



Published in final edited form as:

J Food Prot. 2013 November ; 76(11): 1824–1828. doi:10.4315/0362-028X.JFP-13-037.

Contributing Factors in Restaurant-Associated Foodborne Disease Outbreaks, FoodNet Sites, 2006 and 2007†

L. HANNAH GOULD^{1,*}, IDA ROSENBLUM¹, DAVID NICHOLAS², QUYEN PHAN³, and TIMOTHY F. JONES⁴

¹Centers for Disease Control and Prevention, Enteric Diseases Epidemiology Branch, Atlanta, Georgia 30330

²New York State Department of Health, Albany, New York 12237

³Connecticut Department of Public Health, Hartford, Connecticut 06106

⁴Tennessee Department of Health, Nashville, Tennessee 37243, USA

Abstract

An estimated 48 million cases of foodborne illness occur each year in the United States, resulting in approximately 128,000 hospitalizations and 3,000 deaths. Over half of all foodborne disease outbreaks reported to the Centers for Disease Control and Prevention are associated with eating in restaurants or delicatessens. We reviewed data from restaurant-associated foodborne disease outbreaks to better understand the factors that contribute to these outbreaks. Data on restaurant-associated foodborne disease outbreaks reported by sites participating in the Foodborne Diseases Active Surveillance Network (FoodNet) were analyzed to characterize contributing factors reported in foodborne disease outbreaks and the levels of evidence used to identify these factors. Of 457 foodborne disease outbreaks reported in 2006 and 2007 by FoodNet sites, 300 (66%) were restaurant associated, and of these 295 (98%) had at least one reported contributing factor. One to nine (with a median of two) contributing factors were reported per outbreak. Of the 257 outbreaks with a single etiology reported, contributing factors associated with food worker health and hygiene were reported for 165 outbreaks (64%), factors associated with food preparation practices within the establishment were reported for 88 outbreaks (34%), and factors associated with contamination introduced before reaching the restaurant were reported for 56 outbreaks (22%). The pronounced role of food workers in propagating outbreaks makes it clear that more work is needed to address prevention at the local level. Food workers should be instructed not to prepare food while ill to prevent the risk of transmitting pathogens.

An estimated 48 million cases of foodborne illness occur each year in the United States, resulting in approximately 127,000 hospitalizations and 3,000 deaths (15). Although outbreak-associated infections account for only a small proportion of culture-confirmed infections, outbreaks are associated with substantial morbidity and play an important role in our understanding of the epidemiology of foodborne illness (12). Outbreaks can occur in

†The findings and conclusions in this report are those of the authors and do not necessarily reflect the official position of the Centers for Disease Control and Prevention.

* Author for correspondence. Tel: 404-639-3315; Fax: 404-639-2205; lgould@cdc.gov.

many settings, but eating in a restaurant is a risk factor for acquiring a foodborne illness (11). More than half of all foodborne disease outbreaks reported to the Centers for Disease Control and Prevention (CDC) are associated with eating in restaurants or delicatessens (11). Thus, to make recommendations for preventing and controlling foodborne disease outbreaks, public and environmental health professionals must understand what factors contribute to these restaurant-associated foodborne disease outbreaks.

Contributing factors are defined as conditions identified during an outbreak investigation that either enable an outbreak to occur or amplify an outbreak caused by other means; these factors contribute to the contamination, survival, or proliferation of the pathogen (2). Thirty-two contributing factors have been defined and classified into three categories: 15 contamination factors (that introduce or otherwise permit pathogen contamination), 12 proliferation and/or amplification factors (that allow proliferation or growth of the agent), and 5 survival factors (that allow survival or fail to inactivate a contaminant) (2).

Determination of contributing factors associated with outbreaks is important for appropriately implementing mitigation and prevention efforts. For contributing factors to be more accurately reported for a foodborne disease outbreak, both an environmental health assessment and an epidemiological investigation are needed, and public health resources must be adequate to support such investigations. We evaluated contributing factors reported during investigations of foodborne disease outbreaks to better understand the factors that lead to outbreaks in restaurants. The data evaluated were collected in 2006 and 2007 by the Foodborne Diseases Active Surveillance System (FoodNet).

