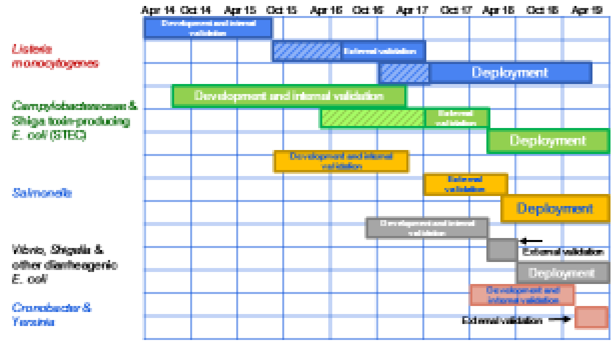
Projected wgMLST Database Validation and Deployment Timeline



This the WGS roll out schedule for state lab capacity building as of Feb 2016
Presently, 45 states have the equipment, the WGS sequencers.

1. The Integrated Food Safety Centers of Excellence now has over 100 products available on their products page. The URL is CoEFoodSafetyTools.org. (The site is under revision and very soon will be much easier to navigate and search.)

2. FoodNet data is now more available for public use at the FoodNet Fast website: https://www.cdc.gov/foodnet/foodnet-fast.html

3. NARMS data is more accessible to the public at the NARMS Now website: https://wwwn.cdc.gov/narmsnow/

4. National foodborne outbreak data is much easier to find and use now on the FOOD (Foodborne Outbreak Online Database) tool website: https://wwwn.cdc.gov/foodborneoutbreaks/

5. CDC Feature: Raw Milk

Read CDC's feature to learn about the harmful bacteria that can be in raw milk and foodborne illness outbreaks linked to raw milk. Also available in Spanish.
https://www.cdc.gov/foodsafety/rawmilk/raw-milk-index.html

Want to share these features or other syndicated CDC content through your website or blog? Get them free, from CDC's public health media library.
https://tools.cdc.gov/medialibrary/index.aspx#/res

ults

6. New Article: Outbreak Associated with Imported Foods

A small but increasing percentage of foodborne outbreaks in the United States are associated with imported food, according to an article recently published in the CDC journal *Emerging Infectious Diseases*. Fish and produce were the imported foods most commonly linked to outbreaks. Knowing what imported foods are most often linked to outbreaks can help focus efforts to improve food safety and prevent future illnesses. **Gould L, Kline J, Monahan C, Vierk K. Outbreaks of Disease Associated with Food Imported into the United States, 1996–2014. Emerg Infect Dis. 2017;23(3):525-528. https://dx.doi.org/10.3201/eid2303.161462**

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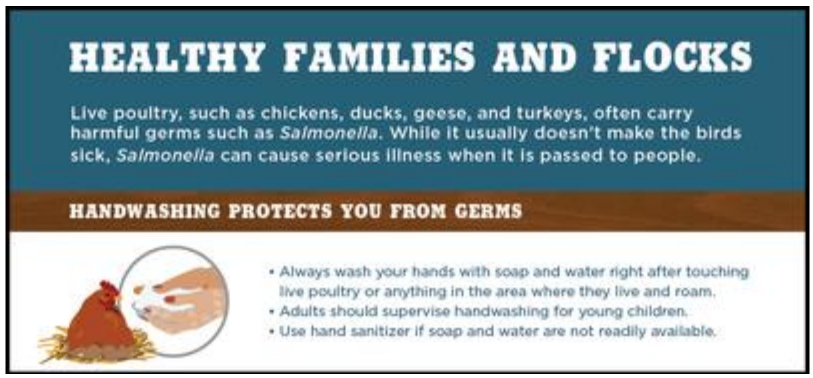
7. Fact Sheet: Healthy Families and Flocks



It's spring, which means many people are buying chicks and ducklings for backyard flocks. Yet backyard flock owners can get sick if they don't follow proper precautions, as shown by the record number of *Salmonella* infections linked to backyard flocks in 2016. CDC's updated fact sheet shares simple tips to handle and care for backyard flocks while reducing the chance of *Salmonella* illness.
https://www.cdc.gov/salmonella/live-poultry-05-16/index.html

--CIFOR is looking at several forms of after-action reviews that would enable Council members to engage in lessons-learned discussions
--CIFOR is just at the beginning stages of developing the Third Edition of the CIFOR Guidelines and Toolkit.

There are four Regional PulseNet/OutbreakNet meetings, three of which have taken place and the fourth is set for April in Providence RI. Approximately 8-12 environmental health staff from local and state health departments have received travel scholarships to attend each of the meetings.

The 2017 InFORM meeting will be held in Garden Grove/Anaheim California in November. There will be an environmental health track. A limited number of travel scholarships will be available and will be announced in the coming months.

Modules 2 and 3 (application of environmental assessment skills and food defense) of our environmental assessment training (e-Learning) will be released this spring. The new name will be the Environmental Assessment Training Series (EATS. https://www.cdc.gov/nceh/ehs/activities/food.html

Epidemiol. Infect., Page 1 of 12. © Cambridge University Press 2016
doi:10.1017/S0950268816002314

Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998–2013

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Received 27 July 2016; Final revision 1 September 2016; Accepted 14 September 2016

SUMMARY

Although contamination of food can occur at any point from farm to table, restaurant food workers are a common source of foodborne illness. We describe the characteristics of restaurant-associated foodborne disease outbreaks and explore the role of food workers by analysing outbreaks associated with restaurants from 1998 to 2013 reported to the Centers for Disease Control and Prevention's Foodborne Disease Outbreak Surveillance System. We identified 9788 restaurant-associated outbreaks. The median annual number of outbreaks was 620 (interquartile range 618–629). In 3072 outbreaks with a single confirmed aetiology reported, norovirus caused the largest number of outbreaks (1425, 46%). Of outbreaks with a single food reported and a confirmed aetiology, fish (254 outbreaks, 34%) was most commonly implicated, and these outbreaks were commonly caused by scombroid toxin (219 outbreaks, 86% of fish outbreaks). Most outbreaks (79%) occurred at sit-down establishments. The most commonly reported contributing factors were those related to food handling and preparation practices in the restaurant (2955 outbreaks, 61%). Food workers contributed to 2415 (25%) outbreaks. Knowledge of the foods, aetiologies, and contributing factors that result in foodborne disease restaurant outbreaks can help guide efforts to prevent foodborne illness.

Key words: Infectious disease epidemiology, outbreaks, public health.

INTRODUCTION

Foodborne illness caused by a known pathogen causes an estimated 9·4 million illnesses, 56 000 hospitalizations, and over 1300 deaths annually in the United States [1]. Over 90% of these illnesses are caused by 15 major pathogens, including various viruses, bacteria, and parasites, but most commonly norovirus and *Salmonella enterica* [2, 3].

Annually, over 800 foodborne disease outbreaks are reported to the Centers for Disease Control and Prevention (CDC) and most commonly occur in a restaurant setting [2]. In 2013, 51% of single-setting foodborne disease outbreaks were caused by food prepared in a restaurant [4]. Americans eat at restaurants an average of five times weekly [5] and it is estimated

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that 47% of every dollar spent on food in 2015 was spent at a restaurant [6].

The U.S. Food and Drug Administration (FDA) provides guidelines designed to prevent foodborne disease in restaurant settings; states are responsible for adopting and enforcing restaurant food-safety regulations. These guidelines address the standards for personnel management and employee health, food-safety practices, equipment storage and cleanliness, waste disposal, physical facility optimization to avoid contamination with pathogens, and poisonous material handling and storage [7]. Contamination of food served in a restaurant can occur at any point from farm to table. The guidelines aim to minimize restaurants' role in foodborne illness.

The study objective was to describe the characteristics of restaurant-based foodborne disease outbreaks, identify outbreak contributing factors, and examine the role of food workers in these outbreaks. Results of this analysis can help guide efforts to prevent foodborne illness.

MATERIALS AND METHODS

CDC collects foodborne disease outbreak reports from state and local health departments through the Foodborne Disease Outbreak Surveillance System (FDOSS) [8]. The information collected for each outbreak includes year, month, state, number of illnesses, hospitalizations and deaths, confirmed aetiology, implicated food, settings where food was prepared, and contributing factors.

We reviewed foodborne disease outbreaks that occurred during 1998–2013 in which a restaurant was the only place where food was prepared. We analysed implicated food categories, aetiology, restaurant type, and factors contributing to outbreak occurrence.

Implicated foods were categorized using the Interagency Food Safety Analytics Collaboration's (IFSAC) scheme [9]. Implicated foods that contained ingredients belonging to more than one category were classified as 'complex' when the food category responsible for illness could not be determined. For most pathogens, an aetiology was defined as confirmed if the organism was detected in samples from two or more ill persons, or in an epidemiologically implicated food(s). For marine and other toxins, confirmation requires a clinically compatible illness in two or more ill persons who ate an implicated food (e.g. as with the distinct clinical syndromes of botulism, scrombroid toxin, or heavy metals) [10, 11]. Aetiologies not meeting the criteria were classified as suspect; these suspect aetiologies included toxin-mediated illness (e.g. *Bacillus cereus, Clostridium perfringens, Staphylococcus aureus* enterotoxin) and uncommon aetiologies (e.g. *Trichinella, Cyclospora*, pesticides) in which laboratory confirmation was only performed for a single ill person or illness was identified through clinical presentation and/or epidemiological risk factors without laboratory testing. Only confirmed aetiologies were included in aetiology analyses. The restaurant type (i.e. sit-down, fast-food, other) was reported starting in 2009. Contributing factors, or reasons for contamination, were grouped into one of four categories for analysis: food worker health and hygiene, food contamination before arrival at the restaurant, food handling and preparation practices in the restaurant, and other factors (Appendix A). Because more than one contributing factor could be reported for an outbreak, an outbreak could be included in more than one contributing factor category. Food workers were implicated if a contributing factor indicating lapses in food worker health and hygiene (e.g. bare-hand contact with food) was reported or if a food worker was explicitly implicated as the cause.

The Wilcoxon test was used to compare the median number of ill persons in outbreaks. All analysis was performed using SAS v. 9.3 (SAS Institute Inc., USA).

RESULTS

Of 17 445 outbreaks reported during 1998–2013, 9788 (56%) outbreaks involved food prepared in a restaurant (Appendix B), resulting in 124 608 illnesses, 4427 hospitalizations, and 32 deaths. There were a median of 620 outbreaks annually [interquartile range (IQR) 618–629], resulting in 3151 to 11 426 illnesses each year. The median outbreak size was five persons (IQR 3–12). The largest number of restaurant-associated outbreaks were reported from Florida (1742 outbreaks, 18%), California (1289 outbreaks, 13%), and Ohio (666 outbreaks, 7%). The annual number of restaurant-associated outbreaks and the percentage of all outbreaks linked to restaurants declined from 2000 (884, 63%) to 2013 (431, 52%) (Fig. 1).

Implicated foods

A food was implicated in 4102 (42%) outbreaks. Of these, 1775 (43%) had a food that could be assigned to a single category, most commonly fish (387

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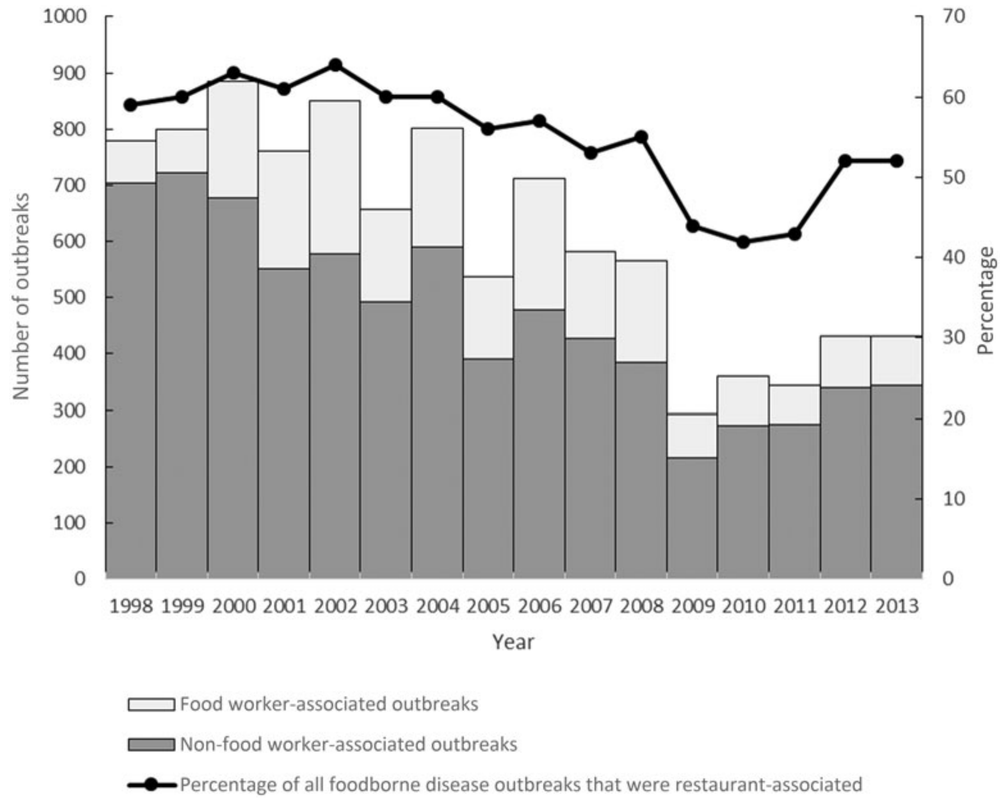

Fig. 1. Number of restaurant-associated foodborne disease outbreaks and percentage of all foodborne disease outbreaks, by year, Foodborne Disease Outbreak Surveillance System, 1998–2013. □, Number of foodworker-associated outbreaks; ■, number of non-foodworker-associated outbreaks; —•—, percentage of all foodborne disease outbreaks that were restaurant-associated.

outbreaks, 33%), beef (314 outbreaks, 27%), chicken (239 outbreaks, 20%), and molluscs (147 outbreaks, 13%) (Table 1).

Aetiology

A single confirmed aetiology was reported in 3072 (31%) outbreaks; norovirus caused the most outbreaks (1425, 46%) and outbreak-associated illnesses (52630, 42%) (Table 2). The median number of ill persons in norovirus outbreaks was 14 (IQR 7–26). Most deaths were due to *Salmonella* infections (5/23 deaths with a reported aetiology, 22%).

Other common confirmed aetiologies were *Salmonella enterica* (728 outbreaks, 24%), scombroid toxin (238 outbreaks, 8%), *C. perfringens* (123 outbreaks, 4%), Shiga toxin-producing *Escherichia coli* (117 outbreaks, 4%), and *Shigella* (76 outbreaks, 2%) (Table 2). The percentage of restaurant-associated outbreaks caused by norovirus increased during the study period, comprising 15% of outbreaks in 1998 and 40% of outbreaks in 2013. In contrast, the second most common confirmed aetiology, *Salmonella*, comprised 33% of outbreaks in 1998 and 31% in 2013 (Fig. 2).

Of the 750 outbreaks with a confirmed aetiology linked to a single food category, the most common pairs were scombroid toxin in fish (219 outbreaks, 29%), *S. enterica* in eggs (66 outbreaks, 9%), *Vibrio* spp. in molluscs (33 outbreaks, 4%), *C. perfringens* in beef (25 outbreaks, 3%), and norovirus in vegetable row crops (22 outbreaks, 3%).

Restaurant type

Of the 1859 single restaurant-associated outbreaks reported from 2009 to 2013, 1463 (79%) were at sit-down dining establishments and 246 (13%) were at fast-food establishments. Of the 804 outbreaks with both a restaurant type and a confirmed aetiology, norovirus outbreaks associated with sit-down restaurants were most common (321, 40%) (Table 3). Of the 278 outbreaks with both an implicated food category and information on restaurant type available, fish (57 outbreaks), molluscs (38 outbreaks), and chicken

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Table 1. *Foods implicated in restaurant-associated foodborne disease outbreaks, Foodborne Disease Outbreak Surveillance System, 1998–2013 (n = 1775)*

Food category	Outbreaks *n* (%)	Illnesses *n* (%)	Hospitalizations *n* (%)	Deaths *n* (%)
Fish	387 (22)	1532 (7)	79 (6)	0 (0)
Beef	314 (18)	2831 (12)	151 (11)	3 (38)
Chicken	239 (13)	2274 (10)	99 (7)	1 (13)
Molluscs	147 (8)	786 (3)	32 (2)	0 (0)
Grains/beans	108 (6)	602 (3)	11 (1)	0 (0)
Vegetable row crops	97 (6)	3378 (15)	236 (17)	0 (0)
Pork	94 (5)	1173 (5)	132 (10)	1 (12)
Eggs	85 (5)	1770 (8)	186 (13)	0 (0)
Crustaceans	64 (4)	537 (2)	7 (0·5)	0 (0)
Fruits	48 (3)	2321 (10)	46 (3)	1 (12)
Seeded vegetables	44 (2)	2437 (11)	190 (14)	0 (0)
Root/underground	38 (2)	387 (2)	7 (0·5)	0 (0)
Dairy	34 (2)	662 (3)	31 (2)	0 (0)
Turkey	33 (2)	716 (3)	99 (7)	2 (25)
Other*	43 (2)	1456 (6)	78 (6)	0 (0)
Total	1775	22 862	1384	8

* Other outbreak food categories were fungi (*n* = 5), game (*n* = 2), herbs (*n* = 10), nuts/seeds (*n* = 1), oils/sugars (*n* = 2), other meat or poultry not otherwise specified (*n* = 10), and sprouts (*n* = 13).

