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Research Paper

Food Safety Management Systems, Certified Food Protection Managers, and Compliance with Food Safety Practices Associated with the Control of *Listeria monocytogenes* in Foods at Restaurants

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ABSTRACT

Listeria monocytogenes is a widespread pathogen of public health concern that is capable of persisting in food processing and retail food environments. Both industry and regulatory agencies continually look for ways to eliminate or prevent the growth of this pathogen. This study investigated the effect of food safety management systems (FSMS) and the presence of a certified food protection manager (CFPM) on the occurrence of proper cold holding and date marking—two food safety practices associated with the control of *L. monocytogenes* in restaurants. Observational data collected as part of a national study of randomly selected fast food and full-service restaurants were analyzed. Regression analysis found FSMS was the strongest predictor of out-of-compliance observations. Although CFPM was not a significant predictor of out-of-compliance observations when FSMS was taken into account, restaurants with no CFPM employed had a significantly higher mean number of out-of-compliance observations than did restaurants with a CFPM employed but not present and than restaurants with a CFPM present. Having sufficient refrigeration capacity and accessible temperature measuring devices was associated with better cold-holding compliance. Establishments located in jurisdictions requiring the date marking of time-temperature control for safety foods were more likely to properly date mark those foods than those not located in such jurisdictions.

HIGHLIGHTS

- Proper cold holding and date marking practices help control *Lm* growth in foods.
- Most restaurants had ≥1 instance of improper cold holding.
- Less than 50% of all cold holding observations were found to be out of compliance.
- Restaurants in areas requiring date marking of food were more likely to date mark.
- CFPM did not predict out-of-compliance observations when FSMS effects were considered.

Key words: Certified food protection manager; Date marking; Food safety; *Listeria monocytogenes*; Restaurants; Temperature control

Listeria monocytogenes (*Lm*) remains a persistent public health concern throughout the United States *(28)*. Research has found foods prepared in restaurants contribute significantly to *Lm* illness and outbreaks *(8, 29)*. Ubiquitous in the environment, *Lm* is recognized as an important foodborne pathogen capable of persisting in food processing and retail food environments because of its high salt tolerance and capability of growth at refrigeration temperatures *(1, 18)*. The dynamic and often complex aspects of retail and food service operations pose challenges to the development and application of suitable control measures *(6, 10, 11, 25)*. As such, regulatory agencies, researchers, and food service operators continue to pursue ways to better control *Lm* in the retail environment *(7, 21, 27)*.

The U.S. Food and Drug Administration (FDA) supports state, local, territorial, and tribal agencies responsible for regulating retail food and food service industries in the United States by issuing the FDA Food Code (Food Code), which includes provisions relevant to the control of *Lm*. The Food Code establishes science-based guidance for mitigating risk factors known to cause or contribute to foodborne illness at retail and food service establishments. Regulators at all levels of government use the Food Code to develop or update their retail food regulations and policies *(20)*. Proper cold holding and date

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marking of foods are two safety practices long associated with controlling the growth of *Lm* in retail foods. Since 1993, the Food Code has referenced a cold holding or refrigeration temperature of 5°C (41°F) or less for foods requiring temperature control for safety—known as time/temperature control for safety (TCS) foods—to control the growth of pathogens. However, even in foods held at refrigeration temperatures, *Lm* can still grow, albeit at a slow rate, such that products should be used or discarded within 7 days to ensure the safety of the food *(33)*. Therefore, the Food Code specifies that (i) refrigerated, ready-to-eat, TCS food prepared in a food establishment and held longer than 24 h; and (ii) refrigerated, commercially prepared, ready-to-eat, TCS food opened in a food establishment and held longer than 24 h should be marked to indicate the date or day by which the food must be consumed, sold, or discarded when held at a temperature of 5°C or less for a maximum of 7 days *(33)*.

Regulatory agencies and retail operators promote adherence to cold holding and date marking requirements through endorsing mandatory or voluntary food safety training and certification of managers and/or staff and by encouraging the implementation of daily, active managerial control (AMC) *(17)*. AMC is defined as "the purposeful incorporation of specific actions or procedures by industry management into the operation of their business to attain control over foodborne illness risk factors" *(33)*. The specific set of actions or procedures to help achieve AMC are termed food safety management systems (FSMS). Although studies have investigated the effect of food safety training and certification on food safety practices and behaviors, which have had mixed results *(4, 17, 31),* the literature is void of much research into the relative effect of training and certification and FSMS on the occurrence of food safety practices associated with the control of *Lm* in retail establishments. The primary purpose of this study was to investigate the effect of FSMS and the presence of a certified food protection manager (CFPM) on the occurrence of proper cold holding and date marking of TCS food—food safety practices associated with controlling the growth of *Lm* in restaurants.