MATERIALS AND METHODS

FoodNet tracks important foodborne illnesses, generating information that provides a foundation for food safety policy and prevention efforts. FoodNet is a collaborative effort among CDC's Emerging Infections Program, 10 participating state health departments, the U.S. Department of Agriculture's Food Safety and Inspection Service, and the U.S. Food and Drug Administration (FDA). FoodNet conducts active surveillance for nine pathogens transmitted commonly through food in Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, and Tennessee and in selected counties in California, Colorado, and New York. In 2006, the FoodNet surveillance area included an estimated 45 million persons (approximately 15% of the U.S. population).

We defined a foodborne disease outbreak as an incident in which two or more persons experienced a similar illness resulting from the ingestion of a common food (5). Outbreaks were investigated by state and local health departments and reported to the CDC via the national electronic Foodborne Outbreak Reporting System (eFORS). A standard form (CDC form 52.13, investigation of a foodborne outbreak) was used to collect information on each outbreak. Data collected included etiology, number of illnesses, setting, and contributing factors (5). Multiple contributing factors could be reported for each outbreak. In 2006 and 2007, personnel at FoodNet sites also collected supplemental information regarding contributing factors for all restaurant-associated foodborne disease outbreaks, including information on who identified the contributing factors and the identification methods used.

These methods were grouped into six main categories for analysis: environmental inspection, epidemiologic study, interviews with operators or food workers, food preparation review, laboratory data, or investigator's assumption.

For analysis, we linked eFORS reports of outbreaks in FoodNet sites with the supplemental data on contributing factors reported for each outbreak in 2006 and 2007. We limited the analysis to foodborne disease outbreaks in which food was reported to be prepared in a restaurant or delicatessen (restaurant associated). For some analyses, contributing factors were grouped into three general categories (Table 1): factors related to food preparation practices within the establishment (S1, S2, P1, P2, P3, P4, P6, C9, C13, and C14), factors related to food worker health and hygiene (C10, C11, and C12), and factors related to contamination of food outside of the restaurant (C1, C6, C7, and C8). All data manipulation, linking, and analyses were performed with SAS 9.1 (SAS Institute, Cary, NC).

RESULTS

Of 457 foodborne disease outbreaks reported in 2006 and 2007 in FoodNet sites, 300 (66%) were restaurant associated. Of these 300 outbreaks, at least one contributing factor was reported in 295 (98%) outbreaks. Of these 295 outbreaks, 271 (92%) had an identified etiology, and for 257 (95%) of these outbreaks a single etiology was reported: 154 (60%) were caused by norovirus, 33 (13%) were caused by *Salmonella*, 18 (7%) were caused by *Clostridium perfringens*, 18 (7%) were caused by histamine fish poisoning, and the remainder were caused by other pathogens.

A median of two contributing factors was reported for each outbreak (range, one to nine). Of the 32 possible contributing factors, 24 were reported at least once: 11 contamination factors, 9 proliferation factors, and 4 survival factors. Contamination factors were reported in 229 outbreaks (78%). The most commonly reported contamination factors (Table 1) were "handling by an infected person or carrier of pathogen" (137 outbreaks), "bare-handed contact by a handler/worker/preparer" (87 outbreaks), and "inadequate cleaning of processing/preparation equipment/ utensils that leads to contamination of vehicle" (32 outbreaks). Proliferation factors were reported for 70 outbreaks (24%), and "inadequate cold-holding temperatures" (47 outbreaks) and "slow cooling" (34 outbreaks) were most commonly reported. Survival factors were reported for 35 (12%) outbreaks, and "insufficient time and/or temperature during reheating" (16 outbreaks) and "insufficient time and/or temperature during initial cooking/ heat processing" (15 outbreaks) were most commonly reported.

