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Vital Signs: Incidence and Trends of Infection with Pathogens Transmitted Commonly Through Food — Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 1996–2010

Abstract

Background: In the United States, contaminated food causes approximately 1,000 reported disease outbreaks and an estimated 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths annually. This report summarizes 2010 surveillance data and describes trends since 1996.

Methods: The Foodborne Diseases Active Surveillance Network (FoodNet) conducts surveillance among 15% of the U.S. population for laboratory-confirmed infections with nine pathogens transmitted commonly through food. Overall and pathogen-specific changes in incidence were estimated from 1996–1998 to 2010 and from 2006–2008 to 2010.

Results: A total of 19,089 infections, 4,247 hospitalizations, and 68 deaths were reported from FoodNet sites in 2010. *Salmonella* infection was the most common infection reported (17.6 illnesses per 100,000 persons) and was associated with the largest number of hospitalizations (2,290) and deaths (29); no significant change in incidence of *Salmonella* infection has occurred since the start of surveillance during 1996–1998. Shiga toxin–producing *Escherichia coli* (STEC) O157 infection caused 0.9 illnesses per 100,000. Compared with 1996–1998, overall incidence of infection with six key pathogens in 2010 was 23% lower, and pathogen-specific incidence was lower for *Campylobacter*, *Listeria*, STEC O157, *Shigella*, and *Yersinia* infection but higher for *Vibrio* infection. Compared with a more recent period, 2006–2008, incidence in 2010 was lower for STEC O157 and *Shigella* infection but higher for *Vibrio* infection.

Conclusions: The incidence of STEC O157 infection has declined to reach the 2010 national health objective target of ≤1 case per 100,000. This success, as well as marked declines since 1996–1998 in overall incidence of six key foodborne infections, demonstrates the feasibility of preventing foodborne illnesses.

Implications for Public Health Practice: *Salmonella* infection should be targeted because it has not declined significantly in more than a decade, and other data indicate that it is one of the most common foodborne infections, resulting in an estimated $365 million in direct medical costs annually. The prevention measures that reduced STEC O157 infection need to be applied more broadly to reduce *Salmonella* and other infections. Effective measures from farm to table include preventing contamination of meat during slaughter and of all foods, including produce, during processing and preparation; cooking meat thoroughly; vigorously detecting and investigating outbreaks; and recalling contaminated food.

Introduction

Contaminated food consumed in the United States causes an estimated 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths annually (*1,2*). The occurrence of approximately 1,000 reported disease outbreaks (local, regional, and national) each year highlights the challenges of preventing these infections (*3*). However, most foodborne illnesses occur in persons who are not part of recognized outbreaks (*2*). The U.S. food supply is changing, with increased centralization of production, global sourcing of ingredients, and growth in the number of meals

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prepared outside the home (*4,5*). Outbreak investigations continue to identify long-standing problems for which implementation of effective solutions has been slow. For example, a national outbreak of *Salmonella* infections in 2010 was caused by contamination of eggs, leading to a massive recall of approximately 500 million eggs. This occurred just before implementation of new egg regulations, which could have prevented the outbreak and the associated recall (*6*). Investigations also identify new problems for which solutions need to be devised.

Most foodborne infections cause diarrheal illness, ranging from mild to severe. Also, persons in susceptible populations and some healthy persons can develop severe complications, such as hemorrhagic colitis, bloodstream infection, meningitis, joint infection, kidney failure, paralysis, miscarriage, and other problems. Beyond their health effects, foodborne illnesses can cause emotional and economic hardship; for example, *Salmonella* alone causes approximately 1 million foodborne infections (*2*) and costs $365 million in direct medical expenditures* annually (*7*), and the societal cost of a single fatal case of *Escherichia coli* (STEC) O157 infection has been estimated at $7 million (*8*).