An FSMS is an important indicator of the ongoing and routine efforts that exist in a food establishment to address food safety. Although the breadth and scope vary across the retail and food service industry, the purposeful implementation of procedures, training, and monitoring (PTM) are consistent components of FSMS. Several systems, standards, and certifications are available internationally, including International Organization for Standardization (ISO) 22000 *(13),* good management practices, hazard analysis critical control points (HACCP), the British Retail Consortium, and Safe Quality Food *(15, 16, 22),* but the ongoing prevalence and degree of implementation of these or similar systems within restaurants in the United States remains understudied. FSMS signals the ongoing and routine efforts in place to address food safety. Inadequate FSMS is thought to contribute to the worldwide burden of foodborne disease *(22)*. For example, HACCP has positive effects on food safety, but poor implementation of HACCP has been described as an antecedent to foodborne outbreaks *(5, 23, 26)*. For that reason, FSMS is hypothesized to have a significant negative effect on the occurrence of out-of-compliance observations for proper cold holding and date marking of TCS food. Because previous research has shown *(24)* that the number of routine annual restaurant inspections did not affect compliance with food safety regulations, it is further hypothesized that the amount of time that has passed since the last regulatory inspection will not have a significant effect on the occurrence of out-of-compliance observations for proper cold holding and date marking of TCS food.

A CFPM refers to an individual who has shown proficiency in food safety information through passing a test that is part of an accredited program *(33)*. Studies have found the knowledge or presence of a CFPM and the presence of trained food employees are associated with an improvement in food safety knowledge, compliance, and behavior *(2, 4, 19)*. However, other studies have found no such relationship *(3, 4, 17)*. Hedberg et al. *(12)* found that the presence of a CFPM was the key difference in a study investigating food safety differences between outbreak and nonoutbreak restaurants. Kassa et al. *(17)* found the value of having certified personnel was limited to nonchain restaurants. The 2009 "FDA Report on the Occurrence of Foodborne Illness Risk Factors in Selected Institutional Foodservice, Restaurant, and Retail Food Store Facility Types" *(32)* found the presence of a CFPM was positively correlated to the overall compliance percentages of food safety practices and behaviors in full-service restaurants. For the purposes of this study, we hypothesized that the presence of a CFPM is associated with fewer out-of-compliance observations for proper cold holding and date marking of TCS food.

Widespread availability of state-issued information identifying safe cold holding temperatures of 5°C or less for TCS foods suggests adoption of the cold holding requirements of the Food Code among state, local, territorial, and tribal regulatory authorities to be common. The capacity of refrigeration equipment to keep refrigerated foods at 5°C or less and the availability of temperature measuring devices assist food employees and managers in ensuring TCS foods maintain proper temperatures *(9, 14, 36)*. As such, it was hypothesized that the occurrence of out-of-compliance observations for proper cold holding would differ significantly among restaurants based on the accessibility of a temperature measuring device and the capability of refrigeration to maintain proper temperatures.

Although cold holding requirements of 5°C are thought to be commonplace among retail regulatory authorities, the prevalence of requirements for date marking ready-to-eat, TCS foods among retail regulatory agencies is unknown. Therefore, as part of this study, adoption of date marking provisions from the 2013 Food Code among retail regulatory agencies was assessed. Because the practice of date marking foods may be a factor of the regulatory requirement to do so, it was further hypothesized that the occurrence of out-of-compliance observations for proper date marking of ready-to-eat, TCS foods would differ significantly among restaurants based on jurisdictional requirements to date mark ready-to-eat, TCS foods.

TABLE 1. *Food safety practices and corresponding data items*

Data item[a]	Food safety practice
5A	TCS food is maintained at 41°F (5°C) or below, except during preparation, cooking, or when time is used as a public health control
8A	Date marking (TCS food prepared on site, date marked if held more than 24 h)
8B	Date marking (commercially prepared TCS food opened on site, date marked if held more than 24 h)
8C	Date marking (discarded if exceeding 7 days at ≤5°C)
15A	Refrigeration/cold-holding units have sufficient capacity to maintain TCS Foods at 5°C or below
15D	Accurate temperature measuring device, with appropriate probe, is provided and accessible for use to measure internal food temperatures

[a] Data item refers to the item location on the data collection form.