(26 outbreaks) were the most common foods associated with sit-down restaurants, and vegetable row crops and sprouts were most common in fast-food restaurants (five outbreaks each) (Table 3). Certain foods were more frequently implicated in sit-down than fast-food restaurants, including eggs (8% of outbreaks in sit-down dining restaurants *vs.* 0% in fast-food restaurants), pork (8% *vs.* 4%), molluscs (18% *vs.* 0%), chicken (12% *vs.* 4%), and fish (27% *vs.* 16%).

Outbreak contributing factors

In the 9788 restaurant-associated outbreaks, 4941 (50%) outbreaks contained information on at least one contributing factor, with a total of 6907 contributing factors recorded (Appendix A). The most common were those related to food handling and preparation practices in the restaurant (2995 outbreaks, 61% of those with any contributing factor recorded) followed by those related to food worker health and hygiene (2344 outbreaks, 47%). Factors related to food contamination before reaching the restaurant (761 outbreaks, 15%) were less common.

The most common outbreak contributing factors related to food handling and preparation practices in the restaurant were improper adherence of an approved plan to use time as a public health control (962 outbreaks, 32%), inadequate or insufficient thawing of frozen products leading to the proliferation of pathogens (957 outbreaks, 32%), and cross-contamination by a non-food handler who was suspected of being infectious (954 outbreaks, 32%).

In the 1875 outbreaks with a confirmed aetiology and contributing factor information available, *Salmonella* was the most common confirmed aetiology in outbreaks in which food contamination before entering the restaurant was cited as a contributing factor [157 (33%) outbreaks of 481] and food handling and preparation practices in the restaurant was cited as a contributing factor [341 (40%) of 861 outbreaks]. Norovirus was the most common confirmed aetiology in outbreaks in which contamination related to food worker health and hygiene was cited as a contributing factor [706 (71%) of 997 outbreaks] and other contamination methods [68 (27%) of 253 outbreaks].

Scombroid toxin in fish was the most common food-aetiology pair in outbreaks with a confirmed aetiology related to contamination of food before reaching the restaurant (136 outbreaks), outbreaks related to food handling and preparation practices occurring within the restaurant (75 outbreaks), and outbreaks related to other contributing factors (33 outbreaks). Norovirus in vegetable row crops was the most common food-aetiology pair in outbreaks with a confirmed aetiology related to food worker health and hygiene (15 outbreaks).

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Table 2. *Aetiologies in restaurant-associated foodborne disease outbreaks, Foodborne Disease Outbreak Surveillance System, 1998–2013*

Aetiology	Confirmed *n* (%)	Suspected *n* (%)	Total *n* (%)	Median outbreak size (IQR)*
Norovirus	1425 (46)	1178 (48)	2603 (47)	14 (7–26)
Salmonella enterica	728 (24)	93 (4)	821 (15)	9 (4–20)
Scombroid toxin	238 (8)	61 (3)	299 (5)	2 (2–3)
Clostridium perfringens	123 (4)	240 (10)	363 (6)	11 (6–24)
Shiga toxin-producing *E. coli*	117 (4)	2 (0)	119 (2)	8 (4–19)
Shigella spp.	76 (2)	9 (0)	85 (2)	10 (5–26)
Staphylococcus aureus enterotoxin	74 (2)	287 (12)	361 (7)	10 (4–20)
Campylobacter spp.	65 (2)	37 (2)	102 (2)	6 (3–11)
Hepatitis virus	50 (2)	1 (0)	51 (1)	9 (6–32)
Bacillus cereus	47 (2)	298 (12)	345 (6)	6 (3–11)
Vibrio spp.	47 (2)	36 (1)	83 (2)	4 (2–5)
Ciguatoxin	26 (1)	7 (0)	33 (1)	4 (2–6)
Other†	47 (2)	207 (8)	254 (4)	n.a.
Total	3072	2456	5528	

n.a., Not applicable.
* Interquartile range in outbreaks with confirmed aetiologies.
† Other confirmed aetiologies were amnesic shellfish poisoning ($n = 1$), astrovirus ($n = 1$), *Cyclospora* ($n = 9$), *Enterococcus* ($n = 1$), *Giardia* ($n = 6$), heavy metals ($n = 2$), *Listeria* ($n = 5$), monosodium glutamate ($n = 1$), other chemicals and toxins not otherwise specified ($n = 10$), pesticides ($n = 3$), rotavirus ($n = 1$), sapovirus ($n = 2$), *Trichinella* ($n = 1$), and *Yersinia* ($n = 2$).

Implication of food workers

Food workers were implicated as the source in 2344 (24%) of the 9788 outbreaks. The median size of outbreaks in which a food worker was implicated was eight ill persons (IQR 4–20), compared to a median of four (IQR 2–9) for all other outbreaks ($P < 0{\cdot}001$).

A single food category was identified in 1372 (59%) of 2344 outbreaks involving a food worker, most commonly beef (62 outbreaks), chicken (45 outbreaks), and vegetable row crops (41 outbreaks). Most outbreaks where food workers were implicated occurred in sit-down restaurants [274 (82%) out of 336 outbreaks since 2009].

Information was available on a confirmed aetiology for 1131 of the 2344 outbreaks involving food workers. Norovirus was the most frequent cause (794 outbreaks, 70% of outbreaks involving a food worker), followed by *S. enterica* (191 outbreaks, 17%), and *Staphylococcus aureus* enterotoxin (35 outbreaks, 3%). The *Salmonella* serotypes most commonly implicated in food worker-associated outbreaks were Enteritidis (60 outbreaks), Typhimurium (26 outbreaks), Heidelberg (18 outbreaks), and Newport (14 outbreaks).

DISCUSSION

This study highlights the significant burden of foodborne disease outbreaks that occur in restaurants in the United States. Over half of all foodborne disease outbreaks reported to the CDC from 1998 to 2013 involved a restaurant setting.

We found that factors related to food handling and preparation practices in restaurants, including inadequate thawing resulting in pathogen proliferation and cross-contamination were the most frequent contributors to restaurant outbreaks. Food workers have reported that obstacles such as sink accessibility and clean cutting board availability, time demands, restaurant management and coworker influence, and lack of food-safety training and procedures, all negatively impact their ability to safely prepare foods in accordance with guidelines and regulations [12] and are likely reasons for food preparation lapses. Of these outbreaks with contributing factors related to food handling and preparation in the restaurant, *Salmonella* was the most common confirmed aetiology. This likely indicates that food enters the restaurant contaminated (i.e. poultry contaminated with *Salmonella*) and proper procedures are not followed to eliminate this organism once in the restaurant. Although the FDA Food Code was established to minimize five major risk factors in restaurant-associated foodborne illness, including improper holding temperatures, inadequate cooking, contaminated equipment, obtaining food from unsafe sources, and poor personal

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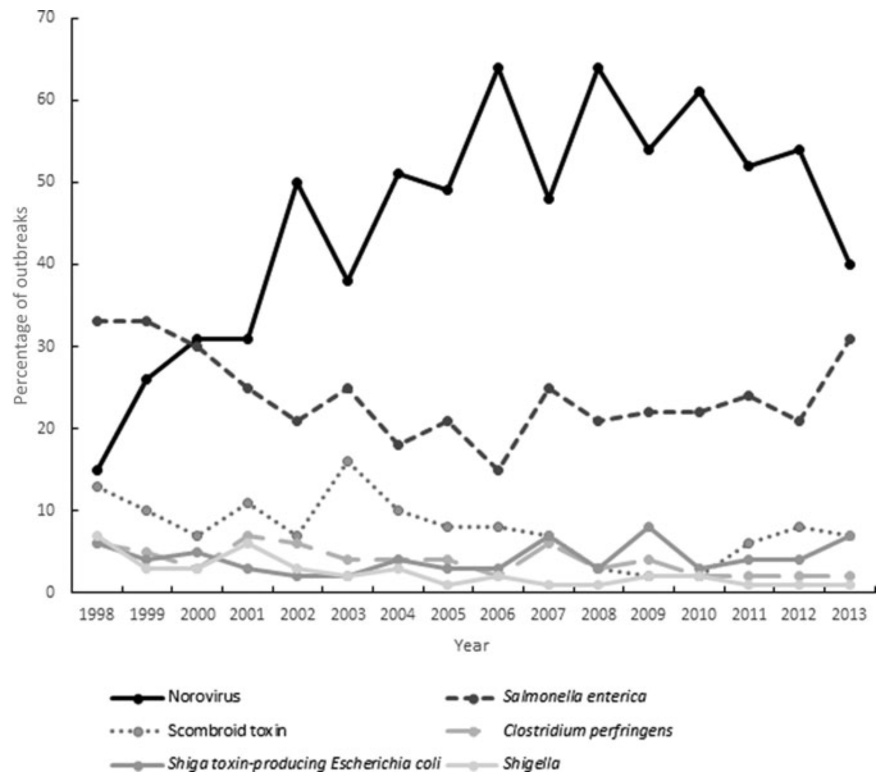

Fig. 2. Percentage of restaurant-associated outbreaks caused by the most common confirmed aetiologies, by year, Foodborne Disease Outbreak Surveillance System, 1998–2013.

hygiene [7], obstacles to implementing and following these guidelines must be addressed.

We found that food workers contributed to a quarter of all restaurant-associated outbreaks, and outbreaks associated with food workers tended to be larger than others. This underscores the role of food worker health and hygiene and safe food preparation practices in restaurant settings in foodborne illness prevention. Food workers can contribute to food contamination by failing to adhere to safe food preparation time and temperature guidelines, directly introducing pathogens while preparing food when ill, or cross-contaminating ready-to-eat foods or cooked foods with raw food [12–14]. A recent survey of restaurant food workers found that most lacked knowledge about foodborne disease prevention, including correct handwashing technique, proper food storage, adequate meat temperatures, and how to tell if food has gone bad [14]. Food workers report not always wearing gloves while handling ready-to-eat foods and not changing gloves in between handling raw meat and ready-to-eat foods [15]. Inadequate handwashing is a well-established method for spreading illness [7]; food workers are less likely to practice appropriate handwashing when they are busy [14]. In an observational study assessing food workers' handwashing frequency, hands were washed only 39 (7%) of the 582 times they should have been washed. Hands were not washed after touching aprons, and rarely when changing tasks or handling different food products. Moreover, compliance with the FDA Food Code handwashing guideline was extremely low (5%) [16]. A survey from 2010 revealed that close to 88% of restaurant workers do not receive paid sick days and over 63% had cooked or served food while sick [17]. Moreover, one-third of restaurants do not have clear policies about when to allow a sick food worker to work and 20% of food workers went to work while ill at least once in the previous year [5, 17].

An implicated food was not reported in half of restaurant-associated outbreaks. This is in part because linking a food to an outbreak is often difficult, as it requires identifying a common food exposure. Ill persons may have many common exposures, making it difficult to distinguish which food item caused the outbreak. In outbreaks in which an implicated food was identified, half were linked to complex foods in which an ingredient in a single food category could not be identified. This is likely due to the

Table 3. *Number of restaurant-associated foodborne disease outbreaks by food, aetiology, and restaurant type, Foodborne Disease Outbreak Surveillance System, 2009–2013*

	Restaurant type, *n* (%)			
	Sit-down	Fast-food	Other*	Total
Confirmed aetiology				
Norovirus	321 (51)	56 (51)	41 (65)	418
Salmonella enterica	151 (34)	29 (27)	14 (22)	194
Clostridium perfringens	17 (3)	1 (1)	1 (2)	19
Scombroid toxin	36 (6)	4 (4)	1 (2)	41
Shiga toxin-producing *E. coli*	27 (4)	9 (8)	1 (2)	37
Campylobacter spp.	20 (3)	0 (0)	1 (2)	21
Vibrio spp.	16 (3)	0 (0)	1 (2)	17
Ciguatoxin	10 (2)	0 (0)	1 (2)	11
Shigella spp.	6 (1)	4 (4)	0 (0)	10
Bacillus cereus	6 (1)	2 (2)	0 (0)	8
Staphylococcus enterotoxin	4 (1)	0 (0)	1 (2)	5
Hepatitis	2 (0)	3 (3)	0 (0)	5
Other†	16 (3)	1 (1)	1 (2)	18
Total	632	109	63	804
Food category				
Fish	57 (24)	4 (16)	3 (17)	64
Molluscs	38 (16)	0 (0)	1 (6)	39
Chicken	26 (11)	1 (4)	1 (6)	28
Vegetable row crops	18 (8)	5 (20)	2 (11)	25
Beef	21 (9)	2 (8)	0 (0)	23
Grains/beans	20 (9)	2 (8)	0 (0)	22
Pork	16 (7)	1 (4)	2 (11)	19
Eggs	16 (7)	0 (0)	1 (6)	17
Sprouts	1 (0)	5 (20)	1 (6)	7
Fruits	5 (2)	0 (0)	1 (6)	6
Seeded vegetables	2 (1)	2 (8)	1 (6)	5
Other‡	15 (6)	3 (12)	5 (28)	23
Total	235	25	18	278

* Other (e.g. mall food court, stand-alone deli, banquet) or unknown restaurant type.

† Other confirmed etiologies were amnesic shellfish poisoning ($n = 1$), *Cyclospora* ($n = 2$), *Enterococcus* ($n = 1$), *Giardia* ($n = 1$), *Listeria* ($n = 1$), other chemicals and toxins not otherwise specified ($n = 1$), pesticides ($n = 2$), sapovirus ($n = 2$), and *Trichinella* ($n = 1$).

‡ Other outbreak food categories were crustaceans ($n = 3$), dairy ($n = 3$), fungi ($n = 1$), herbs ($n = 1$), nuts/seeds ($n = 1$), other meat or poultry not otherwise specified ($n = 6$), root/underground ($n = 4$), and turkey ($n = 4$).

inherent difficulty in determining the causative food category in a complex food consumed by many people. In some outbreaks, more than one food category may be responsible for illness (i.e. contamination of several food items by ill workers, or cross-contamination).

Overall, over 70% of outbreaks were due to animal-based foods (meat and seafood items). Animal-based foods were also more commonly implicated in sit-down restaurants (67% of outbreaks) than fast food restaurants (32% of outbreaks). Many animal-based food types are likely inherently contaminated before consumption and temperature abuse can lead to bacterial proliferation and toxin production. Appropriate cooking practices, including cooking to the appropriate internal temperature and limiting time at room temperature are imperative to decrease pathogen burden or toxin production before serving.

Nearly half of restaurant-associated outbreaks were caused by norovirus, including most food worker-associated outbreaks. Detection of norovirus outbreaks has increased since the 1990s, likely due in part to improved and more widely used molecular diagnostics, including real-time reverse transcription–polymerase chain reaction assays and sequence analysis [18, 19]. Norovirus outbreaks were also larger than those caused by other pathogens. This is likely due in part to norovirus' high infectivity and low infectious dose (as few as 18 viral particles may cause illness) [20]. Norovirus was the most common aetiology in outbreaks linked to vegetable row crops, foods that are commonly eaten raw and may not undergo a heat step to kill pathogens. Outbreaks due to food contaminated with norovirus during production (i.e. before arriving at the restaurant) are rarely identified [19, 21]. Consistently, our study found that most restaurant-associated norovirus outbreaks were associated with food worker health and hygiene lapses during food preparation or serving. A study reported that restaurants with certified kitchen managers have fewer food contamination events and fewer norovirus outbreaks [22], suggesting that this may be an important intervention.

Scombroid toxin (histamine) was the third most common aetiology identified and was most commonly associated with consumption of fish. Although the median outbreak size involving scombroid toxin was small, it is likely that illness from scombroid toxin is under-recognized since the clinical presentation is similar to an allergy [23]. Cooking contaminated foods does not destroy histamine [23], highlighting the importance of proper handling at the source. Over 85% of fish consumed in the United States is imported [24], and ensuring immediate freezing of

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raw fish after initial catch and proper storage during transport is crucial to prevent foodborne illness.