Gathering information from persons who are ill enough to seek medical care and submit a specimen for laboratory testing is essential for measuring progress in food safety. Measuring changes in the annual incidence of common foodborne infections can track progress toward national health objectives, inform regulatory and industry efforts to reduce food contamination, and monitor the effectiveness of prevention measures. Since 1996, the Foodborne Diseases Active Surveillance Network (FoodNet) has conducted active, population-based surveillance for infections with nine pathogens transmitted commonly through food and for post-diarrheal pediatric hemolytic uremic syndrome (HUS) (*9*). This report describes preliminary results of FoodNet surveillance for 2010 and summarizes trends in incidence of these infections since 1996.

Methods

FoodNet† is a collaborative program among CDC, 10 state health departments,§ the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS), and the Food and Drug Administration (FDA). It has conducted active, population-based surveillance for laboratory-confirmed infections caused by *Campylobacter*, *Listeria*, *Salmonella*, STEC O157, *Shigella*, *Vibrio*, and *Yersinia* since 1996; *Cryptosporidium* and *Cyclospora* since 1997; and STEC non-O157 since 2000. The surveillance area includes approximately 15% of the United States population (46 million persons). FoodNet personnel regularly contact clinical laboratories to ascertain laboratory-confirmed infections occurring in residents of the surveillance area (*9*) and record which were associated with outbreaks. Hospitalizations occurring within 7 days of specimen collection date are recorded, as is the patient's vital status at hospital discharge or at 7 days after the specimen collection date, if not hospitalized. Hospitalizations and deaths are attributed to the infection if they occur within 7 days of specimen collection.

Surveillance for HUS, a major complication of STEC infection characterized by renal failure, thrombocytopenia, and microangiopathic hemolytic anemia, is conducted through a network of nephrologists and infection control practitioners as well as hospital discharge data review. This report contains HUS data for children (persons aged <18 years) for 2009.

Incidence for 2010 was calculated by dividing the number of laboratory-confirmed infections by U.S. Census Bureau population estimates for the surveillance area for 2009.¶ Case-fatality ratios (CFRs) were calculated by dividing the number of deaths by the number of laboratory-confirmed infections and multiplying by 100. A main-effects, log-linear Poisson regression model (negative binomial) was used to estimate changes in incidence from 1996–1998 to 2010 and from 2006–2008** to 2010 with 95% confidence intervals (CIs). The model accounts for site-to-site variation and expansion of FoodNet over time (*10*). As a measure of overall trends in incidence, data were combined for *Campylobacter*, *Listeria*, *Salmonella*, STEC O157, *Yersinia*, and *Vibrio*, six key bacterial pathogens for which >50% of illnesses are estimated to be transmitted by food, weighting by incidence of infection for each pathogen (*2*). Trends were not assessed for STEC non-O157 and *Cyclospora* because data were sparse. A negative binomial model also was used for HUS to estimate incidence changes from 2006–2008 to 2009 with 95% CIs for all children.

Results

In 2010, a total of 19,089 laboratory-confirmed cases of infection, 4,247 hospitalizations, and 68 deaths were identified

* The direct medical cost estimate was prepared using the U.S. Department of Agriculture's Economic Research Service (ERS) foodborne illness cost calculator for *Salmonella* (*7*) and 1) the CDC estimate of annual number of cases of *Salmonella* infection (*2*); 2) the average cost of a physician office visit, emergency department visit, or outpatient department visit derived from the 2008 Medical Expenditures Panel Survey (available at http://www.meps.ahrq.gov/mepsweb); and 3) the average cost of a hospital admission for *Salmonella* infection derived from the 2008 Nationwide Inpatient Sample (available at http://www.hcup-us.ahrq.gov/nisoverview.jsp).

† Additional information about FoodNet is available at http://www.cdc.gov/foodnet.

§ Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee, and selected counties in California, Colorado, and New York.

¶ Final incidence rates will be reported when population estimates for 2010 are available.

