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Foodborne Outbreaks Reported to the U.S. Food Safety and Inspection Service, Fiscal Years 2007 through 2012

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ABSTRACT

The U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS) works closely with federal, state, and local public health partners to investigate foodborne illness outbreaks associated with its regulated products. To provide insight into outbreaks associated with meat and poultry, outbreaks reported to FSIS during fiscal years 2007 through 2012 were evaluated. Outbreaks were classified according to the strength of evidence linking them to an FSIS-regulated product and by their epidemiological, etiological, and vehicle characteristics. Differences in outbreak characteristics between the period 2007 through 2009 and the period 2010 through 2012 were assessed using a chi-square test or Mann-Whitney U test. Of the 163 reported outbreaks eligible for analysis, 89 (55%) were identified as possibly linked to FSIS-regulated products and 74 (45%) were definitively linked to FSIS-regulated products. Overall, these outbreaks were associated with 4,132 illnesses, 772 hospitalizations, and 19 deaths. Shiga toxin–producing *Escherichia coli* was associated with the greatest proportion of reported outbreaks (55%), followed by *Salmonella enterica* (34%) and *Listeria monocytogenes* (7%). Meat and poultry products commercially sold as raw were linked to 125 (77%) outbreaks, and of these, 105 (80%) involved beef. Over the study period, the number of reported outbreaks definitively linked to FSIS-regulated products ($P = 0.03$) declined, while the proportion of culture-confirmed cases ($P = 0.0001$) increased. Our findings provide insight into the characteristics of outbreaks associated with meat and poultry products.

Key words: Foodborne outbreaks; Illness; Meat; Poultry

Foodborne illness represents an important public health burden in the United States. According to the Centers for Disease Control and Prevention (CDC), an estimated 48 million foodborne illnesses occur every year nationwide, resulting in 128,000 hospitalizations and 3,000 deaths *(17, 18)*. The U.S. Department of Agriculture (USDA) Economic Research Service attributes an estimated annual loss of $14 billion and 61,000 quality-adjusted life years to infections with 14 foodborne pathogens, with nontyphoidal *Salmonella enterica* contributing the most losses among all pathogens *(8)*. The ramifications of foodborne illness extend beyond affected consumers. Financial costs to the food industry also can be substantial, particularly when product recalls, trade restrictions, litigation, and lost market share result from large-scale outbreaks (*1, 2, 13*).

Upon notification of a foodborne illness outbreak, the USDA Food Safety and Inspection Service (FSIS) works closely with CDC and state and local public health partners to determine whether meat or poultry are the source. FSIS Directive 8080.3 *(20)* describes the process FSIS follows during foodborne illness investigations. In some instances, FSIS may also investigate reports of only one recognized illness when preliminary evidence strongly suggests meat or poultry is the responsible vehicle. Possible outcomes of an investigation include product recalls, public health alerts, and enforcement actions at the implicated FSIS-regulated establishment.

To provide insight into outbreaks associated with meat and poultry, outbreaks reported to FSIS across multiple years were reviewed.

MATERIALS AND METHODS

This study included outbreaks reported to FSIS between 1 October 2007 and 30 September 2012. Data were obtained from an FSIS database used to maintain records for outbreak investigations. When available, data from the online CDC National Outbreak Reporting System, CDC Web postings for multistate outbreaks, and FSIS investigative reports were used to verify data accuracy and completeness. Outbreaks were excluded from analysis when a public health investigation failed to establish the route of exposure (e.g., foodborne versus waterborne) or an investigation conclusively ruled out FSIS-regulated food as the source. Reports of a single illness were included in our analysis when evidence strongly suggested that meat or poultry consumption led to the illness (e.g., indications that the case patient ate rare meat in the absence of other high-risk exposures).