Contributing factors associated with food worker health and hygiene were reported for 165 (64%) of the 257 outbreaks for which a single etiology was reported; factors associated with food preparation practices within the establishment were reported for 88 outbreaks (34%), and factors associated with contamination introduced before reaching the restaurant were reported for 56 outbreaks (22%). Nearly all (89%) of the outbreaks of norovirus infections and nearly half (15 outbreaks, 45%) of the outbreaks of *Salmonella* infections had contributing factors related to food worker health and hygiene (Table 2). Food worker health and hygiene contributing factors were not reported in outbreaks of *Listeria* or *Vibrio*

infections and were reported only once in an outbreak caused by *C. perfringens*. Food preparation practices in the establishment were most commonly associated with outbreaks of *Escherichia coli* O157 (100% of outbreaks), *C. perfringens* (81%), and *Salmonella* (58%) infections. Factors relating to contamination outside the restaurant were most common among outbreaks of *Vibrio* infection (100% of outbreaks), histamine fish poisoning (89%), and *E. coli* O157:H7 infection (80%).

Contributing factors were determined most commonly by environmental inspection (26% of outbreaks), interview with an operator or food worker (22%), and review of food preparation (21%) (Table 3). In the 165 outbreaks for which deficiencies in food worker health and hygiene were reported, the most common methods used to determine contributing factors were environmental inspection (32%) and interviews with restaurant managers or workers (31%). In the 88 outbreaks in which food handling deficiencies were noted in the establishment, in 23% the contributing factors were determined by environmental inspection and in 22% these factors were determined by food preparation review. Among the 54 outbreaks in which outside contamination factors were reported, in 19% these factors were assumed based on etiology or symptoms and in 15% these factors were determined by environmental inspection.

DISCUSSION

In this analysis of contributing factors in restaurant-associated foodborne disease outbreaks, we identified broad categories of contributing factors that are common root causes of these types of outbreaks. Outbreaks commonly resulted from contamination of food within the establishment, particularly from contamination introduced by an infected food handler (e.g., norovirus) or inadequate hand washing by food handlers. Fewer outbreaks resulted from food mishandling or cross-contamination between products. These findings have important implications for the control of outbreaks and the targeting of resources to prevent them.

Norovirus and *Salmonella* are the two most common pathogens implicated in foodborne disease outbreaks, together accounting for nearly 75% of outbreaks reported in the United States (8). In this and previous studies (9, 10, 16), norovirus played a predominant role in restaurant-associated outbreaks, particularly through transmission by food workers. Transmission of *Salmonella* by food workers was also reported for nearly half of outbreaks in this study and has been documented in other outbreaks; in one series of restaurant-associated outbreaks of *Salmonella* infection in Minnesota, an infected food worker was identified in 83% of these outbreaks (13). At the national level, substantial resources have been allotted to federal agencies to prevent contamination of the food supply at levels before the point of service. The continued and pronounced role of food workers in propagating outbreaks (10, 13, 16) makes it clear that more work is needed to address prevention at the local level (i.e., in restaurants and other establishments that serve food). Employee turnover in the restaurant industry is very high, and employees often lack sufficient training about proper food handling (14) and hand washing (1) practices. Food workers might also report to work and deny illness for a variety of reasons (16). Food workers should be instructed not to prepare food while ill to prevent the risk of transmitting pathogens. Unfortunately, although

exclusion of ill food workers is extremely important (17), provision of paid sick leave is uncommon in the industry.

Although factors related to food worker health and hygiene were common in outbreaks of norovirus infection, these same factors were uncommon for outbreaks caused by other pathogens (i.e., *C. perfringens* and *E. coli*). Restaurant owners and public health practitioners should continue to educate food workers on the importance of proper time and temperature procedures to reduce the risk of pathogen amplification. Because pathogens can also be brought into the restaurant setting on items that will be cooked (e.g., raw meat), restaurant managers and owners should assure that workers are aware that raw poultry and meat are commonly contaminated with pathogens that can cross-contaminate other foods unless rigorous controls are in place. Many national restaurant chains already maintain rigorous training and restaurant engineering standards to ensure food safety; these practices should be encouraged and continued. Guidance such as the FDA Food Code provides a model of key practices that must be continually reinforced to reduce the number of foodborne disease outbreaks (17). The findings in the present study provide additional evidence to support strengthening and updating the Food Code, particularly guidance regarding exclusion and restriction of ill food workers to reduce the risk of foodborne disease transmission in restaurants through food worker contamination.