MATERIALS AND METHODS

Study population. Data were collected by the FDA under Office of Management and Budget control no. 0910-0744 as part of a national observational study of fast food and full-service restaurants throughout the United States *(35)*. A geographic information system database maintained by FDA that contains a list of U.S. businesses from 2012 business location data (ESRI, Redlands, CA) was used as the establishment inventory for the restaurant data collection. The 472,243 full-service and fast food restaurants in the database for the United States in August 2013 comprised the study population. A full-service restaurant refers to a restaurant in which customers place their orders at their tables, are served their meals at the tables, receive the service of the wait staff, and pay at the end of the meal. A fast food restaurant refers to a restaurant that is not a full-service restaurant and includes restaurants commonly referred to as quick-service restaurants and fast casual restaurants. Twenty-two FDA regional retail food specialists (specialists) situated throughout the country and standardized in applying and interpreting the FDA Food Code were assigned to conduct the data collections. Data collections were performed in restaurants randomly selected from among all eligible establishments located within a 150-mile radius of the home locations of the 22 specialists. The total number of eligible establishments was 295,003, accounting for 62% of the study population. A total of 821 restaurants (396 data full-service restaurants [48%] and 425 fast food restaurants [52%]) were randomly selected and voluntarily participated in the study.

Data collection. Specialists performed data collections between November 2013 and September 2014 at the randomly selected restaurants using a standardized data collection protocol *(34)*. Observations and findings of food safety practices and behaviors were marked on a data collection form. The specialists determined whether observations of employee food safety practices or behaviors were in compliance, out of compliance, not observed, or not applicable. Table 1 presents the food safety practices evaluated as part of this study.

Study variables. FSMS was assessed by the method described in the "FDA Report on the Occurrence of Foodborne Illness Risk Factors in Fast Food and Full-Service Restaurants, 2013–2014" *(35)*. The three PTM elements were used to assess a restaurant's FSMS: "Procedures" refers to a defined set of actions adopted by food service management for accomplishing a task in a way that minimizes food safety risks. "Training" is the process of management informing employees of the food safety procedures within the restaurant and teaching employees how to carry them out. "Monitoring" comprises the routine observations and measurements conducted to determine whether food safety procedures are being followed and maintained. The specialists assessed each restaurant's FSMS to determine the extent to which FSMS was developed. Each of the three PTM elements was rated as nonexistent (no system in place), underdeveloped (in early development and efforts are being made, but there are crucial gaps in completeness and/or consistency), or well developed (system is complete, consistent, and oral or a combination of oral and written). A single, overall PTM rating for each restaurant was calculated by adding all individual PTM ratings for each data item and dividing by the number of individual ratings given. Time since the last regulatory inspection was assessed as a dichotomous variable with possible values of 1 (less than 120 days), and 2 (greater than 120 days).

As shown in Table 2, CFPM was assessed as 1 (no CFPM employed, complete absence of CFPM), 2 (CFPM employed but not present), or 3 (CFPM employed and present). Jurisdictional requirements for date marking of ready-to-eat TCS foods were determined for all 50 states and the District of Columbia by Lexis Advance (LexisNexis, New York, NY), current as of July 2017 (Table 3).

Proper cold holding was measured by taking food product temperature measurements at the time of the data collection with a calibrated digital thermometer. Proper date marking, sufficient refrigeration capacity, and accessibility of temperature measuring devices were analyzed by direct observations. These food safety practices were assessed per the marking instructions for the corresponding data items (Table 1) from the data collection form of the "FDA Report on the Occurrence of Foodborne Illness Risk Factors in Fast Food and Full-Service Restaurants, 2013–2014"

TABLE 2. *Descriptors of study variables*

Variable	Descriptor	Variable type
FSMS	Overall PTM rating: 1, nonexistent; 2, underdeveloped; 3, well developed	Continuous
CFPM	1, no CFPM employed; 2, CFPM employed but not present; 3, CFPM employed and present	Ordinal
Food safety practice compliance	Compliance with data items: 5A, 8A, 8B, and 8C	Continuous
Last regulatory inspection	1, <120 days; 2, >120 days	Dichotomous