Norovirus, *B. cereus, Staphylococcus aureus* enterotoxin, and *C. perfringens* were the most common suspect aetiologies in restaurant-associated foodborne disease outbreaks. Since most outbreaks caused by these pathogens are short and illness is self-limited, it is often difficult to confirm the aetiology if ill persons do not seek care or if clinical specimens are not tested. In these instances, epidemiologists may assess the clinical syndrome, incubation period, food category, and outbreak setting and designate a suspect aetiology [25].

We found that more outbreaks occurred in sit-down restaurants than fast-food restaurants. There may be several explanations for this observation. First, different food types are prepared differently, for example, sit-down restaurants traditionally have a 'cook-to-order' option in comparison to standard cooking protocols in fast-food restaurants. 'Cook-to-order' food may be more prone to preparation errors, predisposing consumers to foodborne illness. Second, a customer may be more likely to consume raw or undercooked products at a sit-down restaurant, including raw fish, oysters, beef, or eggs. Third, outbreaks in sit-down restaurants might be more likely to be detected because food is usually consumed in group settings, thus more easily allowing ill persons to be identified and linked epidemiologically. Last, many fast-food restaurants have standardized cooking and supplier guidelines as a result of previous high-profile outbreaks; a decrease in the number of outbreaks in this setting may be a direct result of practice improvements.

In 2009, the surveillance system for foodborne disease outbreaks transitioned to a new electronic reporting platform and subsequently the total number of foodborne disease outbreaks decreased. A survey suggested that this overall decline in foodborne outbreaks was due to decreased resources available for outbreak detection during the influenza A(H1N1) epidemic and a surveillance artifact [26], given that the percentage of aetiologies and food categories did not change. In our study, the percentage of foodborne outbreaks that were restaurant-associated outbreaks declined annually since 2002, but has averaged 55% throughout the study period. Also, the percentage of illnesses associated with restaurant-associated foodborne outbreaks did not change dramatically over the study period (range 7–9%). The decrease in restaurant-associated outbreaks may be due to improved food handling practices and improved restaurant guidance to prevent foodborne illness or more outbreaks in multiple states are being identified as part of a single, multistate outbreak.

This study has a few limitations. The surveillance system relies on reporting and outbreak investigations by state, local, and territorial public health departments. Changes in the surveillance system, described above, may have contributed to the decrease in the number of outbreaks reported to CDC the health departments that year. Restaurant-related regulations and resources to perform outbreak investigations vary by state, and within a state can vary by jurisdiction. Results might have been influenced by states that receive more funding or resources or have larger populations. Restaurant-associated outbreaks may also be inherently more likely to be reported than other outbreaks.

Knowledge of the foods, aetiologies, and contributing factors that result in restaurant outbreaks can help guide efforts to prevent foodborne illness. Given that the majority of outbreaks were in sit-down restaurants and involved food preparation practices in the restaurant, more work needs to be done to address this issue. Emphasis must be placed on continued education, including refresher trainings for kitchen and serving staff including demonstrations of food-safety knowledge, effective management and appropriate restaurant practices oversight including having a trained manager on duty at all times, implementation of employee health controls including policies during illness and an emphasis on appropriate handwashing, and strict adherence to all food code guidelines.

ACKNOWLEDGEMENTS

We acknowledge the local, state, and territorial public health departments who report their outbreaks to CDC and the FDOSS surveillance team for their database management and expertise. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC. This study received no financial support.

DECLARATION OF INTEREST

None.

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http://dx.doi.org/10.1017/S0950268816002314

APPENDIX A

Categories used for analysis of contributing factors in restaurant-associated foodborne disease outbreaks, Foodborne Disease Outbreak Surveillance System, 1998–2013 (n = 6907 contributing factors)*

Category	Contributing factors 1998–2008	Contributing factors 2009–2012	No. of outbreaks (%)
	Bare-handed contact by handler/worker/preparer (e.g. with ready-to-eat food)	Bare-hand contact by a food handler/worker/preparer who is suspected to be infectious	1451 (62)
Food worker health & hygiene	Handling by an infected person or carrier of pathogen (e.g. *Staphylococcus, Salmonella*, norovirus)	Other mode of contamination (excluding cross-contamination) by a food handler/worker/preparer who is suspected to be infectious	1073 (46)
	Glove-handed contact by handler/worker/preparer (e.g. with ready-to-eat food)	Glove-hand contact by a food handler/worker/preparer who is suspected to be infectious	463 (20)
Any of the above			2344 (34)
	Raw product/ingredient contaminated by pathogens from animal or environment (e.g. *Salmonella* Enteriditis in egg, norovirus in shellfish, *E. coli* in sprouts)	Contaminated raw product – food was intended to be consumed after a kill step	396 (52)
Contamination of food before reaching the restaurant	Toxic substance part of tissue (e.g. ciguatera)	Toxic substance part of the tissue	220 (29)
	Ingestion of contaminated raw products (e.g. raw shellfish, produce, eggs)	Contaminated raw product – food was intended to be served raw or undercooked/under processed	187 (29)
	Obtaining foods from polluted sources (e.g. shellfish)	Foods originating from sources shown to be contaminated or polluted (such as a growing field or harvest area)	22 (3)
Any of the above			761 (11)
		Improper adherence of approved plan to use time as a public health control	962 (32)
	Inadequate thawing of frozen products (e.g. room thawing)	Food preparation practices that support proliferation of pathogens (during food preparation)	
	Insufficient thawing, followed by insufficient cooking (e.g. frozen turkey)		957 (32)
		Foods contaminated by a non-food handler/worker/preparer who is suspected to be infectious	954 (32)
	Cross-contamination from raw ingredient of animal origin (e.g. raw poultry on the cutting board)	Cross-contamination of ingredients (cross-contamination does not include ill food workers)	710 (24)
	Preparing foods a half day or more before serving (e.g. banquet preparation a day in advance)	No attempt was made to control the temperature of implicated food or the length of time food was out of temperature control (during food service or display of food)	566 (19)
	Insufficient time and/or temperature during hot holding (e.g. malfunctioning equipment, too large a mass of food)	Improper hot holding due to malfunctioning equipment	426 (14)

http://dx.doi.org/10.1017/S0950268816002314

APPENDIX A (*cont.*)

Category	Contributing factors 1998–2008	Contributing factors 2009–2012	No. of outbreaks (%)
	Insufficient time and/or temperature during initial cooking/heat processing (e.g. roasted meats/poultry, canned foods, pasteurization)	Insufficient time and/or temperature control during initial cooking/heat processing	382 (13)
Food handling and preparation practices in the restaurant	Inadequate cold-holding temperatures (e.g. refrigerator inadequate/not working, ice holding inadequate)	Improper cold holding due to malfunctioning refrigeration equipment	311 (10)
	Insufficient time and/or temperature during reheating (e.g. sauces, roasts)	Insufficient time and/or temperature during reheating	303 (10)
	Storage in contaminated environment B leads to contamination of vehicle (e.g. store room, refrigerator)	Storage in contaminated environment	268 (9)
		Improper cold holding due to an improper procedure or protocol	110 (4)
	Allowing foods to remain at room or warm outdoor temperature for several hours (e.g. during preparation or holding for service)	Improper hot holding due to improper procedure or protocol	72 (2)
	Slow cooling (e.g. deep containers or large roasts)	Improper/slow cooling	61 (2)
		Insufficient or improper use of chemical processes designed for pathogen destruction	44 (1)
	Prolonged cold storage for several weeks (e.g. permits slow growth of psychrophilic pathogens)	Prolonged cold storage	35 (1)
	Anaerobic packaging/modified atmosphere (e.g. vacuum packed fish, salad in gas flushed bag)	Inadequate modified atmosphere packaging	7 (0)
		Insufficient time and/or temperature control during freezing	5 (0)
	Inadequate acidification (e.g. mayonnaise, tomatoes canned) Inadequate fermentation (e.g. processed meat, cheese) Insufficiently low water activity (e.g. smoked/salted fish) Insufficient acidification (e.g. home canned foods)	Inadequate processing (acidification, water activity, fermentation)	4 (0)
Any of the above			2995 (43)
	Other source of contamination	Other source of contamination	475 (59)
	Other process failures that permit the agent to survive	Other process failures that permit the agent to survive	246 (30)
Other	Other situations that promote or allow microbial growth or toxic production	Other situations that promote or allow microbial growth or toxic production	130 (16)
	Toxic container of pipelines (e.g. galvanized containers with acid food, copper pipe with carbonated beverages)	Toxic container	15 (2)
	Poisonous substance intentionally added (e.g. cyanide or phenolphthalein added to cause illness)	Poisonous substance intentionally/ deliberately added	9 (1)

http://dx.doi.org/10.1017/S0950268816002314

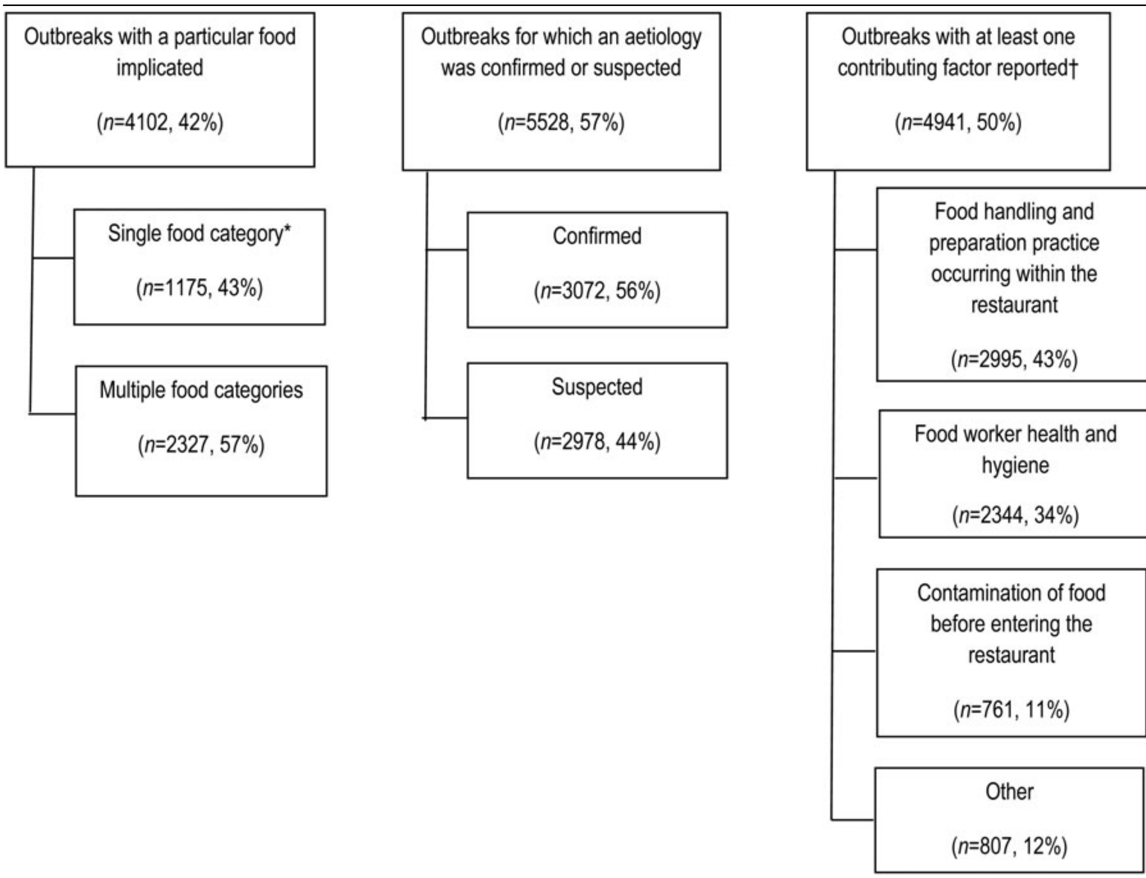
APPENDIX A (*cont.*)

Category	Contributing factors 1998–2008	Contributing factors 2009–2012	No. of outbreaks (%)
	Addition of excessive quantities of ingredients that are toxic under these situations (e.g. niacin poisoning in bread)	Addition of excessive quantities of ingredients that are toxic in large amounts	4 (1)
	Poisonous or physical substance accidentally/incidentally added (e.g. sanitizer or cleaning compounds	Poisonous substance accidentally/ inadvertently added	2 (0)
Any of the above			807 (12)

* Contributing factor definitions were revised in 2009 and outbreaks may be listed under more than one factor.

APPENDIX B

Foodborne disease outbreaks associated with a restaurant setting, Foodborne Disease Outbreak Surveillance System, 1998–2013 (n = 9788)



* Foods were classified according to the Interagency Food Safety Analytics Collaboration's (IFSAC) scheme and include the following categories: dairy, eggs, fish, fruits, fungi, game, grains-beans, herbs, meat (e.g. beef, pork), oils/sugars, nuts/seeds, poultry (e.g. chicken, turkey), shellfish (e.g. crustaceans, molluscs), sprouts, vegetables (e.g. root-underground, seeded, vegetable row crops), and other poultry or meat.

† More than one contributing factor categories may be reported.

http://dx.doi.org/10.1017/S0950268816002314

Journal of Food Protection, Vol. 79, No. 9, 2016, Pages 1527–1536
doi:10.4315/0362-028X.JFP-16-088

A State-by-State Assessment of Food Service Regulations for Prevention of Norovirus Outbreaks

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MS 16-088: Received 24 February 2016/Accepted 12 May 2016

ABSTRACT

Noroviruses are the leading cause of foodborne disease in the United States. Foodborne transmission of norovirus is often associated with contamination of food during preparation by an infected food worker. The U.S. Food and Drug Administration's Food Code provides model food safety regulations for preventing transmission of foodborne disease in restaurants; however, adoption of specific provisions is at the discretion of state and local governments. We analyzed the food service regulations of all 50 states and the District of Columbia (i.e., 51 states) to describe differences in adoption of norovirus-related Food Code provisions into state food service regulations. We then assessed potential correlations between adoption of these regulations and characteristics of foodborne norovirus outbreaks reported to the National Outbreak Reporting System from 2009 through 2014. Of the 51 states assessed, all (100%) required food workers to wash their hands, and 39 (76%) prohibited bare-hand contact with ready-to-eat food. Thirty states (59%) required exclusion of staff with vomiting and diarrhea until 24 h after cessation of symptoms. Provisions requiring a certified food protection manager (CFPM) and a response plan for contamination events (i.e., vomiting) were least commonly adopted; 26 states (51%) required a CFPM, and 8 (16%) required a response plan. Although not statistically significant, states that adopted the provisions prohibiting bare-hand contact (0.45 versus 0.74, $P = 0.07$), requiring a CFPM (0.38 versus 0.75, $P = 0.09$), and excluding ill staff for $\geq$24 h after symptom resolution (0.44 versus 0.73, $P = 0.24$) each reported fewer foodborne norovirus outbreaks per million person-years than did those states without these provisions. Adoption and compliance with federal recommended food service regulations may decrease the incidence of foodborne norovirus outbreaks.

Key words: Food service; Norovirus; Prevention; Regulation; Retail food code

Noroviruses are the leading cause of acute gastroenteritis and foodborne disease in the United States *(11)*. From 2009 through 2012, approximately 48% of foodborne disease outbreaks reported to the National Outbreak Reporting System (NORS) that had a single known etiology were caused by noroviruses *(15)*. Symptoms of norovirus infection generally include vomiting and diarrhea; however, infected individuals can be asymptomatic *(13)*. Noroviruses can be spread by ingestion of contaminated food or water, contact with contaminated fomites, direct person-to-person contact, and inhalation and subsequent ingestion of aerosolized vomitus *(13, 21)*. Norovirus can be shed in high quantities by infected individuals, and shedding can occur before, during, and after presentation of symptoms *(1)*. The virus has a low infectious dose (18 to 2,800 viral particles) *(2, 24)*, can withstand freezing temperatures and heating, and is difficult to kill with common disinfectants *(13)*. Therefore, norovirus can spread quickly in food service settings, where a contaminated food item can potentially expose hundreds of people.

Foodborne norovirus outbreaks are typically associated with contamination of food during preparation by an infected food service worker, often involving bare-hand contact with ready-to-eat (RTE) foods or working while ill *(3, 11)*. Among foodborne norovirus outbreaks occurring from 2009 through 2012, infected food workers were implicated as the source of contamination in 70% of outbreaks in which factors contributing to contamination were reported; bare-hand contact was specifically implicated in over half of these outbreaks *(15)*. Of the reported foodborne norovirus outbreaks, 90% involved foods prepared in food service facilities, most commonly in restaurants *(15)*.