** *MMWR* reports on FoodNet surveillance data from 2008 and 2009 used the preceding 3 years, a moving period, for comparison; this report initiates use of 2006–2008 as a stable comparison period.

by FoodNet sites (Table 1). *Salmonella* infection was the most common infection reported (8,256 infections; 17.6 illnesses per 100,000 persons) and had the largest number of hospitalizations (2,290) and deaths (29). Incidence was highest in children aged <5 years (69.5 infections per 100,000 children) (Table 2), and 407 (5%) of infections were associated with recognized outbreaks. The incidence of *Salmonella* infection in 2010 was not significantly different than during 1996–1998 but was significantly higher than during 2006–2008 (10% increase; CI = 4%–17%) (Figures 1 and 2). Among the 7,564 (92%) *Salmonella* isolates serotyped, the most common serotypes were Enteritidis (22%), Newport (14%), and Typhimurium (13%). In 2010, compared with 1996–1998, incidence was significantly lower for Typhimurium (53% decrease; CI = 46%–58%) and higher for Newport (116% increase; CI = 67%–180%) and Enteritidis (76% increase; CI = 45%–113%). Compared with 2006–2008, incidence was significantly higher for Enteritidis (36% increase; CI = 17%–57%) and Newport (47% increase; CI = 22%–78%); incidence of Typhimurium did not change significantly.

For the other pathogens, the number of infections and incidence were: *Campylobacter* (6,365; 13.6 per 100,000), *Shigella* (1,780; 3.8 per 100,000), *Cryptosporidium* (1,290; 2.8 per 100,000), STEC non-O157 (451; 1.0 per 100,000); STEC O157 (442; 0.9 per 100,000), *Vibrio* (193; 0.4 per 100,000), *Yersinia* (159; 0.3 per 100,000), *Listeria* (125; 0.3 per 100,000), and *Cyclospora* (28; 0.1 per 100,000) (Table 1). Incidence was highest in children aged <5 years for *Campylobacter* (24.4 per 100,000), *Shigella* (16.4 per 100,000), *Cryptosporidium* (5.1 per 100,000), STEC non-O157 (5.0 per 100,000), STEC O157 (3.3 per 100,000), and *Yersinia* (1.9 per 100,000) infections; in persons aged 20–59 years for *Cyclospora* (0.1 per 100,000); and in persons aged ≥60 years for *Listeria* (1.1 per 100,000) and *Vibrio* (0.8 per 100,000) infections (Table 2).

Among the 327 STEC non-O157 infections with O serogroup identified, the most common were O26 (37%), O103 (24%), and O111 (17%). In 2010, a total of 77 (17%) STEC O157 infections were associated with recognized outbreaks; complete information for other pathogens for 2010 is not yet available. Among the 186 (96%) *Vibrio* isolates with species information, the most common were *parahaemolyticus* (57%) and *vulnificus* (13%).

The percentage of patients hospitalized ranged from 0% for *Cyclospora* to 90% for *Listeria* infection. CFRs ranged from 0% for *Cyclospora* and *Shigella* to 13% for *Listeria* infection. Overall, the percentage of patients hospitalized (40%) and CFRs (1.5%) were highest among persons aged ≥60 years.

The overall incidence for the six key pathogens (*Campylobacter, Listeria, Salmonella*, STEC O157, *Yersinia,* and *Vibrio*) was 23% lower in 2010 than during 1996–1998. For individual pathogens, the incidence was significantly lower for *Shigella* (57% decrease; CI = 39%–69%), *Yersinia* (52% decrease; CI = 40%–62%), STEC O157 (44% decrease; CI = 31%–55%), *Listeria* (38% decrease; CI = 22%–51%), and *Campylobacter* (27% decrease; CI = 21%–32%) but higher for *Vibrio* (115% increase; CI = 60%–187%). It did not change significantly for *Cryptosporidium* (Figure 1).