TABLE 3. *States with a regulatory requirement to date mark TCS foods*

State	Date marking required
Alabama	Yes
Alaska	No
Arizona	Yes
Arkansas	Yes
California	No
Colorado	Yes
Connecticut	Yes
Delaware	Yes
District of Columbia	Yes
Florida[a]	Yes
Georgia[a]	Yes
Hawaii	Yes
Idaho	Yes
Illinois	Yes
Indiana	Yes
Iowa	Yes
Kansas	Yes
Kentucky	Yes
Louisiana	Yes
Maine[a]	No
Maryland	Yes
Massachusetts	No
Michigan	Yes
Minnesota[a]	No
Mississippi[a]	Yes
Missouri	Yes
Montana	Yes
Nebraska	Yes
Nevada	Yes
New Hampshire	Yes
New Jersey	No
New Mexico	Yes
New York[a]	No
North Carolina	Yes
North Dakota	Yes
Ohio[a]	Yes
Oklahoma	Yes
Oregon[a]	Yes
Pennsylvania	Yes
Rhode Island	Yes
South Carolina	Yes
South Dakota	Yes
Tennessee[a]	Yes
Texas	Yes
Utah[a]	Yes
Vermont[a]	No
Virginia[a]	Yes
Washington	No
West Virginia	Yes
Wisconsin[a]	Yes
Wyoming	Yes

[a] More than one regulatory agency in the state.

(35). Data item 5A was marked out of compliance when one or more product temperatures of TCS food that require refrigeration were greater than 5°C. Data items 8A and 8B were marked out of compliance when it was determined that a system for date marking was not in place for ready-to-eat TCS foods prepared on site and held for more than 24 h or commercial containers of ready-to-eat foods were held for more than 24 h, respectively. Data item 8C was marked out of compliance when it was observed that one or more date-marked, ready-to-eat, TCS foods were held for more than 7 days.

TABLE 4. *Occurrence and out-of-compliance percentages for food safety practices*

Data item	No. of establishments out of compliance[a]	Total observations[b]	% out of compliance[c]
5A	629	821	76.61
8A	349	730	47.81
8B	317	708	44.77
8C	281	692	40.61
15A	77	821	9.38
15D	246	821	29.96

[a] Number of establishments receiving an out-of-compliance rating.

[b] Total observations = in compliance + out of compliance observations.

[c] Percentage of out-of-compliance observations for each data item represents the proportion of establishments at which that data item was found to be out of compliance.

Data analysis. Statistical analysis of the data was performed with JMP software (version 12, SAS Institute, Cary, NC). Statistical significance of individual variables was determined at $P < 0.05$ using one-way analysis of variance (ANOVA) and pairwise comparisons (Tukey's honest significant difference test was used when the variable had more than two levels) to understand the relative effect of each variable on out-of-compliance food safety practices. Each establishment was evaluated for compliance with data items 5A, 8A, 8B, and 8C collectively. Each of those data items was either in compliance or out of compliance; therefore, each facility had a rating of 0, 1, 2, 3, or 4 of those data items in or out of compliance. The number of instances of out-of-compliance ratings was the variable of interest for this analysis. The explanatory variables in this analysis were FSMS and CFPM. Using hierarchical multiple regression analysis at $P < 0.05$, FSMS was analyzed as a continuous variable, whereas CFPM was analyzed as an ordinal variable. The effect of the CFPM and FSMS on out of compliance was first tested individually and then with the interactions. Nominal logistic regression was used to analyze the effect of the accessibility of the temperature measuring device and the refrigeration capability on compliance with proper cold holding at $P < 0.05$. A simple linear regression model was used to analyze the effect of the jurisdictional requirement to perform date marking of ready-to-eat TCS food on compliance with proper date marking at $P < 0.05$.