Descriptive statistics were used to summarize outbreaks based on their epidemiological, clinical, etiological, and vehicle characteristics. Outbreaks also were classified according to the strength of evidence linking them to an FSIS-regulated product at the close of

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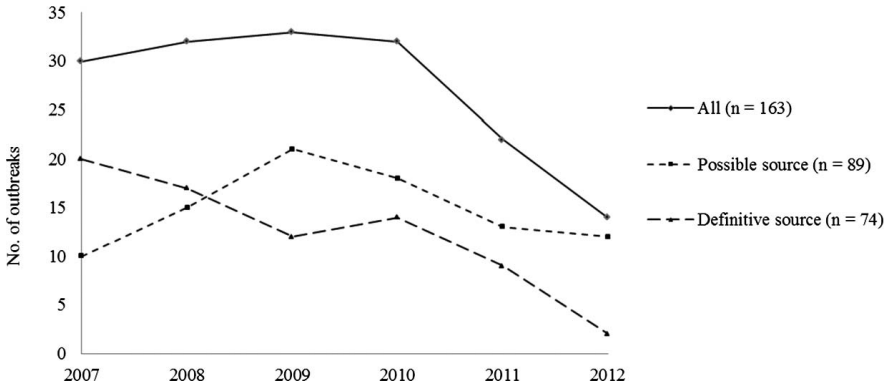

FIGURE 1. *Foodborne outbreaks reported each year by strength of attribution to an FSIS-regulated product, fiscal years 2007 through 2012.*

the investigation. Outbreaks were classified as possibly linked when evidence indicated that an FSIS-regulated product was a possible cause of the outbreak, but the evidence was not strong enough to exclude all other possible sources. Evidence rising to this level included a moderate to high proportion of case patient food histories with a particular food in common but with key corroborating evidence missing (e.g., an epidemiologic study revealing a significant association, microbiological test results revealing pathogen contamination in leftover food, or traceback records confirming a common exposure). Outbreaks were classified as definitively linked when an FSIS-regulated product was conclusively implicated through either strong epidemiologic evidence or a combination of epidemiologic evidence, product testing, traceback records, or other compelling support. Internal investigation reports also were reviewed, when available, to ascertain involvement of restaurants and institutions as exposure settings. Differences in outbreak characteristics and outbreak-related illnesses between the first and second halves of the study period were assessed using a chi-square test or Mann-Whitney U test. Associations were considered significant at $P < 0.05$.

RESULTS

From 2007 through 2012, 292 outbreaks were reported to the FSIS. Eighty-one (28%) of the outbreaks were excluded from analysis because records indicated that the transmission route for these events was not conclusively determined. Of the remaining 211 outbreaks, 48 (23%) additional outbreaks were excluded because they were ultimately attributed to sources not regulated by FSIS, such as fruits and vegetables regulated by the U.S. Food and Drug Administration. The remaining 163 outbreaks were eligible for analysis.

Strength of attribution. Of the 163 outbreaks, 89 (55%) were identified as possibly linked and 74 (45%) were identified as definitively linked to FSIS-regulated products. Of these 74 outbreaks, 43 (58%) resulted in a voluntary product recall. During 2010 through 2012, the number of reported outbreaks declined compared with previous years (Fig. 1). The sharpest decline was associated with definitively linked outbreaks, which decreased from an annual average of 16.3 in 2007 through 2009 to 8.3 in 2010 through 2012. When median monthly counts for definitively linked outbreaks were compared between the two time periods, there was a significant difference ($P = 0.03$): one outbreak per month (range, zero to five) in 2007 through 2009 and zero outbreaks per month (range, zero to three) in 2010 through 2012.

Etiologies. Shiga toxin–producing *Escherichia coli* (STEC) was associated with the greatest proportion of reported outbreaks (55%), followed by *S. enterica* (34%), *Listeria monocytogenes* (*Lm*) (7%), and other pathogens (<5%) such as *Campylobacter* spp. (Table 1). The distribution of etiological agents was similar for possibly linked and definitively linked outbreaks.

The reporting of *Salmonella* outbreaks remained fairly stable throughout the study period, but STEC outbreaks decreased toward the end of the study period (Fig. 2). The annual average number of STEC outbreaks decreased from 19.3 in 2007 through 2009 to 10.3 in 2010 through 2012. However, when the monthly median number of STEC outbreaks was compared between the two time periods, the difference was not significant ($P = 0.07$); both periods had a median of one outbreak per month (ranges: zero to five in 2007 through 2009; zero to four in 2010 through 2012).