The U.S. Food and Drug Administration (FDA) Food Code provides model food safety regulations for preventing transmission of foodborne disease in food service facilities *(31)*. Since 2009, the Food Code has been published every 4 years, based on stakeholder input from the food industry, consumer groups, academia, and government through the

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Conference for Food Protection *(7)*. Before 2009, the Food Code was revised every 2 years. Updates or revisions to Food Code provisions may be released between published versions in the form of a supplement to the previously published version. Although the Food Code represents current guidelines for food safety, adoption of the Food Code provisions, in whole or in part, is at the discretion of state and local governments; consequently, adoption varies widely among states *(30)*.

Uniform adherence to food service guidelines has significant potential to improve food safety in the United States. Identification of gaps in adherence to these guidelines would allow lawmakers and the food industry to determine appropriate areas for improvement. The primary objective of our study was to assess adoption of specific norovirus-related food service provisions of the 2013 FDA Food Code *(31)* that were previously identified as important in decreasing transmission of foodborne norovirus *(15)* and to describe differences in the adoption of these provisions among states. We also evaluated associations between the adoption of select provisions and the rate and characteristics of foodborne norovirus outbreaks reported by each state.

MATERIALS AND METHODS

Food service provisions. We searched the government Web sites of all 50 states and the District of Columbia (hereinafter referred to as 51 states) to obtain the most recent food code regulations that were in effect as of 31 December 2014. Publicly accessible regulations (Table 1) were downloaded from government Web sites and/or obtained through contact with state public health departments. Regulations were assessed by two independent reviewers for the presence of provisions on hand washing, bare-hand contact with RTE food, exclusion of ill workers, certified food protection manager (CFPM), and a response plan for contamination events, as described in the 2013 FDA Food Code. Descriptions of each provision and the specific criteria used for assessment of state regulations in this analysis are provided in Table 2.

Outbreak data. Data on all foodborne disease outbreaks with a first illness onset date of 1 January 2009 to 31 December 2014 and that listed norovirus as the only epidemiologically suspected or laboratory-confirmed etiology were obtained from NORS on 4 December 2015. NORS is an Internet-based voluntary surveillance system used by local, state, and territorial public health agencies to report to the Centers for Disease Control and Prevention (CDC) all foodborne and waterborne disease outbreaks and enteric disease outbreaks that are spread by person-to-person contact or environmental contamination or have other or unknown modes of transmission *(6, 14)*. Foodborne outbreaks are defined as two or more cases of a similar illness associated with a common exposure in which food is reported as the primary mode of transmission. The following outbreak characteristics were extracted from NORS: outbreak size and duration, implication of food workers as the source of the outbreak, implication of bare-hand contact by an infected worker, and whether an analytic study (i.e., case-control or cohort) was conducted as part of the outbreak investigation.

Analysis. NORS data were cleaned and analyzed using SAS 9.3 (SAS Institute, Cary, NC) and R *(20, 23)*. State-specific population-based reporting rates (i.e., the number of NORS reports per population in each state during the 6-year reporting period) of foodborne norovirus outbreaks were calculated using 2014 state population estimates from the U.S. Census Bureau *(26)*, under the assumption that each state's population did not change significantly from 2009 through 2014. Reporting rates were presented in person-time, which combines the number of persons at risk (i.e., number of people in each state) and the study period (i.e., 6-year reporting period) and standardized to 1 million persons per year. NORS data were then merged with the data from our assessment of state regulations.

For the analysis, continuous variables (i.e., outbreak size and duration) were dichotomized using the median. An outbreak was defined as large when the estimated number of primary cases was 12 or more persons and small when the estimated number of primary cases was less than 12. An outbreak was considered to be of long duration when the dates of illness onset spanned three or more days and of short duration when dates of illness onset spanned less than 3 days.

We were unable to assess associations with the provision on hand washing because all states had adopted some form of this provision. We also did not assess associations with the provision requiring a contamination response plan because few states had adopted this provision. We used the Wilcoxon rank-sum test to independently compare the outbreak reporting rates of states with and without the specified provisions and used multivariate linear regression to simultaneously assess associations between outbreak reporting rate and adoption of these provisions. We used multivariate logistic regression models to assess associations between adoption of each specific provision and the outbreak characteristics extracted from NORS, controlling for reporting rate and adoption of other provisions. We also controlled for whether a cohort or case-control study was conducted, as an indication of investigation intensity. Statistical significance was determined by the 95% confidence interval (CI) for all analyses.

RESULTS

Food service provisions. Of the 51 states assessed, all adopted at least one of the five norovirus-related food service provisions in their respective food codes. A majority (33 states, 65%) adopted three or fewer provisions (Fig. 1). Thirteen states (25%) adopted four provisions, and five states (10%) adopted all five of the selected provisions.

Hand hygiene provisions, specifically requiring hand washing and prohibiting bare-hand contact, were most widely adopted (Fig. 2). All states had provisions requiring hand washing, and 39 (76%) prohibited bare-hand contact with RTE food; an additional 8 states (16%) did not completely prohibit bare-hand contact but called for limitation or minimization of bare-hand contact with RTE food. Although all states included some type of provision regarding hand washing, not all components outlined in the Food Code were adopted by all states. The Food Code describes nine situations in which a food worker should wash his or her hands (Table 3). All states adopted the subprovision requiring hand washing after using the restrooms, but other subprovisions were not as widely adopted. The subprovision requiring food workers to wash their hands "before donning gloves to initiate a task that involves working with food" was least commonly included in state food codes, with only 40 states (78%) including this subprovision in their respective food codes.

TABLE 1. *State food service regulations*

State	Source	Effective date
Alabama	Rules of Alabama State Board of Health, Bureau of Environmental Services, chapter 420-3-22 for Food Establishment Sanitation	4 Apr. 2013
Alaska	18 AAC 31 Alaska Food Code	24 June 2012
Arizona	Arizona Administrative Code, Title 9, Health Services, chapter 8: Department of Health Services Food, Recreational and Institutional Sanitation	14 July 2000
Arkansas	Rules and Regulations Pertaining to Food Establishments	1 Aug. 2012
California	California Retail Food Code	1 Jan. 2014
Colorado	Colorado Retail Food Establishment Rules and Regulations	1 Mar. 2013
Connecticut	19-13-B42, Sanitation of places dispensing foods or beverages	3 July 2007
Delaware	State of Delaware Food Code	11 May 2014
Florida	Florida Administrative Code, chapter 64e-11, Food Hygiene	1 Jan. 2013
Georgia	Rules of Department of Human Resources Public Health, chapter 290-5-14, Food Service	12 Sep. 2007
Hawaii	Hawaii Administrative Rules, chapter 11-50, Food Safety Code	24 Feb. 2014
Idaho	Idaho Food Code	2 Apr. 2008
Illinois	Illinois Administrative Code, Title 77, Public Health, chapter I, Department of Public Health, subchapter M, Food, Drugs and Cosmetics, part 750, Food Service Sanitation Code	20 Nov. 2014
Indiana	Retail Food Establishment Sanitation Requirements, Title 410 IAC 7-24	13 Nov. 2004
Iowa	Iowa Food Code	1 Jan. 2014
Kansas	Kansas Food Code 2012	1 July 2012
Kentucky	Kentucky Food Code, 902 KAR 45:005	1 May 2009
Louisiana	Louisiana Public Health-Sanitary Code, Title 51	20 June 2002
Maine	State of Maine Food Code 2013	1 Oct. 2013
Maryland	Code of Maryland Regulations, Title 10, Department of Health and Mental Hygiene, Subtitle 15, Food, chapter 03, Food Service Facilities	7 Dec. 2007
Massachusetts	Massachusetts 105 CMR 590.000, Minimum Sanitation Standards for Food Establishments	29 Sep. 2000
Michigan	Michigan Food Law and Food Code	1 Oct. 2012
Minnesota	Minnesota Food Code, Minnesota Rules, chapter 4626	3 Oct. 2013
Mississippi	Mississippi Food Regulations	1 Jan. 1999
Missouri	Missouri Food Code for the Food Establishments of the State of Missouri	30 Sep. 2013
Montana	Administrative Rules of Montana, Title 37, chapter 110, subchapter 2	23 Nov. 2000
Nebraska	Nebraska Food Code	8 Mar. 2012
Nevada	Nevada Administrative Code, chapter 446, Food Establishments	18 Dec. 2013
New Hampshire	Chapter He-P 2300, Sanitary Production and Distribution of Food	12 Oct. 2012
New Jersey	New Jersey Administrative Code, chapter 24, Sanitation in Retail Food Establishments and Food and Beverage Vending Machines	2 Jan. 2007
New Mexico	New Mexico Administrative Code, chapter 7.6.2	12 Aug. 2000
New York	New York State Sanitary Code, part 14	8 Jan. 1997
North Carolina	North Carolina Food Code Manual	1 Sep. 2012
North Dakota	North Dakota Food Code, chapter 33-33-04	1 Apr. 2012
Ohio	Ohio Uniform Food Safety Code	1 Jan. 2014
Oklahoma	Oklahoma Food Code	1 Nov. 2011
Oregon	Oregon Health Authority Food Sanitation Rules	4 Sep. 2012
Pennsylvania	Pennsylvania Food Code, chapter 46	12 May 2014
Rhode Island	Rhode Island Food Code	17 Sep. 2012
South Carolina	South Carolina Retail Food Establishments, Regulation 61-25	27 June 2014
South Dakota	South Dakota Food Service Code, chapter 44:02:07	26 May 1997
Tennessee	Rules of Tennessee Department of Health, Food Service Establishments	1978
Texas	Texas Food Establishment Rules	15 Mar. 2006
Utah	Utah Administrative Code, Food Service Sanitation	10 Sep. 2012
Vermont	Vermont Health Regulations for Food Service Establishments	1 Dec. 2003
Virginia	Virginia Food Regulations	1 Jan. 2010
Washington	Washington State Retail Food Code	1 May 2013
West Virginia	West Virginia Legislative Rule, Title 64, Series 17, Food Establishments	2 Apr. 2008
Wisconsin	Wisconsin Food Code	1 Sep. 2013
Wyoming	Wyoming Food Safety Rule	2012
District of Columbia	District of Columbia Food Code Regulations, Title 25	30 Nov. 2012

TABLE 2. *Assessment criteria for norovirus-related food service provisions in state regulations*

Provision	2013 Food Code	Assessment criteria for state regulation
Hand washing procedure	Food Code details a hand washing procedure for all food workers, including how to wash their hands and for how long, and nine specific instances before or after which employees should wash (Section 2-3).	Any provision requiring hand washing.
Prohibition of bare-hand contact	Food Code prohibits bare-hand contact with ready-to-eat (RTE) food, except in certain circumstances, such as when washing vegetables or when a kill step is involved (Section 3-301.11).	Any regulation prohibiting bare-hand contact with RTE foods; states that called for limitation or minimization of bare-hand contact were not considered as explicitly prohibiting contact.
Certified food protection manager (CFPM)	Provision requires that each establishment have at least one employee with supervisory or managerial duties who has been certified as a food protection manager by passing a test from an accredited program. Food Code also allows for the presence of a CFPM to fulfill a separate provision, which requires a person in charge to be able to demonstrate knowledge of food safety principles during an inspection or other request (Sections 2-102.12 and 2-102.20).	Provision requiring at least one CFPM per food establishment; states that did not require a CFPM but allowed a certification to fulfill knowledge requirements were not considered as explicitly requiring a CFPM.
24-h ill staff exclusion	Food Code recommends that food workers with diarrhea or vomiting be excluded until 24 h after resolution of symptoms. Exclusion means that affected employees do not report to work at all for the specified time. Food Code provides more stringent exclusion periods for employees with laboratory-confirmed norovirus infections, recommending exclusion for 24 h after symptom resolution and then restriction from certain food handling duties for another 24 h after the exclusion period. However, because laboratory confirmation of norovirus infection is rarely performed in sporadic cases due to lack of widely available routine clinical assays, this provision is often not applicable (Section 2-2).	Provision requiring employees with vomiting or diarrhea to be excluded for at least 24 h after symptom resolution. Provisions requiring medical clearance before returning to work were considered to meet this criterion. Provisions allowing either exclusion or restriction for employees with symptoms or not specifying a length of time for exclusion were not considered to meet this criterion. Because most ill workers will not be specifically diagnosed with laboratory-confirmed norovirus, we used adoption of the general vomiting and diarrhea exclusion period as the primary indicator of adopting ill staff exclusion guidelines and used this provision in our subsequent analyses. To descriptively assess differences in regulations, we also examined other exclusion criteria, including the norovirus-specific indicator.
Response plan for contamination events	Provision requires that food establishments have procedures in place for employees to follow during situations in which vomitus or fecal matter is expelled onto surfaces in the establishment. Although Food Code does not recommend specific procedures, it indicates that response plans should include actions that employees should take to prevent transmission of pathogens to other employees and patrons of the establishment (Section 2-501).	Any provision requiring a contamination event response plan.

Wide variation was observed in the adoption of ill staff exclusion policies. Overall, all but one of the 51 states assessed (98%) included some type of provision requiring exclusion or restriction of employees that were ill with vomiting and diarrhea; however, guidelines for the post-symptomatic period differed among states. Thirty states (59%) required employees to be excluded until 24 h after cessation of vomiting and diarrhea, as described in the 2013 FDA Food Code (Fig. 2). Two states (6%) did not explicitly require a 24-h exclusion period but required at a minimum restriction of employees from food handling activities until 24 h after symptoms have resolved (Fig. 3). Restriction allows ill workers to report to work but restricts them from certain food handling activities that may contribute to illness transmission. Seven states (14%) required exclusion or restriction while employees are experiencing vomiting or diarrhea but allowed employees to return to duties when these symptoms ceased. An additional 11 states (22%) required exclusion or restriction while employees are experiencing vomiting or diarrhea but did not specify a length of time for exclusion or restriction. Thirty states (59%) included an additional norovirus-specific exclusion period in their respective food codes, requiring exclusion of those with a lab-confirmed norovirus diagnosis until 24 h after cessation of symptoms then restriction for another 24 h (Fig. 3).

The least commonly adopted provisions were those requiring food establishments to have at least one CFPM and

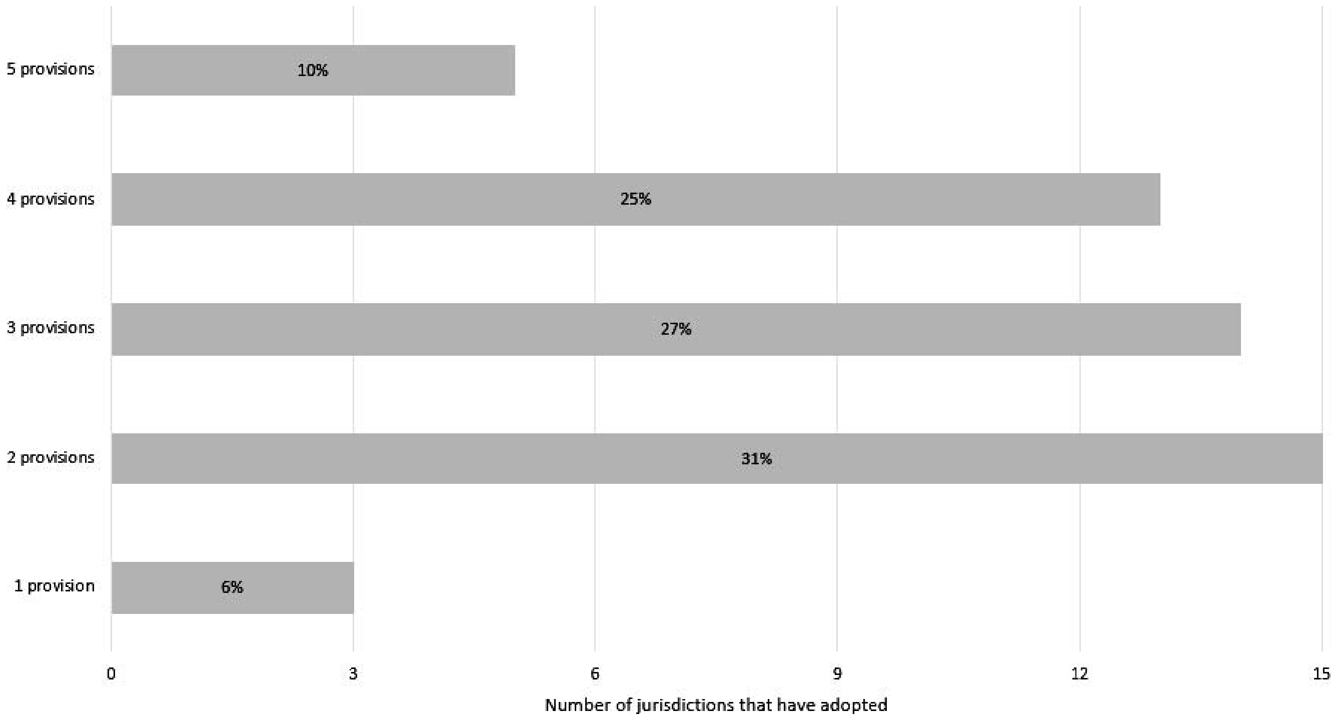

FIGURE 1. *Adoption of selected food service provisions (described in Table 2);* n = *51 states (50 states plus District of Columbia).*