RESULTS

Out-of-compliance percentages for the food safety practices studied are shown in Table 4. In 629 (76.61%) of the 821 restaurants visited, food that required refrigeration was being held at improper temperatures. Food was improperly date marked in 349 (47.81%) of the 730 restaurants visited that used date marking for food prepared on site. In 281 (40.61%) of 692 restaurants visited in which date marking was observed, at least one occurrence of a date-marked food being held under refrigeration more than 7 days was observed. Temperature measuring devices were

TABLE 5. *Number of temperature observations of foods requiring refrigeration*

Temp range[a]	No. of observations[b]	Overall percentage
Within the critical limits (41°F)	6,760	66.9
1–2°F above the critical limit	928	9.2
3–4°F above the critical limit	706	7.0
5–9°F above the critical limit	919	9.1
≥10°F above the critical limit	789	7.8
Total no. of food product temperatures recorded	10,102	100.0

[a] To convert degrees Fahrenheit to degrees Celsius, subtract 32, multiply by 5, and divide by 9.
[b] Observations in 812 food establishments.

accessible in most restaurants ($n = 575$; 70.0%), and most restaurants had sufficient refrigeration capacity to maintain TCS foods at the proper temperature (744; 90.6%).

Temperature ranges for all cold-holding observations are shown in Table 5. A total of 10,102 temperatures were recorded for TCS foods requiring refrigeration across all restaurants. A total of 6,760 of those temperatures (66.9%) taken for TCS foods requiring refrigeration were in compliance (within critical limits), and 3,342 (33.1%) were out of compliance. A total of 1,708 temperatures (16.9%) taken for TCS foods requiring refrigeration were found to be at or above 7.2°C (45°F), exceeding the critical limit of 5°C. A total of 789 of the temperatures (7.8%) taken were found to be at or above 10.6°C (51°F).

Table 6 shows out-of-compliance rates for establishments based on CFPM, FSMS, and associated jurisdictional requirements. Less than half of the establishments visited ($n = 380$; 46.29%) indicated there were mandatory jurisdictional requirements to have a CFPM. However, most establishments in this study ($n = 540$; 65.77%) had a CFPM that was present at the time of data collection. Ninety-eight (11.94%) of the establishments had a CFPM that was employed but not present at the time of data collection, whereas 183 (22.29%) establishments had no CFPM employed. One hundred ninety-seven (24.17%) establishments had well-developed FSMS (a score of 3 or higher), as opposed to 180 (22.09%) establishments with no FSMS (a score of 1).

Most restaurants ($n = 542$; 66.0%) operated in a jurisdiction that required the date marking of ready-to-eat TCS foods. Restaurants located in a jurisdiction in which date marking was required had significantly fewer date marking data items that were out of compliance ($P < 0.01$). There was no significant difference in the number of data items found out of compliance between establishments that had a regulatory inspection more than 120 days before the data collection for this study and those that had an inspection within 120 days before the data collection.

Results of the univariate analysis showed a significant difference in the mean number of data items found out of compliance based on the level of CFPM ($F_{2,818} = 20.94$, $P < 0.01$). Restaurants without a CFPM employed had significantly more data items out of compliance compared with restaurants with a CFPM present ($P < 0.05$) and with

TABLE 6. *Mean number of data items out of compliance for observations of CFPM status, FSMS, CFPM requirement, date marking requirement, and time since last regulatory inspection*

Observation	No. of restaurants[a]	% of restaurants	Mean (SE) data items out of compliance[b]
CFPM			
No CFPM employed	183	22.29	2.503 (0.1039) A
CFPM, not present	98	11.94	1.898 (0.1440) B
CFPM, present	540	65.77	1.726 (0.0602) B
FSMS			
FSMS nonexistent	180[c]	22.09	2.878 (0.0931) A
FSMS underdeveloped	438[c]	53.74	2.071 (0.0667) B
FSMS well developed	197[c]	24.17	0.751 (0.0521) C
CFPM requirement			
CFPM required	380	46.29	1.652 (0.0623) A
CFPM not required	441	53.71	2.150 (0.0692) B
Date marking requirement			
Date marking required	542	66.02	1.046[d] (0.0552) A
Date marking not required	279	33.98	1.342[d] (0.0750) B
Last regulatory inspection			
Last inspection <120 days	37[e]	4.92	2.162 (0.2352) A
Last inspection >120 days	715[e]	95.08	1.892 (0.0535) A

[a] $n = 821$.
[b] Out of compliance with data items 5A, 8A, 8B, and 8C collectively. Cells containing the same letter indicate the means are not significantly different.
[c] $n = 815$, 6 establishments had no data.
[d] Out of compliance with data items 8A, 8B, and 8C collectively.
[e] $n = 752$, 63 establishments had no data.