Outbreak-related illnesses. The 4,132 case patients reported were associated with 163 outbreaks (Table 2). A majority of these illnesses (68%) were caused by *Salmonella* infection, followed by STEC (26%) and *Lm* (7%) infection. Eighty-three percent of all outbreak-related illnesses were culture confirmed; *Lm* infection had the highest rate of culture confirmation (100%). A majority (59%) of outbreaks

TABLE 1. *Outbreaks by etiology and strength of attribution to FSIS-regulated products, fiscal years 2007 through 2012*

Etiology	No. (%) of outbreaks		
	Total	Possibly linked	Definitively linked
Escherichia coli	89 (55)	44 (49)	45 (61)
Salmonella	56 (34)	33 (37)	23 (31)
L. monocytogenes	11 (7)	8 (9)	3 (4)
Clostridium spp.	2 (1)	0	2 (3)
Campylobacter spp.	1 (1)	1 (1)	0
Staphylococcus aureus	1 (1)	1 (1)	0
Norovirus	1 (1)	1 (1)	1 (1)
Unknown	2 (1)	1 (1)	0
Total	163	89	74

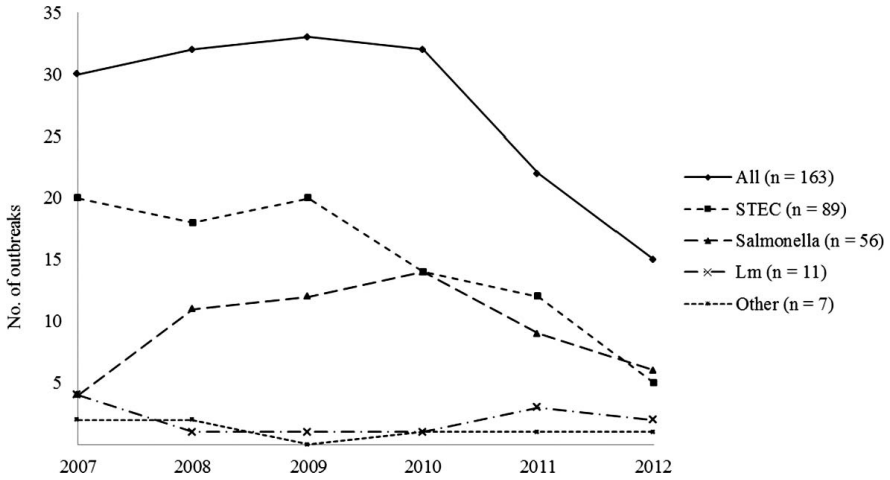

FIGURE 2. *Foodborne outbreaks reported each year by etiological agent, fiscal years 2007 through 2012.*

included more than five reported cases, and in 55% of outbreaks, cases were reported from two or more states.

The number of outbreak-related *Salmonella* illness cases varied throughout the study period and did not have a consistent trend. However, a downward trend in the number of STEC illnesses was noted; it decreased from an annual average of 270 (10.5 illnesses per month; range, 0 to 153) from 2007 through 2009 to an annual average of 92 (1 illness per month; range, 0 to 70) from 2010 through 2012. However, when the monthly median number of STEC illnesses was compared between the two periods, the difference was not significant ($P = 0.07$).

Hospitalizations, deaths, and hemorrhagic uremic syndrome (HUS). A total of 772 hospitalizations were reported in association with 118 outbreaks from available data (Table 3). The largest number of hospitalizations (468) was caused by *Salmonella* infection, but the etiology associated with the highest percentage of hospitalizations (78%) was *Lm*.

A total of 19 deaths were reported in association with 119 outbreaks. *Lm* was associated with the highest percentage of deaths among all reported etiologies (38%).