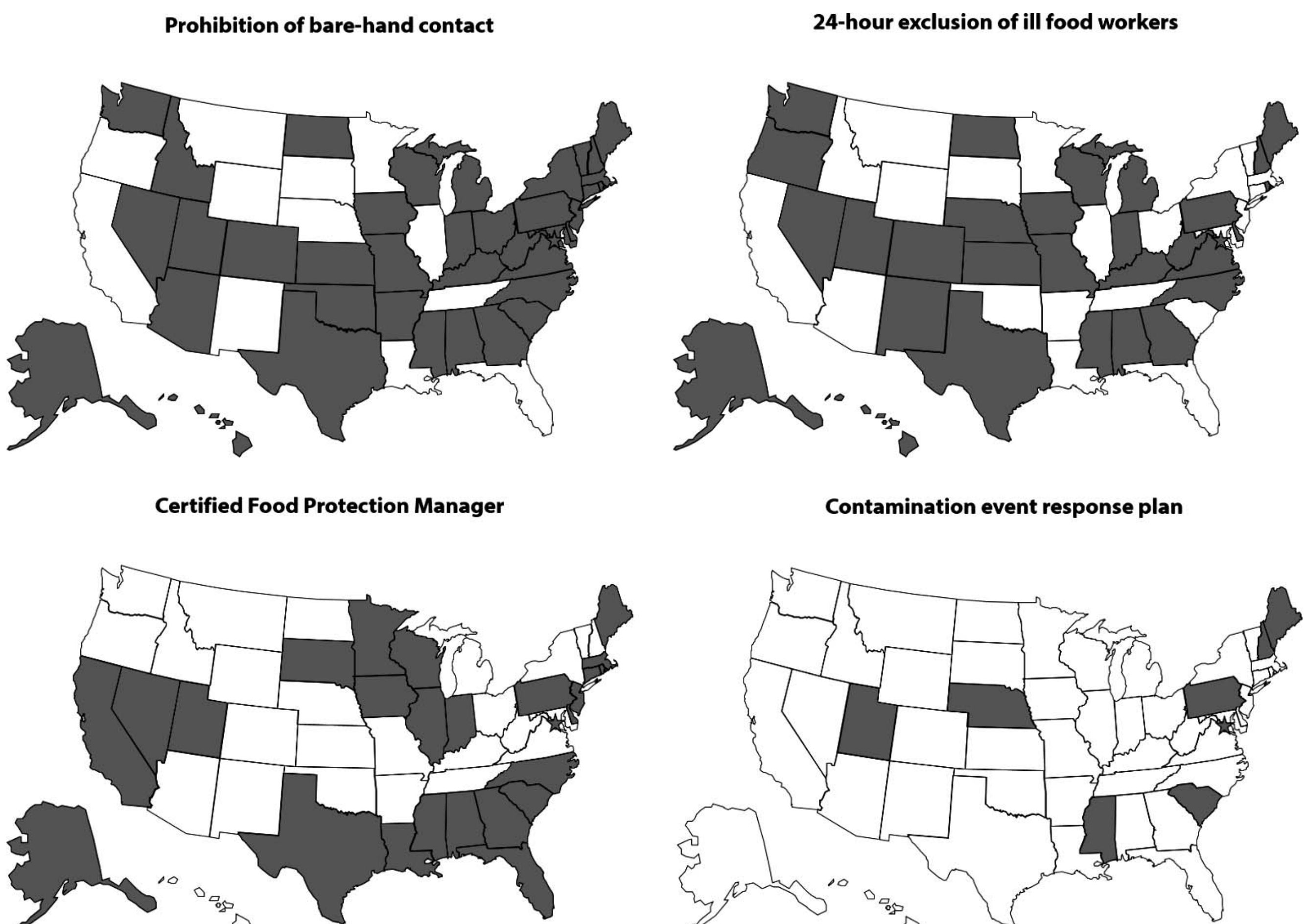

FIGURE 2. *Adoption of selected food service provisions by state.*

TABLE 3. *Adoption of specific hand washing provisions;* n = *51 states (50 states plus District of Columbia)*

When to wash	No. (%) of states that have adopted
After using the restroom	51 (100)
After coughing, sneezing, using a handkerchief or disposable tissue, using tobacco, eating, or drinking	50 (98)
During food preparation, as often as necessary to remove soil and contamination and to prevent cross-contamination when changing tasks	51 (100)
When switching between working with raw food and working with ready-to-eat food	48 (94)
After engaging in other activities that contaminate the hands	47 (92)
After touching bare human body parts other than clean hands and clean exposed portions of arms	46 (90)
After caring for or handling service animals or aquatic animals	46 (90)
After handling soiled equipment or utensils	45 (88)
Before donning gloves to initiate a task that involves working with food	40 (78)

to have a plan in place for responding to contamination events (Fig. 2); only 26 states (51%) included the requirement for a CFPM in their food codes, and only 8 states (16%) required a contamination event response plan.

Associations with outbreak characteristics. In total, 1,475 suspected or confirmed foodborne norovirus infection outbreaks that were reported to NORS occurred between 1 January 2009 and 31 December 2014. Individual states reported 0 to 173 (median, 10) foodborne norovirus outbreaks during the 6-year period, with a median reporting rate of 0.47 outbreaks per million person-years (range, 0.00 to 5.25 outbreaks per million person-years). Three states did not report any foodborne norovirus outbreaks in the 6-year period; therefore, these states were not included in our analysis of associations with outbreak reporting rates or characteristics. Although not statistically significant, states that adopted the provisions prohibiting bare-hand contact (0.45 versus 0.74, $P = 0.07$), requiring a CFPM (0.38 versus 0.75, $P = 0.09$), and excluding ill staff for $\geq$24 h after symptom resolution (0.44 versus 0.73, $P = 0.24$) each reported fewer outbreaks per million person-years than did those states that did not adopt these provisions (Fig. 4). When analyzed in a multivariate model, controlling for the adoption of 24-h ill staff exclusion and the requirement for a CFPM, states that prohibited bare-hand contact had a significantly lower reporting rate ($P < 0.0001$) than did states without the provision.

Controlling for reporting rate, adoption of other provisions, and type of investigation conducted, we found significant associations between certain provisions and specific outbreak characteristics (Table 4). States that adopted the provision requiring a CFPM were 1.7 times (95% CI, 1.3, 2.1) more likely to implicate a food worker as the source of a reported outbreak that were those states without the provision. States that adopted the 24-h ill staff exclusion provision were 0.5 times (0.4, 0.6) more likely to have a smaller outbreaks, 0.7 times (0.5, 0.9) more likely to have shorter outbreaks, and 1.7 (1.0, 2.9) times more likely

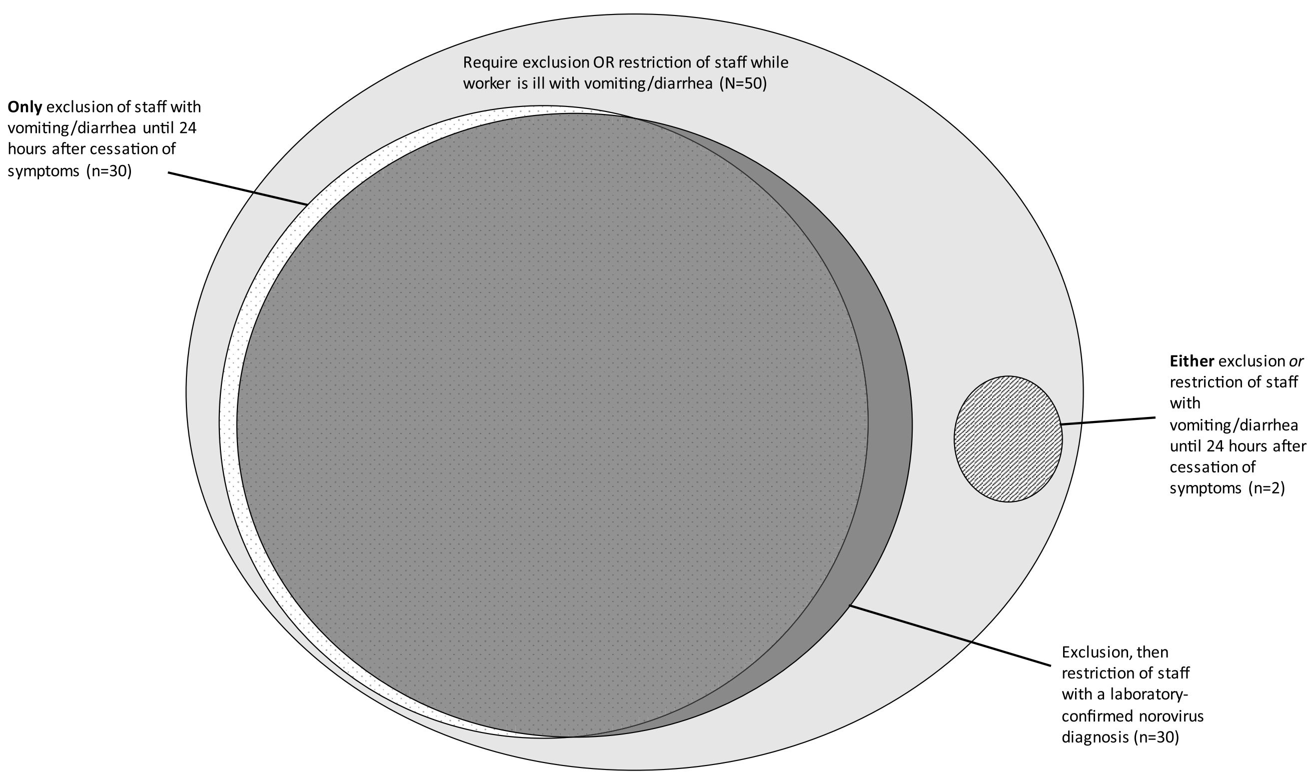

FIGURE 3. *Adoption of specific ill staff exclusion requirements.*

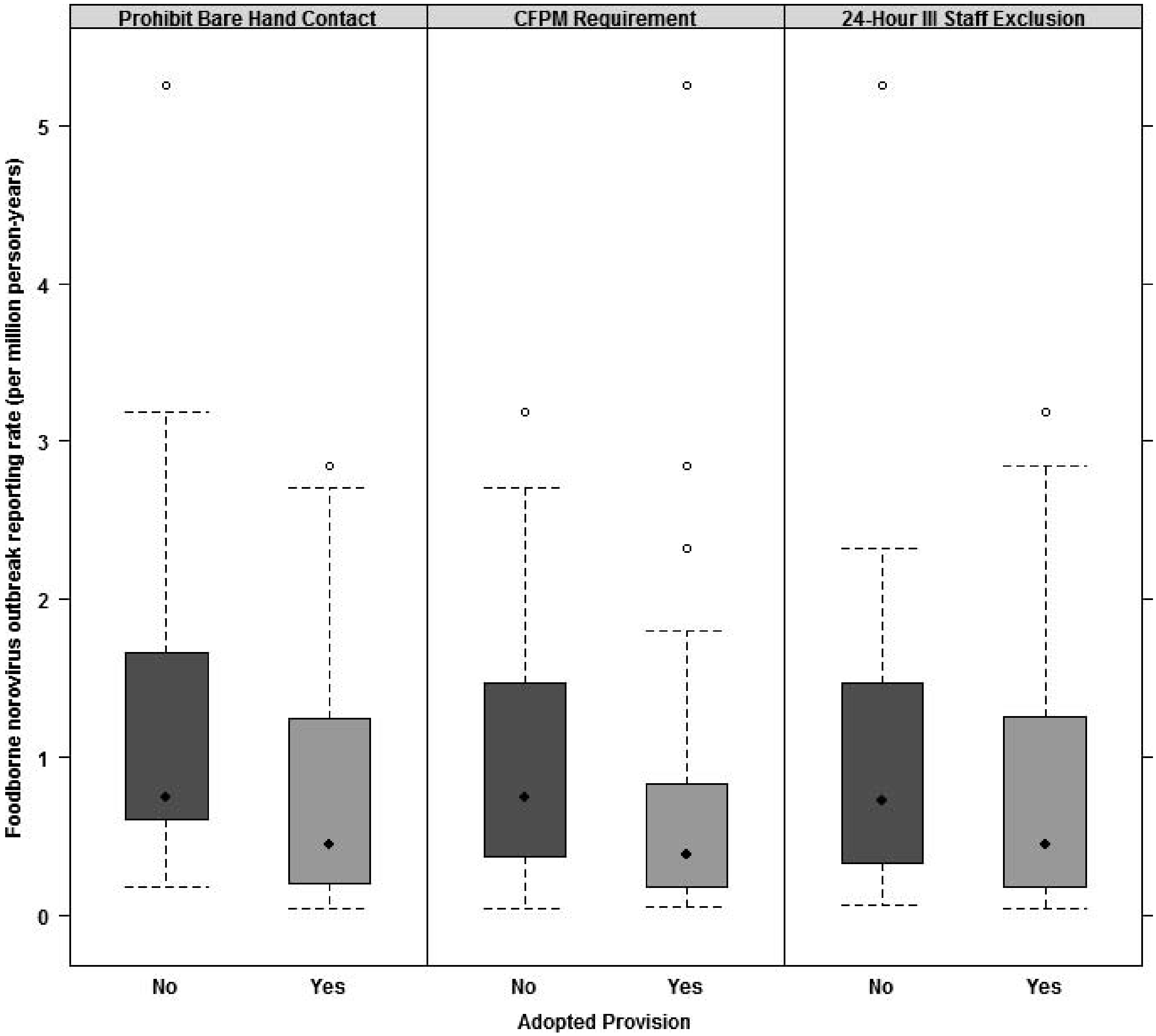

FIGURE 4. *Outbreak reporting rates among 48 states with and without selected food service provisions (three states with no reported outbreaks from 2009 through 2014 were excluded). Solid diamonds denote the median foodborne norovirus outbreak reporting rate among states that did or did not adopt the specified provision; tails indicate the range of reporting rates; open circles indicate outliers.*

to implicate bare-hand contact by a food worker suspected to be infectious than were states without the provision.

DISCUSSION

In this assessment of state food codes, we found that provisions related to hand hygiene were the most widely adopted. Although some requirement for hand washing was adopted by all states, we found variation in adoption of subprovisions that specify times at which food workers should wash their hands. The least commonly adopted of these subprovisions was the requirement to wash hands before donning gloves. Adoption of hand hygiene provisions is crucial to food safety; poor hand hygiene has been cited as a key factor in the transmission of foodborne disease. A systematic review of 81 foodborne disease outbreaks attributed to food contaminated by food workers revealed that nearly all outbreaks were associated with poor hand hygiene, such as improper hand washing and bare-hand contact with food *(22)*. When used properly, gloves can decrease pathogen transmission between food items and the hands of food workers *(19)*. However, gloves are not always used appropriately, which should include changing gloves when necessary and washing hands before and after glove use. In an observational study of over 300 food workers, appropriate hand washing was less likely when gloves were worn *(10)*.

The provisions regarding ill staff exclusion differed considerably among the states assessed. About 60% of states assessed adopted the 2013 Food Code requirement of exclusion of workers with diarrhea or vomiting until 24 h after symptom resolution. The same number of states included the norovirus-specific exclusion period in their codes, requiring that employees with a laboratory-confirmed diagnosis be excluded for 24 h after cessation of symptoms

TABLE 4. *Associations between presence of selected provisions and reported outbreak characteristics in 48 states*[a]

	Adjusted odds ratio (95% confidence interval)[b]		
Comparator	Certified food protection manager	Prohibition of bare-hand contact	24-h ill staff exclusion
Outbreak characteristic			
Small[c]	1.0 (0.8, 1.2)	1.1 (0.8, 1.4)	0.5 (0.4, 0.6)
Short duration[d]	1.2 (0.9, 1.6)	1.0 (0.7, 1.3)	0.7 (0.5, 0.9)
Implication of food workers			
Food worker as source of reported outbreak	1.7 (1.3, 2.1)	1.5 (1.1, 2.0)	1.1 (0.9, 1.5)
Bare-hand contact by a food worker suspected to be infectious	2.5 (1.5, 4.2)	1.4 (0.9, 2.4)	1.7 (1.0, 2.9)

[a] Comparison was between states with and those without the specified provision. Three states with no reported outbreaks from 2009 through 2014 were excluded from this analysis.
[b] Adjusted for adoption of other two provisions, reporting rate, and whether the state conducted an analytic investigation (case-control or cohort study).
[c] Small outbreak defined as <12 estimated primary cases; large outbreak defined as ≥ 12 estimated primary cases.
[d] Short duration defined as <3 days between date of onset of first and last illness; long duration defined as ≥ 3 days between date of onset of first and last illness.

and then restricted for another 24 h after exclusion. Although all but one state required exclusion or restriction of ill food workers while symptomatic, compliance and enforcement may be lacking. In a survey of over 400 restaurant workers, nearly 60% reported working while ill in the previous year, and 20% had worked while ill with vomiting and diarrhea specifically *(4)*. Nearly half of those who worked while ill indicated that their managers, to whom the responsibility of ill staff exclusion belongs, were not aware of their illness *(4)*. This finding suggests that effective enforcement of the recommended regulations requires proper education of food handlers to foster appreciation of the health hazards of working while ill and the importance of reporting illnesses.