Only a small proportion of foodborne illnesses reported each year are associated with outbreaks. For example, in FoodNet sites during 2006 and 2007, an average of only 6% of *Salmonella* illnesses and 16% of *E. coli* O157 illnesses were part of a recognized outbreak (3, 4). Our findings suggest ways that outbreaks can be prevented, but it is not known how many sporadic illnesses are due to the factors we identified and would be preventable with similar interventions.

Nearly 20% of the contributing factors reported were identified without the use of epidemiologic or environmental health data. Environmental health data provide essential evidence for contributing factor determination. Because findings from studies of contributing factors may be used in the development of policies and regulations, contributing factor data must be evidence based. Keeping ill food workers out of the kitchen and promoting proper hand hygiene may be effective ways to reduce restaurant-associated outbreaks, but these practices must be implemented in conjunction with other measures (e.g., time and temperature controls) to be maximally effective. Although guidance for state health departments for reporting contributing factors has been more recently developed (6), definitions and interpretation of contributing factors remain somewhat subjective, leading to possible misclassification. For some outbreaks, the contributing factors reported may represent general deficiencies noted at an establishment rather than the actual causal events leading to a particular outbreak. The methods used to determine contributing factors most likely differ by investigating and reporting jurisdictions.

Because the most common contributing factors differed by pathogen, no single intervention will be sufficient to reduce all outbreaks. In the investigations included in the present study, only one of several deficiencies may have been reported as a contributing factor to an outbreak, e.g., failure to cook foods completely might be noted in a restaurant but not failure

to prevent the meat or poultry from initial contamination during processing. For example, in one outbreak of *C. perfringens* infection food handler health and hygiene deficiencies were reported (deficiencies unlikely to have contributed to the outbreak), and in only 39% of *Salmonella* infection outbreaks was outside contamination reported (likely to be a major contributing factor in many *Salmonella* infection outbreaks). Similarly, contributing factors might not explain all factors influencing foodborne disease outbreaks. Multiple factors can be involved in the same outbreak, illustrating that preventing restaurant-associated outbreaks requires approaches that deal with many issues along the farm-to-fork continuum. These findings in the present study apply only to outbreaks reported from 10 sites over 2 years, and the resulting small sample size makes it difficult to draw conclusions for some pathogens. Additional studies examining factors contributing to outbreaks in restaurants are needed using data from more recent years and more sites.

This study builds on previous studies of contributing factors in restaurant-associated outbreaks, providing additional information about the importance of ensuring quality environmental health assessments. The use of systems such as the National Voluntary Environmental Assessment Information System (7) will help to identify additional factors that can be routinely monitored to prevent or reduce the risk of foodborne disease outbreaks. Data on factors contributing to restaurant-associated outbreaks provide important insight into the epidemiology of foodborne disease and potential preventive interventions. A public health infrastructure adequate for performing accurate and complete outbreak investigations is essential to ensure that these types of data are available to help guide and develop appropriate intervention strategies.

References

1. Allwood PB, Jenkins T, Paulus C, Johnson L, Hedberg CW. Hand washing compliance among retail food establishment workers in Minnesota. *J Food Prot.* 2004; 67:2825–2828. [PubMed: 15633696]
2. Bryan FL, Guzewich JJ, Todd ECD. Surveillance of foodborne disease. III. Summary and presentation of data on vehicles and contributory factors: their value and limitations. *J Food Prot.* 1997; 60:701–714.
3. Centers for Disease Control and Prevention. Preliminary FoodNet data on the incidence of infection with pathogens transmitted commonly through food—10 states, 2006. *Morb Mortal Wkly Rep.* 2007; 56:336–339.
4. Centers for Disease Control and Prevention. Preliminary FoodNet data on the incidence of infection with pathogens transmitted commonly through food—10 states, 2007. *Morb Mortal Wkly Rep.* 2008; 57:366–370.
5. Centers for Disease Control and Prevention. Surveillance for foodborne disease outbreaks—United States, 2007. *Morb Mortal Wkly Rep.* 2010; 59:973–979.
6. Centers for Disease Control and Prevention. [Accessed 2 July 2012] National Outbreak Reporting System guidance document. 2012. Available at: [http://www.cdc.gov/outbreaknet/pdf/NORS_Guidance_5213_06232009\(compliant\).pdf](http://www.cdc.gov/outbreaknet/pdf/NORS_Guidance_5213_06232009(compliant).pdf)
7. Centers for Disease Control and Prevention. [Accessed 21 March 2013] National Voluntary Environmental Assessment Information System (NVEAIS). 2012. Available at: <http://www.cdc.gov/nceh/ehs/EHSNet/resources/nveais.htm>
8. Centers for Disease Control and Prevention. Surveillance for foodborne disease outbreaks—United States, 2009–2010. *Morb Mortal Wkly Rep.* 2013; 62:41–47.
9. Hedberg CW, Palazzi-Churas KL, Radke VJ, Selman CA, Tauxe RV. The use of clinical profiles in the investigation of foodborne outbreaks in restaurants: United States, 1982–1997. *Epidemiol Infect.* 2008; 136:65–72. [PubMed: 17335632]