A total of 57 cases of physician-diagnosed HUS were reported in association with 38 STEC outbreaks with available data. Overall, 8% of STEC illnesses (57 of 719 cases with available data) included HUS; however, half of all STEC outbreaks involved no cases of HUS.

Seasonality and duration. From 2007 through 2012, outbreak onset occurred most frequently between June through August. This pattern was largely influenced by STEC outbreaks, with 41% occurring in June and July. *Salmonella* and *Lm* outbreaks, in contrast, had no clear seasonal pattern.

When outbreaks were summarized by their duration, defined as the number of days between onset of first illness and onset of last illness, the median duration for outbreaks overall was 21.5 days (range, 0 to 94 days). *Salmonella* outbreaks had the longest median duration, at 68 days (range, 0 to 394 days). In contrast, median duration of *Lm* outbreaks was 0 days (range, 0 to 31 days), which is primarily an artifact of the small number of *Lm* outbreaks; in some outbreaks, two or fewer illnesses were reported.

Serotypes. Among STEC serotypes, *E. coli* O157:H7 and *E. coli* O157:nonmotile caused the vast majority of outbreaks, with 79 outbreaks associated with the former and 3 associated with the latter, in total causing 1,013 illnesses. Six outbreaks were associated with non-O157 serotypes (O45, O111, O181:H49, and O26), representing a total of 72 illnesses. In one outbreak, the serotype was either not determined or not reported by the originating state health department.

Among 56 *Salmonella* outbreaks, the largest proportion was caused by *Salmonella* Typhimurium (12 of 56, 21%) followed by *Salmonella* Enteritidis (8 of 56, 14%) and *Salmonella* Newport (8 of 56, 14%). Together these serotypes were responsible for 978 illnesses or 35% of all *Salmonella* illnesses. *Salmonella* Heidelberg and *Salmonella* Hadar were responsible for a relatively small proportion of reported outbreaks (11 and 5%, respectively), and yet

TABLE 2. *Outbreak size and culture confirmation by three most common etiologies reported to FSIS, fiscal years 2007 through 2012*

		Cases			No. (%) of outbreaks by no. of cases				No. (%) of outbreaks by no. of states involved		
Etiology	*n*	Total no.	% culture confirmed	Median (range) no. per outbreak	≤5	6–25	26–100	>100	1	2–10	>10
All	163	4,132	83	8 (1–396)	66 (41)	56 (34)	30 (18)	11 (7)	72 (44)	71 (43)	20 (12)
STEC	89	1,087	76	6 (1–117)	42 (47)	34 (38)	12 (14)	1 (1)	35 (39)	48 (54)	6 (7)
Salmonella	56	2,816	91	23.5 (2–396)	11 (20)	19 (34)	17 (30)	9 (16)	26 (46)	16 (29)	14 (25)
Lm	11	29	100	1 (1–9)	6 (86)	1 (14)	0	0	6 (55)	5 (46)	0

TABLE 3. *Reported hospitalizations and deaths by three most common etiologies reported to FSIS, fiscal years 2007 through 2012*

		Hospitalizations			Deaths		
Etiology	n	Total no.[a]	Median (range) no. per outbreak	% of cases	Total no.[b]	No. (%) of outbreaks with ≥1 death	% of cases
All	118	772	3 (0–108)	23	19	14 (13)	0.6
STEC	68	271	2 (0–23)	28	4	3 (5)	0.5
Salmonella	38	468	5.5 (0–108)	20	6	4 (12)	0.3
Lm	9	21	2.5 (1–5)	78	6	4 (67)	38

[a] Hospitalization data unavailable for 45 outbreaks.
[b] Death data unavailable for 44 outbreaks.

together were responsible for 24% of all *Salmonella* illnesses (586 and 100 illnesses, respectively). Other *Salmonella* serotypes responsible for multiple outbreaks included I4,[5],12:i: (three outbreaks, 480 illnesses), Montevideo (three outbreaks, 443 illnesses), and Infantis (two outbreaks, 16 illnesses).

