	1.22 (0.96, 1.55)	
0	47.1 (147)	1.10 (1.26)	1.26 (1.03, 1.53)	–	
Handwashing sinks are available [b] (N = 308)					.356
1	42.9 (132)	1.37 (1.32)	1.48 (1.24, 1.76)	1.12 (0.89, 1.41)	
2 +	57.1 (176)	1.21 (1.29)	1.33 (1.10, 1.59)	–	
All hand sinks properly supplied [bd] (N = 308)					.510
Yes	70.1 (216)	1.22 (1.30)	1.36 (1.16, 1.60)	–	
No	29.9 (92)	1.42 (1.30)	1.48 (1.21, 1.80)	1.08 (0.86, 1.37)	
Restaurant has a policy on when and where to wash [a] (N = 311)					**.014**
Yes	96.1 (299)	1.23 (1.30)	1.35 (1.17, 1.56)	–	
No	3.9 (12)	2.50 (1.00)	2.27 (1.57, 3.28)	1.68 (1.14, 2.48)	
Restaurant has a policy to minimize bare hand contact with RTE foods [a] (N = 308)					**.008**
Yes	88.3 (272)	1.20 (1.31)	1.29 (1.11, 1.51)	–	
No	11.7 (36)	1.89 (1.21)	1.97 (1.50, 2.58)	1.53 (1.13, 2.07)	
Restaurant has a policy on in-use wet wiping cloth storage (N = 255) [a]					.275

(*continued on next page*)

Table 1 (*continued*)

Restaurant characteristics	% (n)	Number of potential cross-contamination actions			p value
		Mean (SD)	Estimated marginal mean (95% CI) [a]	Ratio of estimated marginal means (95% CI) [b]	
Yes	94.5 (241)	1.16 (1.26)	1.28 (1.09, 1.50)	–	
No	5.5 (14)	1.79 (1.53)	1.65 (1.07, 2.54)	1.29 (0.83, 2.00)	
Restaurant's jurisdiction prohibits bare-hand contact with ready-to-eat food (N = 312)					.711
Yes	66.7 (208)	1.28 (1.34)	1.68 (1.44, 1.95)	1.04 (0.83, 1.31)	
No	33.3 (104)	1.31 (1.26)	1.60 (1.33, 1.94)	–	

[a] Estimated marginal mean is the estimated mean number of cross-contamination actions derived from the stratified zero-inflated Poisson regression model.
[b] Ratio is the ratio of the estimated mean number of actions in the first category to the estimated mean number of actions in the second category (e.g., chains/independent).
[c] Data collected during the manager interview.
[d] Data collected by observation. [e] Data collected through written knowledge assessment administered to the interviewed manager. [f] Properly supplied hand sinks have warm water (min 100°F), soap available, and are equipped with disposable paper towels or an approved drying device.

Table 2
Number and percent of observed potential cross-contamination actions in the restaurant sample

Observed potential cross-contamination actions	% (n)
Potential cross-contamination observed…	
From bare hands to ready-to-eat foods (N = 270) [a]	29.3 (79)
From dirty gloves to ready-to-eat foods (N = 224) [a]	17.0 (38)
COMBINED: From bare hands or dirty gloves to ready-to-eat foods (N = 312) [a]	35.9 (112)
From dirty bare hands to clean equipment or clean food prep surfaces (N = 274) [b]	24.5 (67)
From dirty gloved hands to clean equipment or clean food prep surfaces (N = 226) [b]	16.8 (38)
COMBINED: From dirty bare or gloved hands to clean equipment or clean food prep surfaces (N = 312) [b]	32.1 (100)
From a wiping cloth not properly stored in sanitizer to clean bare or gloved hands (N = 312) [c]	20.2 (63)
From a wiping cloth not properly stored in sanitizer to clean equipment or food prep surfaces (N = 290) [c]	30.7 (89)
COMBINED: From a wiping cloth not properly stored in sanitizer to clean bare or gloved hands, clean equipment, or clean food prep surfaces (N = 312) [c]	31.4 (98)
From dirty equipment or utensils to ready-to-eat foods (N = 269)	14.9 (40)
From raw animal foods stored over or on ready-to-eat foods in a refrigeration unit (N = 303)	17.2 (52)

[a] We grouped observed potential cross-contamination from bare hands to ready-to-eat foods and from dirty gloves to ready-to-eat foods together into one combined category.
[b] We grouped observed potential cross-contamination from dirty bare hands to clean equipment or clean food prep surfaces and from dirty gloved hands to clean equipment or surfaces into one combined category.
[c] We grouped observed potential cross-contamination from a wiping cloth (not properly stored in sanitizer) to clean hands or hands with clean gloves from a wiping cloth (not properly stored in sanitizer) to clean equipment or clean food prep surfaces into one combined category.