TABLE 7. *Odds ratio of establishments properly cold holding TCS foods based on proper refrigeration capacity and temperature measuring devices*

Variable	Odds ratio	95% confidence interval[a]
Refrigeration capacity able to maintain temperature	24.605	5.389–435.619
Refrigeration capacity not able to maintain temperature	0.041	0.002–0.185
Temperature measuring device accessible	1.886	1.279–2.836
Temperature measuring device not accessible	0.530	0.353–0.782

[a] Confidence intervals that do not contain 1 indicate a significant odds ratio.

those with a CFPM that was not present ($P < 0.05$). However, there was no significant difference in the number of data items found out of compliance between restaurants with a CFPM present and those with a CFPM not present. Restaurants without a CFPM averaged 2.50 ± 0.10 data items out of compliance, whereas restaurants with and without a CFPM present averaged 1.90 ± 0.14 and 1.73 ± 0.06, respectively, as shown in Table 6.

There was a significant difference in the mean number of data items out of compliance based on the level of FSMS ($F_{1,813} = 436.65$, $P < 0.01$). Restaurants with well-developed FSMS had significantly fewer data items out of compliance compared with restaurants with underdeveloped or nonexistent FSMS ($P < 0.05$), as shown in Table 6. Restaurants with underdeveloped FSMS had significantly fewer data items out of compliance compared with restaurants with nonexistent FSMS ($P < 0.05$). Restaurants with nonexistent FSMS averaged 2.88 ± 0.09 data items out of compliance, whereas restaurants with underdeveloped FSMS averaged 2.07 ± 0.07, and those with well-developed FSMS averaged 0.75 ± 0.05.

Table 7 shows the odds ratio of establishments to properly cold hold TCS food with and without proper refrigeration capacity and with and without proper temperature measuring devices. Establishments with sufficient refrigeration capacity were more than 24 times more likely to properly cold hold TCS food compared with those establishments that did not (odds ratio = 24.61, 95% confidence interval [CI], 5.39 to 435.62, $P < 0.01$). Establishments with accessible temperature measuring devices were almost twice as likely to cold hold TCS food properly as compared with those establishments that did not have accessible temperature measuring devices (odds ratio = 1.89, 95% CI, 1.28 to 2.84, $P < 0.01$). Having sufficient refrigeration capacity and accessible temperature measuring devices were associated with better cold-holding compliance.

TABLE 8. *Percentage of restaurants with an FSMS and CFPM (*n *= 815).*

	CFPM, %		
FSMS	None	Employed, not present	Employed, present
Nonexistent	33.89	15.56	50.56
Underdeveloped	25.11	11.87	63.01
Well developed	4.57	9.14	86.29

The percentage of restaurants with a CFPM present during the time of data collection was greater for establishments with well-developed FSMS than it was for those that were underdeveloped or nonexistent, with 86% of restaurants with well-developed FSMS having a CFPM present (Table 8). Hierarchical multiple regression analysis results showed the influence of CFPM and FSMS on the out-of-compliance observations of food safety practices (Table 9). FSMS was the strongest predictor of out-of-compliance observations ($\beta = -0.8780$) and accounted for 34.94% of the variation (R^2) when evaluated as the only explanatory variable. The addition of CFPM to the model accounted for only 0.5% (ΔR^2) of the variation and was not significant.

DISCUSSION

Lm continues to be a public health burden in the retail and food service industry. During the time of this study (2013 to 2014), the CDC reported 20 outbreaks of *Lm,* including 145 illnesses, which resulted in 132 hospitalizations (91.0%) and 30 deaths (20.7%) in the United States *(30)*. The results of this study suggest improvements are needed in the proper cold holding and date marking of ready-to-eat TCS foods. More than half of restaurants were found to have at least one occurrence of improper cold holding, but fewer than half of all cold-holding observations were found to be out of compliance for proper cold holding. These findings suggest many foods requiring refrigeration in restaurants are cold held properly but also that continued improvement is needed to ensure a reduction in the average number of restaurants with at least one occurrence of improper cold holding. The significance of improper cold holding may be easily overlooked or underestimated when many of the cold-holding temperatures taken in restaurants are within the critical limits. Managers and food employees must remain vigilant in ensuring every food requiring refrigeration is properly held under temperature control.