Characteristics of FSIS-regulated products linked to outbreaks. Of the163 outbreaks reported to FSIS during the study period, 125 (77%) were linked to a product commercially sold as raw. STEC and *Salmonella* outbreaks were linked to raw and partially cooked products (such as frozen pot pies); however, *Lm* outbreaks were limited to ready-to-eat products, such as hot dogs, deli meats, chicken salad, cooked sausage, ham, and packaged meals. Ready-to-eat products were linked to two (2%) STEC outbreaks and six (11%) *Salmonella* outbreaks.

Of the 129 outbreaks possibly or definitively linked to raw products (including 2 outbreaks that were linked to both raw and ready-to-eat products), 105 (80%) were linked to beef, 13 (10%) to chicken, 6 (5%) to turkey, and 5 (5%) to pork. One outbreak involved multiple raw commodities (beef and pork), and another involved raw ground bison.

Beef was associated with the largest share (99%) of STEC outbreaks for all commodities; ground beef was involved in most (92%) beef-linked outbreaks. Beef also was linked to 22 (55%) raw commodity–involved *Salmonella* outbreaks, and chicken, turkey, and pork were linked to 9 (22%), 6 (15%), and 4 (10%) *Salmonella* outbreaks, respectively. Of the 1,721 *Salmonella* illnesses linked to raw product, beef was linked to 761 (44%), chicken to 603 (35%), turkey to 312 (18%), and pork to 51 (3%) illnesses.

During the study period, 31 (31%) of the 100 outbreaks with available data involved two or more case patients whose suspected exposures included food served by a local commercial food preparer (such as a restaurant or caterer) or an institution (such as a prison or nursing home). The other 69 (69%) outbreaks involved foods that were prepared for personal use at home and similar settings.

Comparison between 2007 through 2009 and 2010 through 2012. To assess trends, outbreaks reported during 2007 through 2009 were compared with those reported during 2010 through 2012 based on the variables listed in Table 4. Between these two periods, no significant differences were apparent for the proportion of outbreaks with less than five cases, restaurant and institution involvement, and illnesses localized to a single state of residence versus multiple states. The proportion of outbreaks that resulted in product recalls also did not significantly differ, even when outbreaks definitely linked to an FSIS-regulated product were assessed separately from those that were not. However, the proportion of outbreak-related illnesses that were culture confirmed was significantly higher in 2010 through 2012 than in the previous 3-year period ($P = 0.0001$). Although no significant changes were observed in the reporting of outbreak etiologies or outbreak-related illnesses (data not shown), t fewer definitively linked outbreaks were reported in 2010 through 2012 than in 2007 through 2009 ($P = 0.03$).

DISCUSSION

We found an overall decline in the number of foodborne illness outbreaks during the study period. However, this decrease did not extend to all outbreaks uniformly. STEC outbreaks appeared to decline while *Salmonella* outbreaks remained relatively unchanged. A significant decrease in outbreaks definitively attributed to FSIS-regulated products also was noted. Improvements in pathogen reduction and consumer education possibly account for this change. Other

TABLE 4. *Comparison of outbreaks in fiscal years 2007 through 2009 with those in 2009 through 2012 by select variables*

	No. (%)		
Variable	2007–2009	2010–2012	*P*
Definitively linked outbreaks	49 (52)	25 (36)	0.03[a]
Outbreaks leading to recall	25 (26)	18 (26)	0.98
Outbreaks with <5 cases	43 (45)	18 (36)	0.12
Culture-confirmed cases	1,436 (76)	1,996 (91)	0.0001
Outbreaks involving only one state	45 (47)	28 (41)	0.38
Restaurant and institution involvement[b]	11 (28)	20 (33)	0.66

[a] Determined by comparing the monthly median number of outbreaks between 2007 through 2009 (one; range, zero to five) and 2010 through 2012 (zero; range, zero to three) using a Mann-Whitney U test. All other *P* values were calculated using a chi-square test.
[b] Percentage derived from 100 outbreaks with available information.

contributors might include decreased health care utilization stemming from the 2008 economic downturn *(12, 14),* recession-associated resource constraints within state and local health departments *(22),* and the shunting of public health resources toward the 2009 influenza A (H1N1) pandemic *(9)*. The growing use of culture-independent diagnostics in place of traditional culture-based methods also has relevant implications for outbreak detection *(4, 6)*. The increase in the proportion of culture-confirmed cases is consistent with increased reliance on molecular subtyping for detecting outbreaks. In a recent study, outbreak reporting rates were highest in the 30 states that require submission of *Salmonella* isolates to their state laboratories *(11)*.