(94.4%) but less than half (43.8%) had any workers *certified* in food safety. Observation data indicated that most restaurants served food items requiring complex food preparation (involves a step designed to reduce or eliminate pathogens ([kill step] and holding beyond same day service or a combination of complex processes [e.g., cooling and reheating]; 60.9%), had at least one critical violation (as defined by the site) on their last inspection (52.9%), had two or more handwashing sinks (57.1%), and had handwashing sinks that were properly supplied (i.e., warm water, soap, and a drying mechanism [towel or mechanical device] and were all available) (70.1%).

Manager interview data revealed that over 85% of restaurants had policies (either written or verbal) designed to minimize cross-contamination. Specifically, 96.1% of restaurants had a policy that described when and where to wash hands, 88.3% had a policy to minimize bare-hand contact with ready-to-eat foods, and 94.5% had an in-use wet wiping cloth storage policy.

At the time the study was conducted, two of the six jurisdictions did not have a provision that prohibited bare-hand contact of ready-to-eat food. One hundred and four (33.3%; 104 of 312) restaurants were in these two jurisdictions.

Observed potential cross-contamination actions. Data collectors observed potential cross-contamination: from bare hands or dirty gloves to ready-to-eat foods in 35.9% of restaurants; from dirty bare or gloved hands to clean equipment or food prep surfaces in 32.1% of restaurants; from a wiping cloth not properly stored in sanitizer to clean bare hands, gloved hands, equipment, or food prep surfaces in 31.4% of restaurants; from dirty equipment or utensils to ready-to-eat foods in 14.9% of restaurants; and from raw animal foods to ready-to-eat foods in a refrigeration unit in 17.2% of restaurants (Table 2). Data collectors observed an average of 1.29 potential cross-contamination actions per restaurant (SD = 1.32, min = 0, max = 6, skewness = 0.82). Data collectors saw no potential cross-contamination actions in 36.9% of restaurants (n = 115 of 312), one action in 26.0% of restaurants (n = 81), two actions in 17.6% of restaurants (n = 55), three actions in 12.2% of restaurants (n = 38), four actions in 5.8% of restaurants (n = 18), and six actions in 1.6% of restaurants (n = 5).

Restaurant characteristics and potential cross-contamination actions. Multiple Poisson regressions identified six characteristics significantly related (at $p < .05$) to potential cross-contamination actions (Table 1). The estimated marginal mean number of observed potential cross-contamination actions was greater in restaurants that were independently owned (REMM = 1.62, $p < .001$), did not require manager certification (REMM = 1.44, $p = .011$), and did not have workers trained in food safety (REMM = 1.73, $p = .043$). Additionally, a greater number of potential cross-contamination actions were observed in restaurants that did not have a handwashing policy (REMM = 1.68, $p = .014$) and did not have a policy minimizing bare-hand contact with RTE foods (REMM = 1.53, $p = .008$). Finally, potential cross-contamination actions were observed more often when interviewed managers had more than 2 years of experience (compared to ≤ 2 years of experience) at their current restaurant (REMM = 1.30, $p = .027$). See Table 1 for an average number of cross-contamination actions per characteristic and corresponding 95% confidence intervals.

Bare-hand contact provisions and potential cross-contamination actions. An independent test showed that the exis-

tence of a regulatory provision prohibiting bare-hand contact with ready-to-eat food was not significantly related to the overall number of mean potential cross-contamination actions (mean in restaurants in sites with a provision = 1.30 vs. mean in restaurants in sites without a provision = 1.28, t(310) = 0.18, p = .855). However, a chi-square test of independence showed that the existence of a regulatory provision prohibiting bare-hand contact was significantly related to the occurrence of this potential cross-contamination action; this action was significantly less common in sites that prohibited it than in sites that did not (20.7% vs. 43.6%, χ^2 = 16.0, p < .001).

Discussion

In most restaurants in the study (63%), data collectors observed at least one food worker action that could lead to contamination of food. This finding indicates that restaurants should consider focusing on improving their cross-contamination prevention practices.

Poor hand hygiene (bare hands or dirty gloves) when preparing ready-to-eat food was observed in over a third of restaurants and was the most common potential cross-contamination action observed. Poor hand hygiene is a leading contributing factor to restaurant-related foodborne outbreaks (Angelo et al., 2017; U.S. Food and Drug Administration, 2017) and has been linked to increased illness due to exposure to foodborne pathogens on ready-to-eat foods (U.S. Department of Agriculture Food Safety and Inspection Service, 2015). Cross-contamination during food storage was relatively less common. These data highlight the ongoing need to focus on good hand hygiene practices in the preparation of ready-to-eat food.