The study also showed having sufficient refrigeration capacity and accessible temperature measuring devices was associated with better cold-holding compliance. Restaurants that had sufficient refrigeration capacity were more than 24 times more likely to properly cold hold food compared with those facilities that did not. Restaurants with accessible temperature measuring devices were almost twice as likely to cold hold food properly as compared with those establishments that did not have accessible temperature measuring devices. It may prove easier to gain increasing control of the behaviors associated with controlling the growth of *Lm* if managers and employees (i) are informed

TABLE 9. *Influence of the CFPM and FSMS on the out-of-compliance rates of food safety practices* (n = *815)*

	Model 1[a]			Model 2[b]			Model 3[c]		
Variable	β	SE β	*t*	β	SE β	*t*	β	SE β	*t*
Intercept	3.748	0.096	39.04[d]	3.872	0.1102	35.14[d]	4.108	0.226	18.16[d]
FSMS	−0.878	0.042	−20.9[d]	−0.861	0.0441	−19.51[d]	−1.012	0.134	−7.53[d]
CFPM [2–1][e]				−0.356	0.1459	−2.44[f]	−0.279	0.163	−1.72
CFPM [3–2]				1.762	0.1283	1.37	0.173	0.130	1.33
FSMS × CFPM [2–1]							0.144	0.186	0.77
FSMS × CFPM [3–2]							0.028	0.138	0.21
R^2	34.94			35.44			35.55		
Change in R^2				0.5			0.11		

[a] FSMS and out-of-compliance rates.
[b] FSMS, CFPM, and out-of-compliance rates: CFPM 2, none; CFPM 1, not present; CFPM 3, present.
[c] FSMS, CFPM, FSMS × CFPM, and out-of-compliance rates.
[d] $P < 0.01$.
[e] Numbers in brackets indicate CFPM status as described in footnote *b*.
[f] $P < 0.05$.

of the importance of cold holding, and (ii) remain vigilant in maintaining proper cold holding temperatures of food by ensuring sufficient refrigeration capacity as well as the accessibility and use of proper temperature measuring devices.

Approximately 40.61% of the foods observed that required date marking were not date marked properly and were not discarded if held under refrigeration for more than 7 days, signaling the need for improved compliance. Furthermore, being located in a jurisdiction in which date marking was required made a restaurant more likely to properly date mark and discard ready-to-eat TCS foods. The incorporation of date marking as a regulatory requirement may prove to be an important factor in controlling the growth of *Lm* in restaurants. Jurisdictions that do not require the date marking provisions may be exposing their populations to conditions that contribute to potential *Lm* contamination and illness. Future research should focus on the relationship between jurisdictional requirements for date marking and the prevalence of *Lm* outbreaks.

As hypothesized, more developed FSMS was associated with fewer out-of-compliance observations for proper cold holding and date marking of TCS food. Improving FSMS has an important role in limiting the number of out-of-compliance food safety practices related to the control of *Lm* in restaurants. Restaurants with well-developed FSMS had significantly fewer out-of-compliance observations than did those with underdeveloped FSMS. Furthermore, restaurants with underdeveloped FSMS had significantly fewer out-of-compliance observations than those with nonexistent FSMS. These relationships were not affected by the time since the last regulatory inspection, signaling support for FSMS as a proxy for the routine controls that are in place within those food establishments. These results also suggest FSMS likely improves adherence to the food safety practices associated with controlling *Lm* in restaurants.

Finding a significant difference in the number of data items found out of compliance between establishments in which a CFPM was employed versus not employed but no significant difference between establishments in which a CFPM was present versus not present, may highlight why previous studies *(4, 17)* have yielded mixed results. Furthermore, finding that CFPM was not a significant predictor of out-of-compliance observations when the effects of FSMS were considered suggests that employing a CFPM likely improves food safety practices, but further improvement may not be achieved through ensuring they are present at all times. Moreover, it was found that the presence of a well-developed FSMS was also associated with having a CFPM employed and present at the time of data collection (Table 8). This suggests that the presence of a CFPM is a component of a restaurant that successfully establishes PTM for food safety practices associated with controlling the growth of *Lm* in the foods they prepare. These findings support prior research *(4)* that concluded CFPMs have an important role in communicating information on proper food handling and preparation to food employees as a means of reducing the risk of foodborne illness. Future research should focus on how an FSMS is established and implemented in restaurants, which PTM element of the FSMS has the greatest effect on reducing out-of-compliance rates, and the use of actual outbreaks or illnesses as an outcome variable.

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