The timing of addition of provisions to the Food Code may affect the inclusion of these provisions in state regulations, because there may be a considerable lag between addition of provisions to the Food Code and state adoption due to state rule-making processes. The two least commonly adopted provisions included in this assessment were those requiring a CFPM and a contamination event response plan. These provisions were also the most recent ones incorporated into the Food Code; the provisions were added in 2011 as a supplement to the 2009 FDA Food Code *(29)* and were subsequently included in the 2013 Food Code. In contrast, the more commonly adopted provision requiring exclusion of ill staff until 24 h after symptoms was added to the Food Code in 2005 *(28)*. Although a CFPM was not explicitly required in previous versions of the Food Code, previous versions allowed for this certification to fulfill the requirement that a person in charge demonstrate knowledge of food safety. Unlike the provision requiring a CFPM, the contamination response plan provision was not mentioned in previous versions of the Food Code. This provision is important for norovirus infection prevention because public vomiting events have been recognized as a cause of outbreaks *(18, 32)*, and without proper cleaning the virus can persist on food preparation surfaces such as stainless steel and ceramic for up to 42 days *(17)*.

The provisions requiring hand washing and prohibiting bare-hand contact with RTE food, which were the two most commonly adopted provisions, were included in Food Code versions as early as 1997 (previous versions of the Food Code were not available on the Internet for analysis). However, the least commonly adopted hand washing subprovision, requiring food workers to wash their hands before donning gloves, was added to the Food Code in 2001 *(27)*. These comparisons revealed that although the year that the provision was incorporated into the Food Code may impact the uptake of these provisions into state food service regulations, other factors may influence state adoption of a provision.

Because the ultimate goal of food safety regulations is to decrease foodborne disease, we sought to explore potential associations between adoption of specific provisions and the frequency and characteristics of reported outbreaks. When we compared the outbreak reporting rates of states, we found that those states that adopted the specified provisions (requirement of a CFPM, prohibition of bare-hand contact with RTE foods, and 24-h exclusion of ill food workers) had lower median outbreak reporting rates than did those states that did not adopt these provisions, although these associations did not reach statistical significance. Controlling for adoption of the 24-h ill staff exclusion provision and the requirement for a CFPM, we found that adoption of the provision prohibiting bare-hand contact was significantly associated with decreased outbreak reporting rate. These findings suggest that adoption of these specific food service provisions may have an impact on reducing the rates of reported norovirus outbreaks.

States that adopted the requirement for a CFPM were significantly more likely than those without this requirement to implicate an ill food worker as the source of a reported outbreak. Because the responsibilities of a CFPM include ensuring that food workers are observing proper food safety protocols *(31)*, including reporting of worker illness, this finding suggests that the presence of a CFPM is helpful for identifying workers who are in violation of the protocols by working while ill. In previous studies, the presence of a

CFPM has had a protective effect on foodborne disease outbreaks, including those specifically caused by norovirus, and the identification of critical violations during restaurant inspections *(5, 16)*.

We also found that states that had adopted the 24-h ill staff exclusion provision were significantly less likely to have outbreaks of a smaller size and shorter duration. This association may reflect the preferential reduction of shorter, smaller outbreaks caused by the relatively brief exposure period from ill food workers as opposed to outbreaks with more protracted periods of exposure, such as those involving foods contaminated during production or processing. Our analyses also indicated that states with the 24-h exclusion provision were significantly more likely to implicate bare-hand contact by an infectious food worker. However, these same states were not significantly associated with implication of ill food workers. Because outbreaks in which bare-hand contact by an infectious food worker was implicated are a subset of those in which an infectious food worker was implicated, this association may be spurious. However, one potential explanation is that those states that are excluding ill food workers are also more actively evaluating the activities of individuals in the kitchen to determine whether those individuals should be excluded and therefore identifying critical violations such as bare-hand contact with food. Another possibility is that the 24-h exclusion period may not be long enough to prevent transmission from a postsymptomatic infected food worker; although individuals infected with norovirus may have symptoms for only 1 to 3 days, they may shed the virus for an average of 4 weeks after infection *(1)*. Therefore, these findings may indicate outbreaks in which ill food workers were excluded in accordance with the regulations but were still shedding infectious virus when they returned to work, suggesting that the 24-h postsymptomatic exclusion period for vomiting and diarrhea may not be sufficient because most norovirus infections are not diagnosed *(9, 12, 25)*. This issue was further reinforced at the 2016 Conference for Food Protection *(8)*, where the Conference voted to increase the postsymptomatic exclusion period for vomiting and diarrhea to 48 h in the 2017 Food Code to align with the postsymptomatic exclusion period for individuals actually diagnosed with norovirus infection.

Although the findings in this study are generally consistent with the notion that adoption of food safety provisions is associated with decreased incidence and improved management of foodborne outbreaks, some associations, such as that observed between the adoption of the 24-h ill staff exclusion and implication of bare-hand contact by an infectious food worker, were contradictory to other observed associations. This discrepancy suggests that the presence of other potential confounders, including variable compliance with these provisions and various reporting biases, may have resulted in spurious associations, and these results should be interpreted with caution. Because NORS is a passive surveillance system, reporting rates may not reflect the true number of outbreaks that occur in a particular state. Although all outbreaks are notifiable events and state health departments are strongly encouraged to report outbreaks to NORS, competing priorities and limited resources may restrict the number of outbreaks that are investigated and reported. These issues are likely reflected in the 100-fold difference in foodborne norovirus outbreak reporting rates between the highest and lowest reporting states *(15)*. Additional food safety provisions may also be adopted at municipal levels that exceed the requirements adopted at the state level, and some restaurants, such as larger chains, may have their own policies that are more stringent than those stipulated by the state food service regulations. Promulgation of regulations or policies on any level does not guarantee compliance by employees or enforcement by management. Finally, our data were collected from outbreaks that occurred during 2009 through 2014, and many of these outbreaks predated adoption of provisions first introduced in the 2011 Food Code supplement *(29)*. However, we analyzed the most recent regulations adopted as of September 2014, because regulations are subject to change at any point and changes do not necessarily follow a calendar year schedule. Therefore, a state's food code may have changed several times during the time period of outbreak analysis, creating difficulties in determining the presence or absence of provisions in place during a specific outbreak.

Despite these limitations, to our knowledge, this study is the first analysis of adoption of specific food service provisions related to norovirus with an attempt to assess potential correlations between adoption of these provisions and reports of outbreaks. The results of this analysis highlight gaps in state adoption of key food service provisions for prevention of norovirus transmission in food service settings and reemphasize the importance of adopting the most recently recommended food service provisions as these are updated in accordance with the latest science. These results also highlight the difficulties of conducting an ecological analysis including numerous unobservable confounders. Improved reporting of foodborne norovirus outbreaks may provide more opportunities for the identification of effective prevention and control measures. Further research is needed to examine barriers to state adoption of recommended provisions, as well as municipal and restaurant implementation of and compliance with state regulations to better elucidate associations with foodborne transmission of norovirus and opportunities for prevention.

ACKNOWLEDGMENTS

This research was supported in part by appointments to the Research Participation Program at the Centers for Disease Control and Prevention (A.K. and K.S.) administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and the CDC. This work was also supported in part by Agriculture and Food Research Initiative Competitive Grant 2011-68003-30395 from the U.S. Department of Agriculture, National Institute of Food and Agriculture. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC.

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Journal of Food Protection, Vol. 79, No. 9, 2016, Pages 1588–1598
doi:10.4315/0362-028X.JFP-16-085

Food Allergy Knowledge and Attitudes of Restaurant Managers and Staff: An EHS-Net Study

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MS 16-085: Received 19 February 2016/Accepted 22 April 2016

ABSTRACT

Dining outside of the home can be difficult for persons with food allergies who must rely on restaurant staff to properly prepare allergen-free meals. The purpose of this study was to understand and identify factors associated with food allergy knowledge and attitudes among restaurant managers, food workers, and servers. This study was conducted by the Environmental Health Specialists Network (EHS-Net), a collaborative forum of federal, state, and local environmental health specialists working to understand the environmental factors associated with food safety issues. EHS-Net personnel collected data from 278 randomly selected restaurants through interviews with restaurant managers, food workers, and servers. Results indicated that managers, food workers, and servers were generally knowledgeable and had positive attitudes about accommodating customers' food allergies. However, we identified important gaps, such as more than 10% of managers and staff believed that a person with a food allergy can safely consume a small amount of that allergen. Managers and staff also had lower confidence in their restaurant's ability to properly respond to a food allergy emergency. The knowledge and attitudes of all groups were higher at restaurants that had a specific person to answer food allergy questions and requests or a plan for answering questions from food allergic customers. However, food allergy training was not associated with knowledge in any of the groups but was associated with manager and server attitudes. Based on these findings, we encourage restaurants to be proactive by training staff about food allergies and creating plans and procedures to reduce the risk of a customer having a food allergic reaction.

Key words: Food allergies; Food allergy attitudes; Food allergy knowledge; Food safety; Restaurants

Food allergies are a growing public health and food safety concern affecting an estimated 15 million U.S. residents, including 1 in every 13 children *(8)*. A food allergic reaction occurs when the immune system overreacts to the proteins in food *(2)*. Currently, the only way to prevent a food allergic reaction is strict avoidance of the allergen *(15)*. Eight foods are responsible for approximately 90% of all food allergic reactions in the United States: milk, eggs, fish, shellfish, wheat, tree nuts, peanuts, and soybeans *(8)*. Symptoms of an allergic reaction range from mild skin rashes to severe, potentially life-threatening anaphylactic reactions *(10)*. In the case of anaphylactic reactions, administration of epinephrine within minutes is crucial to survival *(15)*. Food-related anaphylaxis is responsible for approximately 30,000 emergency room visits, 2,000 hospitalizations, and 150 deaths each year in the United States *(13)*.

A significant number of food allergic reactions occur in restaurants. A survey at the 2007 Food Allergy & Anaphylaxis Network conference *(14)* found that 34% of the 294 respondents had experienced at least one food allergic reaction in a restaurant, and of those, 36% had experienced at least three reactions. Another study revealed that nearly half of fatal food allergic reactions over a 13-year period were caused by food from a restaurant or other food service establishment *(15)*. An investigation of peanut and tree nut allergic reactions in restaurants or other food service establishments found that in 45% of these cases, the food allergic customers had alerted the restaurant to their allergy in advance *(9)*. The same investigation revealed that in 78% of the episodes, someone in the establishment knew that the food contained the allergen as an ingredient.

Managers, food workers, and servers all play unique and crucial roles in preventing food allergic reactions in their restaurants. Managers can provide food allergy training for staff and develop plans for serving food allergic customers. Food workers can become educated about allergens and methods to ensure allergen-free food preparation. Servers can accurately describe menu items to the customer and alert the manager and kitchen staff to requests for allergen-free meals. Miscommunication between any of these groups can

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result in an unsafe meal being served *(3)*. Benefits to restaurants that consistently provide safe meals to food allergic customers include preventing harm to their clientele, avoiding lawsuits, and gaining the loyal patronage of the food allergic community.

A key to preventing food allergic reactions in restaurants is understanding manager, food worker, and server food allergy knowledge, attitudes, and practices. Several studies have been conducted to examine these topics collectively *(1, 3, 5, 6, 11, 12)*. However, the measures used in these studies have been limited with regard to food allergy attitudes and practices. All studies either included a regional or convenience sample *(1, 6, 11)* or were conducted outside of the United States *(3, 5, 11, 12)*; thus, the generalizability of their results must be considered.

In 2014, the Centers for Disease Control and Prevention's (CDC) Environmental Health Specialists Network (EHS-Net) conducted a study on restaurant manager and staff (food workers and servers) food allergy knowledge, attitudes, and practices. Our measures of knowledge, attitudes, and practices were comprehensive and were primarily based on the Food Allergy Research and Education guidance document "Welcoming Guests with Food Allergies" *(7)*. EHS-Net also collected data in six demographically diverse sites, providing good geographic coverage of the United States (Northeast, South, Midwest, West). The goals of this study were threefold: (i) describe restaurant manager and staff food allergy knowledge, attitudes, and practices; (ii) compare knowledge, attitudes, and practices among managers and staff; and (iii) identify factors associated with food allergy knowledge, attitudes, and practices. This article primarily focuses on knowledge and attitudes. Complete practice data will be published at a later date.

MATERIALS AND METHODS

EHS-Net is a network of environmental health specialists and epidemiologists who conduct research designed to identify and understand environmental factors associated with foodborne illness outbreaks and other food safety issues. EHS-Net is a collaborative project of the CDC, the U.S. Food and Drug Administration, the U.S. Department of Agriculture, and state and local health departments. At the time this study was conducted, six state and local health departments were funded by CDC to participate in EHS-Net. The state and local health departments (EHS-Net sites) were in California, Minnesota, New York, New York City, Rhode Island, and Tennessee.

Sample. For this study, we used a random sample from a nonrandomly selected cluster (i.e., site). In each site, EHS-Net personnel chose an area, based on convenience (reasonable travel distance), in their jurisdiction to recruit restaurants for study participation through telephone calls. SAS version 9.3 (SAS Institute, Cary, NC) was used to select a random sample of restaurants from population lists of restaurants in those areas. Data collectors (EHS-Net personnel) collected data in approximately 50 randomly selected restaurants per site. For this study, restaurants were defined as facilities that prepare and serve food or beverages to customers and are not institutions, food carts, mobile food units, temporary food stands, supermarkets, restaurants in supermarkets, or caterers. Only restaurants with English-speaking managers were included in the study.

Data collection. Data were collected from January 2014 through February 2015. The institutional review boards of the participating EHS-Net site health departments approved the study protocol. We did not collect any data that could identify individual restaurants, managers, food workers, or servers. All data collectors participated in training designed to increase data collection accuracy and consistency. Data collectors solicited restaurant participation by contacting randomly selected restaurants within a specified geographic location via telephone using a standardized recruiting script.

After obtaining permission from the restaurant manager, data collectors conducted an on-site interview with a manager (worker with authority over the kitchen), food worker (worker who primarily prepares or cooks food), and server (worker who primarily takes orders or serves food to customers). To increase participation and cooperation, data collectors asked the manager to choose the food worker and server to be interviewed. Manager interviews lasted approximately 20 min and were focused on characteristics of the restaurant (e.g., chain versus independent ownership and number of meals served in a typical day) and the manager (e.g., years of experience in current restaurant and whether they had been food safety certified). Food worker and server interviews lasted approximately 12 min each and were focused on food worker and server characteristics (e.g., highest level of education and whether they had received food allergy training in their current restaurant).

Interviewers asked 19 questions to assess manager, food worker, and server food allergy knowledge (e.g., identifying major food allergens and knowing what to do when a customer has a bad food allergic reaction). Five questions (e.g., should servers be knowledgeable about food allergies and should restaurants try to meet food allergic customers' special requests) were scored on a Likert scale to assess staff food allergy attitudes. Another 13 to 22 questions (e.g., whether the restaurant has a plan for answering questions from food allergic customers and whether the restaurant has a specific person on duty to handle food allergy questions and requests) were used to assess food allergy practices. Data collectors also observed the restaurant and examined its menu to assess additional restaurant characteristics (e.g., highest priced food item and number of critical violations on the restaurant's last inspection) and food allergy documentation (e.g., whether the menu mentioned anything about allergens and whether documentation about allergens was available in the kitchen area).

Data analysis. We initially created knowledge and attitude scores for each participant group (i.e., manager, food worker, and server). For the knowledge score, we summed the number of correct answers (out of 19) and used each group's median score to dichotomize the participants as having more or less knowledge.