10. Hedberg CW, Smith SJ, Kirkland E, Radke V, Jones TF, Selman CA. the EHS-Net Working Group. Systematic environmental evaluations to identify food safety differences between outbreak and nonoutbreak restaurants. *J Food Prot.* 2006; 69:2697–2702. [PubMed: 17133814]
11. Jones TF, Angulo FJ. Eating in restaurants: a risk factor for foodborne disease? *Clin Infect Dis.* 2006; 43:1324–1328. [PubMed: 17051501]
12. Jones TF, Imhoff B, Samuel M, Mshar P, McCombs KG, Hawkins M, Deneen V, Cambridge M, Olsen SJ. Limitations to successful investigation and reporting of foodborne outbreaks: an analysis of foodborne disease outbreaks in FoodNet catchment areas, 1998–1999. *Clin Infect Dis.* 2004; 38(Suppl 3):S297–S302. [PubMed: 15095202]
13. Medus C, Smith KE, Bender JB, Besser JM, Hedberg CW. *Salmonella* outbreaks in restaurants in Minnesota, 1995 through 2003: evaluation of the role of infected foodworkers. *J Food Prot.* 2006; 69:1870–1878. [PubMed: 16924912]
14. Mitchell RE, Fraser AM, Bearon LB. Preventing food-borne illness in food service establishments: broadening the framework for intervention and research on safe food handling behaviors. *Int J Environ Health Res.* 2007; 17:9–24. [PubMed: 17365076]
15. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, Griffin PM. Foodborne illness acquired in the United States—major pathogens. *Emerg Infect Dis.* 2011; 17:7–15. [PubMed: 21192848]
16. Todd ECD, Greig JD, Bartleson CA, Michaels BS. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 3. Factors contributing to outbreaks and description of outbreak categories. *J Food Prot.* 2007; 70:2199–2217. [PubMed: 17900100]
17. U.S. Food and Drug Administration. [Accessed 31 May 2012] Food Code. 2009. Available at: <http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodCode/default.htm>

TABLE 1

Contributing factors reported in 295 restaurant-associated outbreaks, FoodNet sites, 2006 and 2007

Factor	Description	No. of outbreaks reporting factor ^a	Classification ^b
Contamination			
C12	Handling by an infected person or carrier of pathogen	137	Food worker health and hygiene
C10	Bare-handed contact by a handler/worker/preparer	87	Food worker health and hygiene
C13	Inadequate cleaning of processing/preparation equipment/ utensils that leads to contamination of vehicle	32	Food preparation within establishment
C11	Glove-handed contact by handler/worker/preparer	31	Food worker health and hygiene
C6	Raw product/ingredient contaminated by pathogens from animal or environment	29	Outside contamination
C9	Cross-contamination from raw ingredient of animal origin	19	Food preparation within establishment
C1	Toxic substance part of tissue	17	Outside contamination
C7	Ingestion of contaminated raw products	15	Outside contamination
C14	Storage in contaminated environment leading to contamination of vehicle	5	Food preparation within establishment
C8	Obtaining foods from polluted sources	4	Outside contamination
C15	Other source of contamination	17	
Total		229 (78%)	
Proliferation, amplification			
P3	Inadequate cold-holding temperatures	47	Food preparation within establishment
P2	Slow cooling	34	Food preparation within establishment
P1	Allowing foods to remain at room or warm outdoor temperature for several hours	25	Food preparation within establishment
P6	Insufficient time and/or temperature during hot holding	18	Food preparation within establishment
P4	Preparing foods a half-day or more before serving	15	Food preparation within establishment
P5	Prolonged cold storage for several weeks	1	Food preparation within establishment
P7	Insufficient acidification	1	Food preparation within establishment
P9	Inadequate thawing of frozen products	1	Food preparation within establishment
P12	Other situations that promote or allow microbial growth or toxin production	10	
Total		70 (24%)	
Survival			
S2	Insufficient time and/or temperature during reheating	16	Food preparation within establishment
S1	Insufficient time and/or temperature during initial cooking/heat processing	15	Food preparation within establishment
S4	Insufficient thawing, followed by insufficient cooking	1	Food preparation within establishment