The finding that actions that could lead to contamination were more often observed in restaurants that did not require manager certification and did not have workers trained in food safety supports an established body of research showing that food safety training and certification are important to retail food safety. This research has documented links between food safety training and certification and safer retail food preparation practices, such as hand washing and cleaning and sanitizing (Brown, 2013, 2021). Recent research also shows that food safety training and certification may mitigate outbreak size; restaurants with trained and certified staff have smaller outbreaks than restaurants without such staff (Hoover et al., 2020).

The finding that practices that could lead to contamination were more frequent in restaurants that lacked policies on when and where to wash hands and minimizing bare-hand contact with ready-to-eat foods suggests the benefit of hand hygiene policies to food safety. Good hand hygiene practices, including handwashing and minimizing bare-hand contact with ready-to-eat food, reduce contamination risk and are thus critical to preventing foodborne illness and outbreaks. Development and implementation of policies that specify when and how to engage in hand hygiene practices likely increase these practices. Indeed, research shows links between food safety policies and good food safety practices, such as equipment cleaning and sanitizing, staying home when ill, and appropriate date-marking of ready-to-eat foods (Brown et al., 2014).

Independent restaurant ownership was also found to be associated with potential cross-contamination actions. This finding is consistent with research showing that chain restaurants tend to have better food safety practices than independently owned restaurants (Brown, 2013; Lipcsei et al., 2018; Reed et al., 2020). Chain restaurants may have more resources and more or better-trained staff. Chain restaurants may also be more likely to have food safety procedures that meet national food safety standards in all their restaurants.

The finding that potential cross-contamination actions were observed more often in restaurants with more experienced managers is counter-intuitive. However, at least one other study has found a negative relationship between manager experience and food safety outcomes; Holst et al. found that delis with more experienced managers had a higher prevalence of use of improper sanitizing solution concentrations (Holst et al., 2020). These findings may be partly explained by manager complacency or 'burnout'; over time, the high levels of stress retail establishment managers tend to experience may lead to a reduction in their motivation and dedication to work (Clayton et al., 2015; Sahin, 2012). Alternatively, experienced managers may believe that written policies are not needed, given that their experience. More research is needed to explore this relationship between manager experience and food safety.

Bare-hand contact with ready-to-eat food was observed less often in sites that prohibited such contact. This finding is consistent with previous research showing links between jurisdictional requirements and food safety practices; Liggans et al. (2019) found a positive relationship between jurisdictional date-marking requirements and good date-marking practices. These findings suggest, perhaps not surprisingly, that jurisdictional requirements influence restaurant food safety practices.

This study is limited in that less than half of contacted restaurants participated in the study and data were collected only in restaurants with English-speaking managers. Thus, participating restaurants may not represent a diverse restaurant population. Additionally, this study is cross-sectional and does not allow causal inferences about relationships between restaurant characteristics and practices. A potential consequence of this study design is that unassessed confounding variables may account for one or more of the significant relationships between restaurant characteristics and contamination actions. Finally, these data were collected 11 years ago; it is possible that the frequency or pattern of potential cross-contamination actions may differ now. Indeed, one of the sites without a bare-hand contact prohibition at the time of the study adopted one in 2015. It is likely that this prohibition has led to less bare-hand contact with ready-to-eat food in that site. Nevertheless, cross-contamination, including from bare hands, continues to be an issue in restaurants and a top contributing factor in foodborne outbreaks (Angelo et al., 2017; Centers for Disease Control and Prevention, 2019).

Conclusions. Our findings highlight gaps in restaurants' cross-contamination prevention practices, gaps that were larger in restaurants that were independently owned and lacked a food safety certification requirement, workers trained in food safety, and cross-contamination prevention policies. These findings are in line with other research showing that strong food safety management systems, which include food safety training and policies, are critical to retail food safety (Brown, 2021; U.S. Food and Drug Administration, 2018, 2017). To improve food safety, including cross-contamination prevention, the retail industry and food safety officials can consider targeting interventions to independent restaurants and supporting strong food safety management systems. Support of food safety management systems could include encouragement of food workers to take food safety training courses and become certified, and development and implementation of food safety policies. The finding that prohibition of bare-hand contact was associated with less of this potential contamination action also suggests the importance of food safety regulations to contamination prevention.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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