For the attitude score, we assigned point values to each response as follows: strongly disagree = 1, disagree = 2, unsure = 3, agree = 4, and strongly agree = 5. We then averaged each participant's response to the five attitude questions. We used each group's median score to divide participants into those having relatively positive or less positive attitudes.

We used one-way analyses of variance (ANOVAs) to test whether groups were significantly different ($P \leq 0.05$) in knowledge and attitude scores. We then conducted univariate descriptive analyses of restaurant, manager, food worker, and server characteristics; food allergy knowledge, attitudes, and practices; and food allergy documentation. Some continuous variables were recoded to provide approximately even groups to facilitate interpretation. For example, managers' experience was split into <4 years (52.0%) and ≥4 years (48.0%). We next conducted a series of simple logistic regressions to examine associations between potential explanatory variables (restaurant, manager, food worker, and server characteristics; food preparation and service practices; and allergen documentation) and each outcome variable (knowledge and attitude scores) for managers, food workers, and servers (data not shown).We then created multiple logistic regression models for each group and outcome using a forward selection criterion (entrance criterion of $P \leq 0.10$) to further explore the relationship between 20 potential explanatory variables and the outcomes. We choose $P \leq 0.10$ to allow for more inclusiveness, given the relative exploratory nature of these analyses. We used SAS version 9.3 for all analyses.

RESULTS

Restaurant characteristics. Of the 1,307 restaurants contacted for participation in the study, 852 fit the study definition, and 278 (32.6%) of those agreed to participate (Table 1). Manager interview data indicated that 60.1% of the participating restaurants were independently owned. Data collectors classified 56.9% of the restaurants as either quick service (e.g., fast food), fast casual service, or takeout only. Manager interview data indicated that 54.3% of the restaurants had complex food preparation processes (i.e., preparation that includes holding food beyond same day service or some combination of holding, cooling, reheating, and freezing). Additionally, 64.1% had American (nonethnic) menus, 29.7% served more than 300 meals in a typical day, 50.5% had three or more managers, 50.7% employed more than 10 workers, 25.5% had a food item priced more than $20, and 23.0% were cited for more than one critical violation on the last inspection.

Manager, food worker, and server characteristics. Interview data from the 277 managers indicated that 66.4% were male, 81.2% spoke English as their primary language, 61.0% had some college education or more, 48.0% had been working at the restaurant for at least 4 years, and 80.8% had been food safety certified (Table 1). Less than half (44.7%) of managers had received training on food allergies while working at their current restaurant, and 27.8% did not recall serving any meals to food allergic customers in the past month.

Interview data from the 211 food workers indicated that 67.3% were male, 77.7% spoke English as their primary language, 37.0% had some college education or more, and 50.7% had been working at the restaurant for at least 2 years (Table 1). Less than half (44.1%) had received food allergy training while working at their current restaurant, and 21.0% did not recall preparing any meals for food allergic customers in the past month.

Interview data from the 156 servers indicated that 72.9% were female, 85.9% spoke English as their primary language, 50.0% had some college education or more, and 52.6% had been working at the restaurant for at least 2 years (Table 1). Only 33.5% had received training on food allergies while working at their current restaurant, and 12.6% did not recall serving any meals to food allergic customers in the past month.

Practices and observations. According to manager interview data, 70.8% percent of the restaurants had a plan for answering questions from food allergic customers (Table 2). Approximately half (53.3%) of the restaurants typically had a specific person on duty to handle food allergy questions and requests. Data collectors found that 22.0% of menus mentioned allergens. In 55% of these menus, the allergen information was a note for the customer to inform the restaurant whether they or someone with them had a food allergy. Food allergen documentation was available in the front of the restaurant (areas accessible to customers or the dining area) and the kitchen area in 23.1 and 36.3% of restaurants, respectively.

Manager, food worker, and server knowledge. Overall, managers correctly identified peanuts (95.0%), milk and dairy (91.0%), shellfish (92.4%), and eggs (81.6%) as major allergens (Table 3). Managers also recognized that trouble breathing (97.1%), hives or rash (98.2%), and swelling of tongue and throat (97.5%) are symptoms of an allergic reaction to food. Nearly all managers knew to call 911 (99.3%) when a customer has a bad food allergic reaction, such as trouble breathing. Managers (95.0%) knew that a person who eats food they are allergic to can die, and 92.8% of managers correctly said that taking a food allergen out of a meal after the meal had been prepared is not a way to make it safe for a food allergic customer. However, more than 1 in 10 managers (11.9%) incorrectly believed that a person allergic to a specific food ingredient can safely eat small amounts of that food.

Food workers also correctly identified peanuts (95.3%), milk and dairy (88.2%), shellfish (90.5%), and eggs (77.7%) as major allergens (Table 3). Food workers recognized trouble breathing (96.7%), hives or rash (97.2%), and swelling of tongue and throat (95.7%) as symptoms of an allergic reaction to food. Nearly all workers knew to call 911 (98.1%) when a customer has a bad food allergic reaction, such as trouble breathing. Food workers (94.8%) knew that a person who eats food they are allergic to can die, and 91.5% of food workers correctly said that taking a food allergen out of a meal after the meal has been prepared is not a way to make it safe for a food allergic customer. However, more than 1 in 10 food workers (11.8%) incorrectly believed that a person allergic to a specific food ingredient can safely eat small amounts of that food.

Servers correctly identified peanuts (95.5%), milk and dairy (93.0%), shellfish (94.2%), and eggs (72.4%) as major allergens (Table 3). Servers also recognized trouble breathing (99.4%), hives or rash (100%), and swelling of tongue and throat (100%) as symptoms of an allergic reaction to food. All servers knew to call 911 (100%) when a customer has a bad food allergic reaction, such as trouble breathing. Servers (97.4%) knew that a person who eats food they are allergic to can die, and 93.0% of servers correctly said that taking a food allergen out of a meal after the meal has been prepared is not a way to make it safe for a food

TABLE 1. *Descriptive data on restaurant, manager, and staff characteristics*

Parameter	n	%
Restaurant characteristics[a]		
Restaurant type (N = 276)		
Chain	110	39.9
Independent	166	60.1
Service type (N = 276)[b]		
Full service casual or fine dining	119	43.1
Quick service, fast casual service, or takeout only	157	56.9
Establishment type (N = 278)[b]		
Prep serve or cook serve	127	45.7
Complex	151	54.3
Menu type (N = 276)		
American	177	64.1
Non-American	99	35.9
No. of meals served in a typical day (N = 266)		
1–100	95	35.7
101–300	92	34.6
>300	79	29.7
No. of managers or persons in charge that work in this restaurant (N = 277)		
<3	137	49.5
≥3	140	50.5
No. of workers other than managers that work in this restaurant (N = 272)		
≤10	134	49.3
>10	138	50.7
Highest priced food item on the menu (N = 267)[b]		
<$10	95	35.6
$10–$20	104	38.9
>$20	68	25.5
No. of critical violations received after the last inspection (N = 278)[b]		
0	134	48.2
1	80	28.8
>1	64	23.0
Manager characteristics[a]		
Sex (N = 277)		
Male	184	66.4
Female	93	33.6
Primary language spoken (N = 277)		
English	225	81.2
Other	52	18.8
Highest level of education (N = 277)		
High school diploma or less	108	39.0
Some college or more	169	61.0
Experience as a manager in this restaurant (N = 277)		
<4 yr	144	52.0
≥4 yr	133	48.0
Ever been food safety certified (N = 276)		
Yes	223	80.8
No	53	19.2
Received training on food allergies while working at this restaurant (N = 275)		
Yes	123	44.7
No	152	55.3
No. of meals served to food allergic customers in the past month (N = 263)		
0	73	27.8
1–10	115	43.7
>10	75	28.5
Food worker characteristics[c]		
Sex (N = 211)		
Male	142	67.3
Female	69	32.7
Primary language spoken (N = 211)		
English	164	77.7
Other	47	22.3
Highest level of education (N = 211)		
High school diploma or less	133	63.0
Some college or more	78	37.0
Experience in this restaurant (N = 207)		
<2 yr	102	49.3
≥2 yr	105	50.7
Received training on food allergies while working at this restaurant (N = 209)		
Yes	86	41.1
No	123	58.9
No. of meals prepared for food allergic customers per month (N = 195)		
0	41	21.0
1–10	105	53.9
>10	49	25.1
Server characteristics[d]		
Sex (N = 155)		
Male	42	27.1
Female	113	72.9
Primary language spoken (N = 156)		
English	134	85.9
Other	22	14.1
Highest level of education (N = 156)		
High school diploma or less	78	50.0
Some college or more	78	50.0
Experience in this restaurant (N = 156)		
<2 yr	74	47.4
≥2 yr	82	52.6
Received training on food allergies while working at this restaurant (N = 155)		
Yes	52	33.5
No	103	66.5
No. of meals served to food allergic customers per month (N = 151)		
0	19	12.6
1–10	97	64.2
>10	35	23.2

[a] Data were obtained from manager interviews, unless otherwise noted.
[b] Data were obtained from data collector observations.
[c] Data were obtained from food worker interviews.
[d] Data were obtained from server interviews.

allergic customer. However, more than 1 in 10 servers (11.5%) incorrectly believed that someone allergic to a specific food ingredient can safely eat small amounts of that food.

TABLE 2. *Descriptive data on food allergy practices and restaurant environment observations*

Parameter	n	%
Practices[a]		
Restaurant has plan for answering questions from food allergic customers ($N = 267$)		
Yes	189	70.8
No	78	29.2
Specific person typically on duty to handle food allergy questions and requests ($N = 276$)		
Yes	147	53.3
No	129	46.7
Observations[b]		
Menu shows anything about allergens ($N = 273$)		
Yes	60	22.0
No	213	78.0
Documentation in the front of the house (areas accessible to customers) or dining area about allergens ($N = 277$)		
Yes	64	23.1
No	213	76.9
Documentation about allergens in the kitchen area ($N = 278$)		
Yes	101	36.3
No	177	63.7

[a] Data were obtained from manager interviews.
[b] Data were obtained from data collector observations.

Comparisons of manager, food worker, and server knowledge scores. All three groups had similar knowledge scores (Table 4). Median knowledge scores were 13 for managers (mean = 13.7, SD = 2.0, $n = 277$), 12 for food workers (mean = 13.0, SD = 2.5, $n = 211$), and 13 for servers (mean = 13.5, SD = 2.2, $n = 156$).

The overall ANOVA model suggested significant differences between groups ($F_{2,641} = 7.45$, $P < 0.001$). Post hoc tests revealed that managers (mean = 13.75, SD = 2.01, $n = 277$) had significantly higher knowledge scores than did food workers (mean = 12.96, SD = 2.50, $n = 211$). Servers had a mean score of 13.46 (SD = 2.21, $n = 156$), and their scores were not significantly different from those of managers or workers.

Multiple logistic regression of manager, food worker, and server knowledge. A multiple logistic regression analysis identified two characteristics that were significantly associated with manager food allergy knowledge (Table 5). Managers in restaurants that served more than 10 meals to allergic customers in the past month had greater odds of having a higher food allergy knowledge score than did managers in restaurants that served 10 or fewer such meals. Managers in restaurants that had a specific person to answer food allergy questions and requests had greater odds of having a higher food allergy knowledge score than did those managers in restaurants without such a person.

A multiple logistic regression analysis identified four characteristics that were significantly associated with food worker food allergy knowledge (Table 5). Food workers in restaurants with a plan for answering questions from food allergic customers had greater odds of having a higher food allergy knowledge score than did workers in restaurants with no such plan. Female food workers had greater odds of having a higher food allergy knowledge score than did male food workers. Food workers with at least 2 years of experience in the restaurant had greater odds of having a higher food allergy knowledge score than did food workers with less experience. Food workers in restaurants in which the highest priced food item was between \$10 and \$20 had greater odds of having a higher food allergy knowledge score than did those workers in restaurants in which the highest priced food item was less than \$10.

A multiple logistic regression analysis identified three characteristics that were significantly associated with server food allergy knowledge (Table 5). Servers in restaurants with a specific person to answer food allergy questions and requests had greater odds of having a higher food allergy knowledge score. Servers in full service restaurants had greater odds of having a higher food allergy knowledge score than did servers in quick service restaurants. Servers in restaurants that served more than 300 meals in a typical day had greater odds of having a higher food allergy knowledge score than did servers in restaurants that served 300 meals or less.

Manager, food worker, and server attitudes. Managers (97.5%) agreed or strongly agreed that servers should be knowledgeable about food allergies (Table 6). Nearly all managers (99.6%) agreed or strongly agreed that kitchen staff should be knowledgeable about food allergies. Managers (91.3%) agreed or strongly agreed that restaurants should try to meet food allergic customers' special requests. Most managers (87.4%) also agreed or strongly agreed that their restaurant could easily meet food allergic customers' special requests. However, fewer managers (70.7%) agreed or strongly agreed that the staff in their restaurant would know what to do if a customer had a bad food allergic reaction.

All food workers (100%) agreed or strongly agreed that servers should be knowledgeable about food allergies (Table 6). Food workers (99.5%) agreed or strongly agreed that kitchen staff should be knowledgeable about food allergies. Food workers (97.1%) also agreed or strongly agreed that restaurants should try to meet food allergic customers' special requests. Most food workers (92.9%) agreed or strongly agreed that their restaurant could easily meet food allergic customers' special requests. However, only 74.4% of food workers agreed or strongly agreed that the staff in this restaurant would know what to do if a customer had a bad food allergic reaction.

All servers (100%) agreed or strongly agreed that servers should be knowledgeable about food allergies (Table 6). Servers (100%) also unanimously agreed or strongly agreed that kitchen staff should be knowledgeable about food allergies. Nearly all servers (98.1%) agreed or strongly

TABLE 3. *Descriptive data on restaurant manager and staff food allergy knowledge*[a]

Question	Manager (N = 277)		Food worker (N = 211)		Server (N = 156)	
	n	%	*n*	%	*n*	%
Of the following foods, which do you think are major allergens?						
Peanuts (*correct*)	263	95.0	201	95.3	149	95.5
Tomatoes	53	19.1	47	22.3	37	23.7
Milk or dairy (*correct*)	252	91.0	186	88.2	145	93.0
Strawberries	88	31.8	68	32.2	47	30.1
Shellfish (*correct*)	256	92.4	191	90.5	147	94.2
Eggs (*correct*)	226	81.6	164	77.7	113	72.4
Chocolate	64	23.1	59	28.0	27	17.3
Which of the following are symptoms of an allergic reaction to food?						
Trouble breathing (*correct*)	269	97.1	204	96.7	155	99.4
Hives or rash (*correct*)	272	98.2	205	97.2	156	100
Headache	154	55.6	109	51.7	72	46.2
Swelling of tongue and throat (*correct*)	270	97.5	202	95.7	156	100
Fever	166	59.9	122	57.8	102	65.4
Which of the following should you do if a customer is having a bad food allergic reaction, such as trouble breathing?						
Suggest that the customer drink water	67	24.2	59	28.0	41	26.3
Call 911 (*correct*)	275	99.3	207	98.1	156	100
Ask the customer if they have medicine they could take	250	90.3	193	91.5	145	93.0
Suggest that the customer throw up	42	15.2	28	13.3	9	5.8
Someone with a food allergy can safely eat small amounts of the food they are allergic to.						
Yes	33	11.9	25	11.8	18	11.5
No (*correct*)	225	81.2	159	75.4	122	78.2
Unsure or skipped	19	6.9	27	12.8	16	10.3
Someone with a food allergy can die from eating the food they are allergic to.						
Yes (*correct*)	263	95.0	200	94.8	152	97.4
No	7	2.5	6	2.8	2	1.3
Unsure or skipped	7	2.5	5	2.4	2	1.3
Taking a food allergen out of a meal after it has been made is one way to make it safe for a food allergic customer.						
Yes	17	6.1	12	5.7	6	3.8
No (*correct*)	257	92.8	193	91.5	145	93.0
Unsure or skipped	3	1.1	6	2.8	5	3.2

[a] Responses are shown in the order they were asked. *n,* the number of managers and workers that affirmatively answered the question.

agreed that restaurants should try to meet food allergic customers' special requests. Most servers (93.0%) agreed or strongly agreed that their restaurant could easily meet food allergic customers' special requests. However, only three-quarters of servers (75.7%) agreed or strongly agreed that the staff in their restaurant would know what to do if a customer had a bad food allergic reaction.

Comparisons of manager, food worker, and server attitude scores. The three participant groups had approximately equivalent median attitude scores: 4.2 for managers (mean = 4.3, SD = 0.5, $n = 277$), 4.2 for food workers (mean = 4.4, SD = 0.4, $n = 207$), and 4.4 for servers (mean = 4.5, SD = 0.4, $n = 155$) (Table 4). Knowledge and attitude scores were not significantly correlated in any of the respondent groups: managers, $r = 0.06$, $P = 0.317$, $n = 277$; food workers, $r = -0.03$, $P = 0.684$, $n = 207$; and servers, $r = 0.04$, $P = 0.653$, $n = 155$.