Compared with 2006–2008, the measure of overall incidence was not significantly different in 2010. The incidence was significantly lower for STEC O157 (29%

TABLE 1. Number and incidence of laboratory-confirmed bacterial and parasitic infection cases, hospitalizations, and deaths, by pathogen — Foodborne Diseases Active Surveillance Network, United States, 2010*

	Cases		Hospitalizations		Deaths			
Pathogen	No.	Incidence†	No.	(%)	No.	(CFR)	2010 national health objective§	2020 national health objective¶
Bacteria								
Campylobacter	6,365	13.6	928	(14.6)	8	(0.1)	12.3	8.5
Listeria	125	0.3	112	(89.6)	16	(12.8)	0.24	0.2
Salmonella	8,256	17.6	2,290	(27.7)	29	(0.4)	6.8	11.4
Shigella	1,780	3.8	333	(18.7)	0	(0.0)	—**	—**
STEC O157	442	0.9	184	(41.6)	2	(0.5)	1.0	0.6
STEC non-O157	451	1.0	69	(15.3)	1	(0.2)	—**	—**
Vibrio	193	0.4	45	(23.3)	6	(3.1)	—**	0.2
Yersinia	159	0.3	52	(32.7)	1	(0.6)	—**	0.3
Parasites								
Cryptosporidium	1,290	2.8	234	(18.1)	5	(0.4)	—**	—**
Cyclospora	28	0.1	0	(0.0)	0	(0.0)	—**	—**
Total	**19,089**		**4,247**		**68**			

Abbreviations: CFR = case-fatality ratio; STEC = Shiga toxin–producing *Escherichia coli*.
* Data are preliminary.
† Per 100,000 population.
§ *Healthy People 2010* objective targets for incidence per 100,000 population of *Campylobacter*, *Listeria*, *Salmonella*, and STEC O157 infections.
¶ *Healthy People 2020* objective targets for incidence per 100,000 population of *Campylobacter*, *Listeria*, *Salmonella*, STEC O157, *Vibrio*, and *Yersinia* infections.
** No national health objective exists for these pathogens.

TABLE 2. Incidence* of laboratory-confirmed bacterial and parasitic infection cases, by age group and pathogen — Foodborne Diseases Active Surveillance Network, United States, 2010†

	Age group (yrs)				
Pathogen	**<5**	**5–9**	**10–19**	**20–59**	**≥60**
Bacteria					
Campylobacter	24.4	10.6	10.1	13.3	13.9
Listeria	0.3	0.03	0.05	0.1	1.1
Salmonella	69.5	21.4	12.3	12.2	17.0
Shigella	16.4	11.7	2.2	2.5	1.1
STEC O157	3.3	2.5	1.1	0.5	0.7
STEC non-O157	5.0	1.1	1.3	0.5	0.5
Vibrio	0.0	0.3	0.2	0.4	0.8
Yersinia	1.9	0.4	0.2	0.2	0.4
Parasites					
Cryptosporidium	5.1	2.7	2.5	2.6	2.5
Cyclospora	0.0	0.0	0.02	0.1	0.1

Abbreviation: STEC = Shiga toxin–producing *Escherichia coli*.
* Per 100,000 population.
† Data are preliminary.

decrease; CI = 15%–40%) and *Shigella* (29% decrease; CI = 8%–46%) and significantly higher for *Vibrio* (39% increase; CI = 12%–72%). The incidence did not change significantly for *Campylobacter*, *Cryptosporidium*, *Listeria*, and *Yersinia* (Figure 2).