Factor	Description	No. of outbreaks reporting factor ^a	Classification ^b
S5	Other process failures that permit the pathogen to survive	15	
Total		35 (12%)	

^a More than one factor could be reported for each outbreak

^b Contributing factors were grouped into three general categories: factors related to food preparation practices within the establishment (S1, S2, P1, P2, P3, P4, P6, C9, C13, and C14), factors related to food worker health and hygiene (C10, C11, and C12), and factors related to contamination of food outside of the restaurant (C1, C6, C7, and C8).

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

TABLE 2

Contributing factor categories reported in 257 restaurant-associated foodborne disease outbreaks with a single etiology reported, FoodNet sites, 2006 and 2007

Etiology	No. of outbreaks	No. (%) of outbreaks with at least one factor in category ^a		
		Food worker health and hygiene	Food preparation within the establishment	Outside contamination
Norovirus	154	137 (89)	22 (14)	8 (5)
<i>Salmonella</i>	33	15 (45)	22 (67)	13 (39)
<i>Clostridium perfringens</i>	18	1 (6)	16 (89)	4 (22)
Histamine fish poisoning (scombroid toxin)	18	0	5 (28)	16 (89)
<i>Staphylococcus aureus</i>	6	4 (67)	2 (33)	0
<i>Escherichia coli</i> O157:H7	4	0	4 (100)	3 (75)
Other bacteria	4	2 (50)	4 (100)	2 (80)
Other chemical(s)	4	2 (50)	4 (100)	0
<i>Vibrio</i> spp.	4	0	2 (50)	4 (100)
<i>Shigella</i>	3	2 (50)	1 (100)	1 (100)
<i>Campylobacter</i>	3	1 (100)	3 (100)	2 (67)
Enterotoxigenic <i>E. coli</i>	1	0	1 (100)	1 (100)
<i>Bacillus cereus</i>	1	0	1 (100)	0
Hepatitis A virus	1	1 (100)	0	0
<i>Listeria</i>	1	0	1 (100)	0
<i>Paragonimus</i>	1	0	0	1 (100)
Pufferfish tetrodotoxin	1	0	0	1 (100)
All outbreaks with single etiology	257	165 (64)	88 (34)	56 (22)

^a More than one contributing factor could be selected for each outbreak, so rows may sum to more than 100%.

TABLE 3

Methods used to determine contributing factors, FoodNet Sites, 2006 and 2007

Method ^a	No. (%) of outbreaks for which method was used			
	All outbreaks (<i>n</i> ~ 257)	Food worker health and hygiene (<i>n</i> ~ 165)	Food preparation within the establishment (<i>n</i> ~ 88)	Outside contamination (<i>n</i> ~ 54)
Environmental inspection	68 (26)	52 (32)	20 (23)	8 (15)
Interview of operator or food worker	57 (22)	51 (31)	14 (16)	2 (4)
Food preparation review or food flow	55 (21)	40 (24)	19 (22)	8 (15)
Epidemiologic investigation (case-control or cohort study)	36 (14)	27 (16)	8 (9)	4 (7)
Assumed based on etiology or symptoms	34 (13)	19 (10)	9 (10)	10 (19)
Culture of environment or food sample	13 (5)	6 (4)	6 (7)	6 (11)

^aCategories are not mutually exclusive and may total more than 100%.