Salmonella serotypes with a relatively broad host range (e.g., serotypes Typhimurium and Newport) caused a large proportion of *Salmonella* outbreaks linked to meat and poultry. However, three serotypes (Enteritidis, Heidelberg, and Hadar) closely affiliated with poultry *(10)* together were responsible for 30% of *Salmonella* outbreaks and 37% of *Salmonella* illnesses reported to the FSIS. These findings suggest that pathogen reduction strategies targeted to poultry and the serotypes affiliated with poultry could substantially improve foodborne illness prevention. In recent years, FSIS efforts to promote *Salmonella* reduction have expanded to include preharvest contamination prevention, more comprehensive verification sampling, and modernized regulation of slaughtered poultry *(21)*.

Not every outbreak associated with meat and poultry is reported to the FSIS. Because lapses in food safety can occur anywhere along a food supply chain, illnesses can arise from the consumption of food contaminated or mishandled outside the establishment where it was originally processed, such as at retail or in a home. FSIS is inconsistently notified of outbreaks of this type because its authority is largely centered on FSIS-regulated facilities. Illnesses also can go unreported to FSIS even when the root cause originates in an FSIS-regulated facility, and the extent to which this underreporting occurs is uncertain given the considerable amount of state-to-state variability that exists in surveillance, investigation, and reporting practices *(7, 11, 15)*. Thus, outbreaks reported to and investigated by the FSIS represent only a subset of those described in national surveillance reports.

The findings in this report have some limitations. First, because our analysis included possibly linked outbreaks to maximize the data we could draw from, an unknown percentage of illness outbreaks described in this report may not have been caused by FSIS-regulated products but rather by other foods. A second consideration is that reported illness outbreaks are not necessarily representative of all illnesses attributable to an FSIS-regulated product. This applies most evidently to *Campylobacter* illnesses. Although *Campylobacter* is a leading cause of foodborne illness *(3)* and poultry consumption is an important risk factor for infection *(5),* challenges in routinely subtyping this pathogen have limited the amount of molecular data available for *Campylobacter* outbreak surveillance *(19)*. As a consequence, *Campylobacter* outbreaks historically have been detected infrequently relative to the high burden of disease caused by this pathogen. Before June 2013, the FSIS did not routinely use pulsed-field gel electrophoresis (PFGE) to evaluate samples of its regulated products for *Campylobacter*. The resulting lack of product data in the CDC PulseNet database may have impeded efforts to link *Campylobacter* illnesses to FSIS-regulated commodities during the study period in this report. Thus, by focusing on only reported outbreaks, our data underrepresent illnesses caused by *Campylobacter* and illnesses attributable to poultry.

The ongoing study of trends and patterns associated with foodborne outbreaks is a necessary step in understanding the dynamics of food safety, outbreak surveillance, and interagency public health response. Detailed insight into the characteristics of outbreaks attributable to meat and poultry is particularly important because such foods are common sources of foodborne disease and have been associated with more fatal infections than other foods *(16)*. Our findings may advance studies aimed at more precisely quantifying the public health impacts of contaminated meat and poultry.

For most of the outbreaks described in this report, epidemiological evidence and data from PFGE and other molecular subtyping methods formed the basis for grouping illnesses together. The number of outbreaks linked to meat and poultry products and the number of illnesses associated with these outbreaks may change with the adoption of high-resolution subtyping. The findings described in this report reflect criteria used in the age of PulseNet and thus represent points for future comparison as whole genome sequencing becomes a prominent tool in foodborne outbreak detection.

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