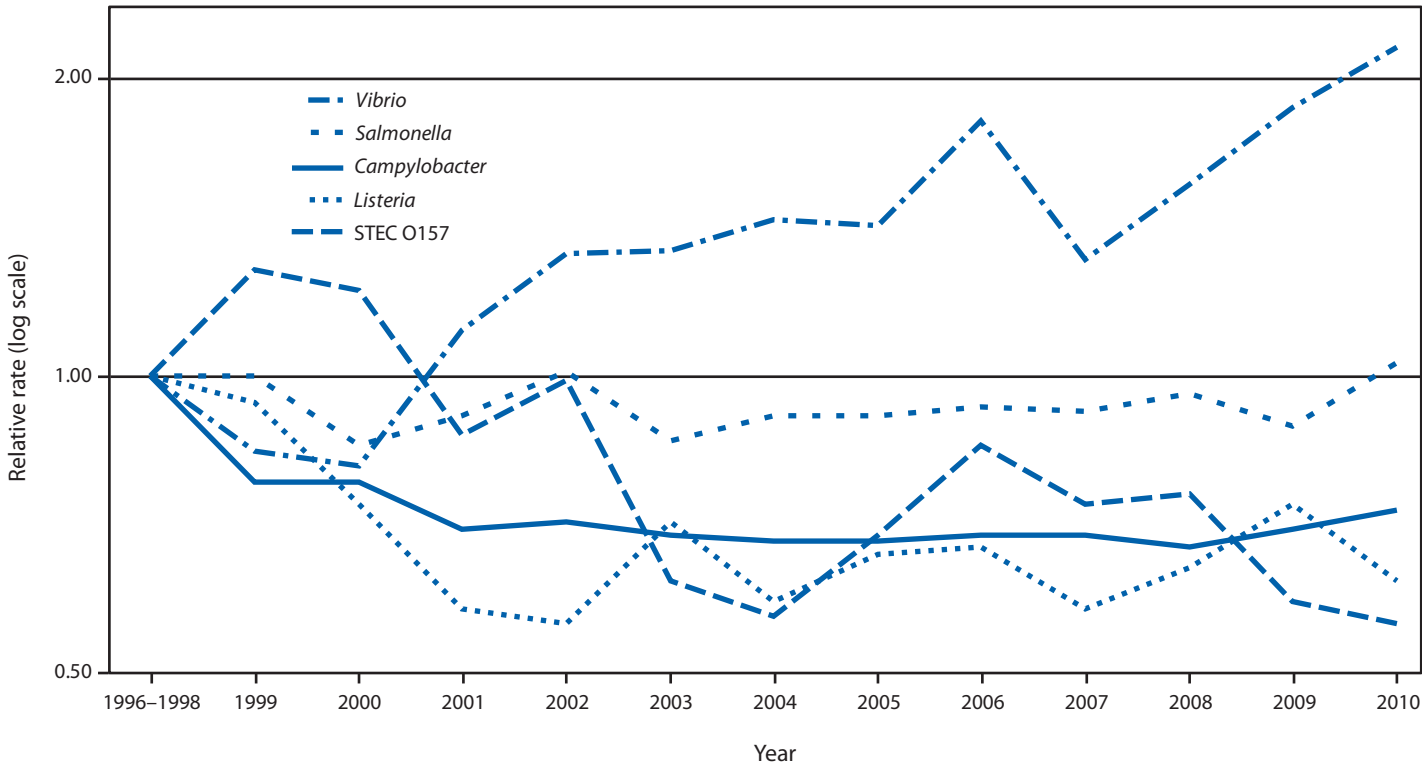
In 2009, FoodNet identified 66 children with HUS (0.59 cases per 100,000), of whom one died and 38 (58%) were aged <5 years (1.2 case per 100,000). Compared with 2006–2008, the incidence was significantly lower for children aged <5 years (36% decrease; CI = 7%–56%) but not significantly different for all children.

Conclusions and Comment

Foodborne infections can be prevented. The incidence of STEC O157 infection has declined to reach the 2010 national health objective target of ≤1 case per 100,000 (*11*).†† This decline was mirrored by a decrease in HUS. Many factors likely contributed to this success. One is improved detection and investigation of STEC O157 outbreaks, resulting not only in contaminated products being removed before more persons became ill but also in enhanced knowledge about preventing contamination that was used to prevent future outbreaks and illnesses. PulseNet,§§ the national molecular subtyping