The overall ANOVA model suggested significant differences between groups ($F_{2,636} = 6.31$, $P = 0.002$). Post hoc tests revealed that servers (mean = 4.46, SD = 0.41, $n = 155$) had significantly higher attitude scores than did managers (mean = 4.30, SD = 0.50, $n = 277$). Food workers had a mean score of 4.39 (SD = 0.44, $n = 211$), and their scores were not significantly different from those of managers or servers.

Multiple logistic regression of manager, worker, and server attitudes. A multiple logistic regression analysis identified six characteristics that were significantly associ-

TABLE 4. *Comparisons of food allergy knowledge and attitude scores by group*

Group	Mean difference	95% confidence interval
Knowledge scores[a]		
Manager vs food worker	0.785	(0.28, 1.29)[b]
Manager vs server	0.292	(−0.26, 0.84)
Server vs food worker	0.493	(−0.08, 1.07)
Attitude scores[c]		
Manager vs food worker	−0.087	(−0.19, 0.02)
Manager vs server	−0.157	(−0.27, −0.04)[b]
Server vs food worker	0.069	(−0.05, 0.19)

[a] Fisher's one-way ANOVA ($F_{2,641} = 7.45$, $P < 0.001$).
[b] $P \leq 0.05$.
[c] Equal variance not assumed. Welch's one-way ANOVA ($F_{2,636} = 6.31$, $P = 0.002$).

ated with manager food allergy attitudes (Table 7). Managers in restaurants that served more than 10 meals to food allergic customers in the past month had greater odds of having a higher food allergy attitude score than did managers in restaurants that served 10 meals or fewer. Managers in restaurants with plans for answering questions from food allergic customers had greater odds of having a higher food allergy attitude score. Managers in restaurants with a specific person to answer food allergy questions and requests had greater odds of having a higher food allergy attitude score than did managers in restaurants without such a person. Managers in restaurants that had allergen information on the menu were less likely to have a higher food allergy attitude score than did managers in restaurants without this information. Managers with at least 4 years of experience in the restaurant were also less likely to have a higher food allergy attitude score than were managers with less experience. Managers who had received food allergy training at their restaurant had greater odds of having a higher food allergy attitude score than did managers with no food allergy training.

TABLE 5. *Multiple logistic regression analysis of characteristics associated with restaurant managers, food workers, and servers scoring in the top 50% of food allergy knowledge scores*[a]

Characteristic	OR (90% CI)	P
Manager scored in top 50%[b]		
No. of meals served to allergic customers in the past month		0.003
1–10 vs 0	1.48 (0.89, 2.48)	0.208
>10 vs 1–10	2.33 (1.35, 4.04)	0.011
>10 vs 0	3.45 (1.87, 6.36)	0.001
Specific person to answer food allergy questions and requests		
Yes vs no	1.71 (1.09, 2.70)	0.052
Food worker scored in top 50%[c]		
Restaurant plan for answering questions from food allergic customers		
Yes vs no	4.23 (2.20, 8.12)	<0.001
Sex		
Female vs male	3.63 (1.81, 7.26)	0.002
Experience in this restaurant		
≥2 vs <2 yr	2.60 (1.43, 4.72)	0.009
Highest priced food item on the menu		0.071
\$10–\$20 vs <\$10	2.72 (1.33, 5.56)	0.022
>\$20 vs \$10–\$20	0.68 (0.32, 1.42)	0.389
>\$20 vs <\$10	1.84 (0.80, 4.24)	0.228
Server scored in top 50%[d]		
Specific person to answer food allergy questions and requests		
Yes vs no	2.49 (1.33, 4.66)	0.017
Service type		
Full service vs quick service	2.71 (1.40, 5.24)	0.013
No. of meals served in a typical day		0.077
101–300 vs 1–100	1.03 (0.51, 2.05)	0.953
>300 vs 101–300	2.54 (1.20, 5.38)	0.042
>300 vs 1–100	2.60 (1.19, 5.69)	0.045

[a] Overall models were created using a forward selection criterion of $P < 0.10$. Variables are presented in order of steps at which they entered the model. OR, odds ratio; CI, confidence interval. OR > 1 indicates that the odds of the outcome (knowledge score in top 50%) were greater for the first mentioned category (e.g., 1 to 10) than for the second mentioned category (e.g., 0).
[b] $\chi^2 = 17.18$, df = 3, $P < 0.001$, $N = 262$.
[c] $\chi^2 = 30.50$, df = 5, $P < 0.001$, $N = 192$.
[d] $\chi^2 = 16.97$, df = 4, $P = 0.002$, $N = 149$.

TABLE 6. *Descriptive data on restaurant manager and staff food allergy attitudes*[a]

	Manager (N = 277)		Food worker (N = 211)		Server (N = 156)	
Statement	*n*	%	*n*	%	*n*	%
Servers should be knowledgeable about food allergies						
Strongly agree	173	62.5	137	64.9	113	72.4
Agree	97	35.0	74	35.1	43	27.6
Unsure	0	0	0	0	0	0
Disagree	7	2.5	0	0	0	0
Strongly disagree	0	0	0	0	0	0
Kitchen staff should be knowledgeable about food allergies						
Strongly agree	194	70.0	147	69.7	125	80.1
Agree	82	29.6	63	29.8	31	19.9
Unsure	0	0	1	0.5	0	0
Disagree	1	0.4	0	0	0	0
Strongly disagree	0	0	0	0	0	0
Restaurants should try to meet food allergic customers' special requests						
Strongly agree	133	48.0	106	50.2	88	56.4
Agree	120	43.3	99	46.9	65	41.7
Unsure	7	2.6	0	0	2	1.3
Disagree	15	5.4	4	1.9	1	0.6
Strongly disagree	2	0.7	2	1.0	0	0
This restaurant can easily meet food allergic customers' special requests						
Strongly agree	113	40.8	82	38.9	74	47.5
Agree	129	46.6	114	54.0	71	45.5
Unsure	9	3.2	4	1.9	1	0.6
Disagree	26	9.4	10	4.7	10	6.4
Strongly disagree	0	0	1	0.5	0	0
The staff in this restaurant know what to do if a customer has a bad food allergic reaction						
Strongly agree	66	23.8	51	24.2	36	23.1
Agree	130	46.9	106	50.2	82	52.6
Unsure	27	9.8	29	13.7	22	14.1
Disagree	49	17.7	25	11.9	16	10.2
Strongly disagree	5	1.8	0	0	0	0

[a] Strongly disagree = 1; disagree = 2; unsure = 3; agree = 4; strongly agree = 5.

A multiple logistic regression analysis identified four characteristics that were significantly associated with food worker food allergy attitudes (Table 7). Food workers in restaurants with a plan for answering questions from food allergic customers were more likely to have a higher food allergy attitude score than were workers in restaurants without such a plan. Food workers with at least some college education had greater odds of having a higher food allergy attitude score than did workers with less education. Food workers in restaurants that employed fewer than five workers for every manager were more likely to have a higher food allergy attitude score than were those workers in restaurants with five workers or more for every manager. Food workers in chain restaurants had greater odds of having a higher food allergy attitude score than did workers in independent restaurants.

A multiple logistic regression analysis identified four characteristics that were significantly associated with server food allergy attitudes (Table 7). Servers with at least some college education were more likely to have a higher food allergy attitude score than were servers with less education. Servers who had received food allergy training at the restaurant had greater odds of having a higher food allergy attitude score than did servers with no food allergy training. Servers in restaurants with a plan for answering questions from food allergic customers were more likely to have a

TABLE 7. *Multiple logistic regression analysis of characteristics associated with restaurant managers, food workers, and servers scoring in the top 50% of food allergy attitude scores*[a]

Characteristic	OR (90% CI)	P
Manager scored in top 50%[b]		
No. of meals served to allergic customers in past month		<0.001
1–10 vs 0	1.29 (0.73, 2.28)	0.467
>10 vs 1–10	3.72 (2.00, 6.92)	0.001
>10 vs 0	4.80 (2.35, 9.77)	<0.001
Restaurant plan for answering questions from food allergic customers		
Yes vs no	2.77 (1.59, 4.81)	0.003
Specific person to answer food allergy questions and requests		
Yes vs no	1.71 (1.02, 2.85)	0.085
Allergen information on menu		
Yes vs no	0.42 (0.22, 0.79)	0.023
Experience in this restaurant		
≥4 vs <4 yr	0.57 (0.35, 0.94)	0.061
Received food allergy training at this restaurant		
Yes vs no	1.71 (1.00, 2.92)	0.099
Food worker scored in top 50%[c]		
Restaurant plan for answering questions from food allergic customers		
Yes vs no	2.43 (1.33, 4.43)	0.015
Highest level of education		
Some college or more vs high school diploma or less	3.35 (1.83, 6.14)	0.001
Worker:manager ratio		
<5:1 vs ≥5:1	2.44 (1.37, 4.35)	0.011
Restaurant type		
Chain vs independent	2.04 (1.13, 3.70)	0.048
Server scored in top 50%[d]		
Highest level of education		
Some college or more vs high school diploma or less	3.33 (1.80, 6.17)	0.001
Received food allergy training at this restaurant		
Yes vs no	2.60 (1.32, 5.08)	0.020
Restaurant plan for answering questions from food allergic customers		
Yes vs no	2.43 (1.16, 5.12)	0.050
Experience in this restaurant		
≥2 vs <2 yr	1.89 (1.01, 3.52)	0.093

[a] Overall models were created using a forward selection criterion of $P < 0.10$. Variables are presented in order of steps at which they entered the model. OR, odds ratio; CI, confidence interval. OR > 1 indicates that the odds of the outcome (attitude score in top 50%) were greater for the first mentioned category (e.g., 1 to 10) than for the second mentioned category (e.g., 0).
[b] $\chi^2 = 52.00$, df = 7, $P < 0.001$, $N = 248$.
[c] $\chi^2 = 27.86$, df = 4, $P < 0.001$, $N = 196$.
[d] $\chi^2 = 24.43$, df = 4, $P < 0.001$, $N = 149$.

higher food allergy attitude score than were servers in restaurants with no such plan. Servers with at least 2 years of experience in the restaurant had greater odds of having a higher food allergy attitude score than did servers with less experience.

DISCUSSION

The overarching goal of this study was to describe food allergy knowledge, attitudes, and practices in restaurants. This multisite study revealed that restaurant managers and staff are knowledgeable and have positive attitudes concerning accommodations for food allergic customers. One positive finding was that nearly all restaurant staff could correctly identify symptoms of an allergic reaction and knew to call emergency medical services (i.e., 911) in these situations. Most managers and staff thought it was important for food workers and servers to be knowledgeable about food allergies and that their restaurant could easily meet food allergic customers' special requests. However, we identified important gaps in knowledge and attitudes. For example, restaurant staff members were less likely to recognize eggs as a major allergen, and conversely, some foods such as strawberries were incorrectly believed to be major allergens. Another troubling finding was that more than 10% of managers and staff believe that someone with a food allergy can safely consume a small amount of that allergen. These findings for food workers are particularly troubling, because their main job responsibilities include food preparation. Accurate knowledge is critical to preventing an allergic reaction. Managers and staff also had lower confidence in their restaurants' ability to properly respond to a food allergy emergency. This finding suggests that restaurant plans and trainings may not adequately prepare staff for these emergencies. Because the incidence of food allergies continues to increase, it is important for restaurants to be prepared for potential anaphylaxis emergencies.

Identifying areas of concern is only the first step in preventing food allergic reactions in restaurants. Our additional analyses quantified the associations between restaurant, manager, and staff characteristics, practices, and observations and their food allergy knowledge and attitudes. Understanding these relationships is critical to creating effective interventions.

We found that several individual characteristics were significantly associated with food allergy knowledge and attitudes, e.g., education, work experience, and sex. Food worker knowledge level was higher among female workers and those with more experience working in their current restaurant. These findings suggest that it is important for restaurants to engage less experienced workers in food allergy trainings. Work experience and education were also significantly related to attitudes for managers, food workers, and servers. Managers with less experience had positive attitudes. In this case, experience might be a proxy for age. Anecdotal information from our data collectors suggests that younger managers were more receptive to accommodating food allergens than were older managers. In contrast, servers with more experience had positive attitudes. The contradiction between these findings is not readily explainable. Both food workers and servers with higher levels of education had positive attitudes.

Our findings also revealed a number of restaurant characteristics associated with food allergy knowledge and attitudes. Food workers in restaurants with higher priced food and servers in full service restaurants were more knowledgeable about food allergies. These characteristics might be indicative of restaurants with more resources to hire and retain staff who are more knowledgeable in general. Servers who served more meals per day also were more knowledgeable, perhaps because they recited the ingredients in meals to customers more frequently. Food workers in chain restaurants and those in restaurants with a lower worker-to-manager ratio also had positive food allergy attitudes.

Several allergy-specific practices were consistently related to knowledge and attitudes for managers, food workers, and servers. Serving more meals to food allergic customers was positively related to manager knowledge and attitudes but not to food worker and server knowledge and attitudes. Although staff are all involved in the process of serving food allergic customers, managers have more of the burden to ensure a meal is allergen free, especially if they are designated as the specific person in the restaurant to handle food allergy questions and requests. Having a plan for answering questions from food allergic customers or having a specific person to answer food allergy questions and requests was positively related to food allergen knowledge and attitudes for all staff groups. Both of these practices are recommended by the Food Allergy Research and Education group *(8)* as part of a restaurant's food allergy management plan. Research concerning the direction of the relationship between restaurant practices and food allergy knowledge and attitudes should be explored.

Food allergy training was associated with positive manager and server attitudes but not with knowledge in any staff group. These findings suggest that food allergy trainings influence attitudes but either do not impart enough food allergy knowledge or do not result in retention of that knowledge. Relevant material for these trainings can include information on major food allergens, menu items containing food allergens, symptoms of an allergic reaction, interacting with food allergic customers, preparing for a food allergic reaction, and preventing cross-contact with allergens. Food allergy training can also be provided to new employees, and existing staff can be retrained periodically. Further research could explore which training techniques are most effective and result in long-term retention of important food allergy information.

Counterintuitively, the presence of allergen information on the menu was associated with less positive attitudes for managers. In 55% of these menus, the allergen information was a note for the customer to inform the restaurant if they or someone with them had a food allergy. In at least one of the data collection sites, legislation requires restaurants to state in the menu that customers should notify the server of any food allergies. Such legislation may produce situations in which even managers with less positive food allergy attitudes still include such notices on their menus. As more states and cities adopt food allergy laws, the extent to which these laws affect restaurants' food allergy practices can be evaluated. In any case, alerting customers to menu items containing allergens or encouraging these customers to notify staff regarding their allergies might help prevent allergic reactions. Only 22% of restaurant menus mentioned anything about allergens; we encourage more restaurants to include information about allergens on their menus.

This study had several limitations. Because we included only English-speaking managers, food workers, and servers in the study, the findings might not generalize to non-English speakers. Similarly, because the interviewed food workers and servers were chosen by managers rather than randomly, the food worker and server data might not be representative of these groups as a whole. This study also had a low participation rate (32.6%). The low response rate might have resulted in an overrepresentation of better and safer restaurants in the sample. In reporting results of a food allergen survey that also had a low response rate *(4),* the authors suggested that a lack of participation might reflect "a general discomfort in responding to an inquiry regarding food allergies." In comparison to other food safety topics, food allergies have emerged more recently, and managers might not feel as comfortable participating in research. Almost all participants in the present study had very favorable food allergy attitudes. This range restriction limited our ability to investigate the relationship between explanatory variables and attitudes. We also were not able to make causal inferences about the relationships between explanatory and outcome variables. For example, knowledgeable managers may attract and retain more customers with food allergies, or an increase in customers with food allergies may compel staff to acquire additional knowledge about allergens. We cannot determine whether serving more customers with food allergies leads to higher knowledge levels. Thus, although our data suggest significant relationships between several restaurant, manager, and staff characteristics and food allergy knowledge and attitudes, more research is needed to determine the causal nature of those relationships.

Overall, these findings suggest that managers, food workers, and servers are knowledgeable and have positive attitudes about accommodating customers with food allergies. We encourage restaurants to develop plans and designate a specific person to handle food allergy requests. Such practices were consistently associated with better knowledge and more positive attitudes. Food allergy training is also recommended for new and existing managers and staff.

ACKNOWLEDGMENTS

We thank the restaurant managers, workers, and servers who participated in this study and the EHS-Net staff who assisted with study design and data collection. This publication is based on data collected and provided by CDC EHS-Net, which is supported by a CDC grant award 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.

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