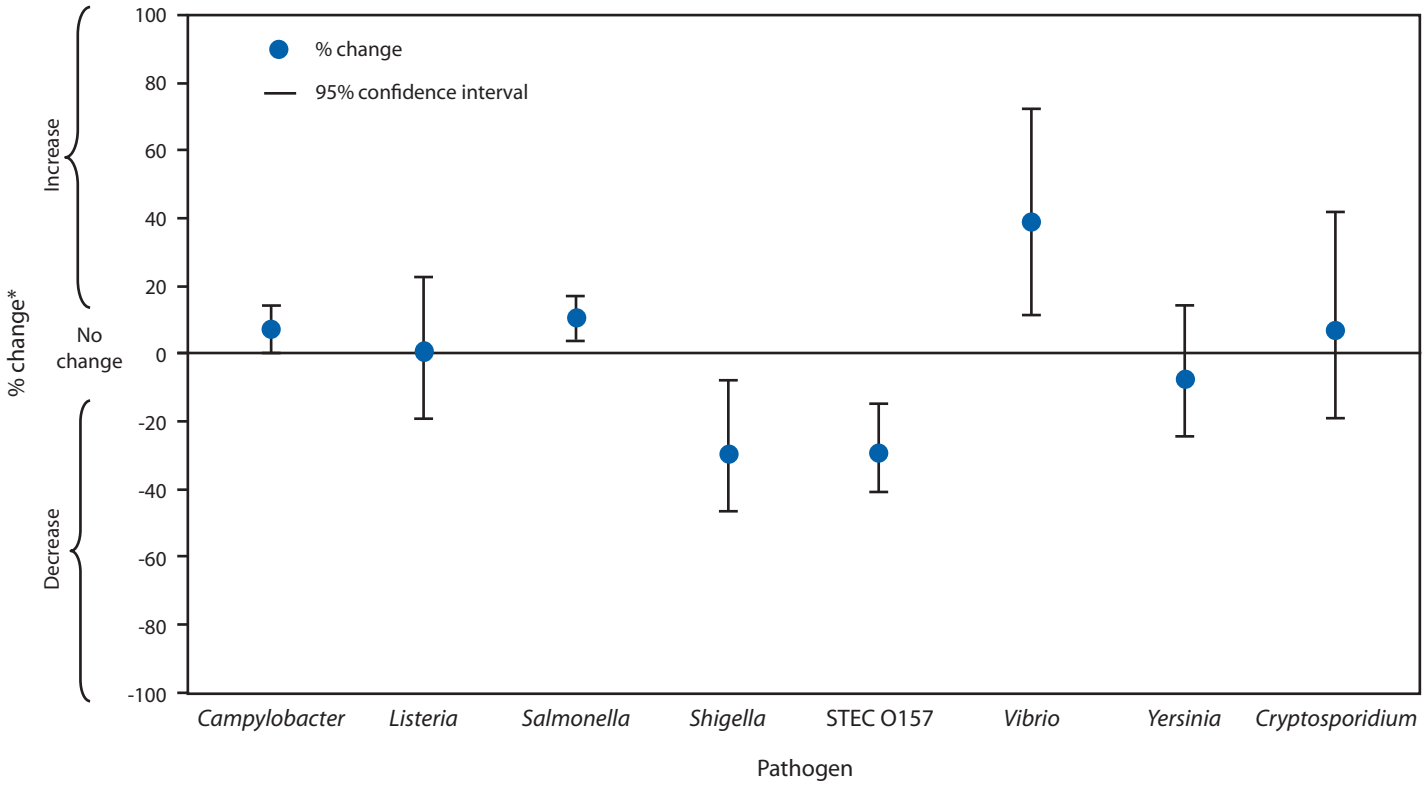
†† This goal was set as a 50% reduction of the 1997 incidence as measured in the initial FoodNet sites.
§§ Additional information about PulseNet is available at http://www.cdc.gov/pulsenet.

FIGURE 1. Relative rates of laboratory-confirmed infections with *Campylobacter*, STEC O157, *Listeria*, *Salmonella*, and *Vibrio*, compared with 1996–1998 rates, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2010*



Abbreviation: STEC = Shiga toxin–producing *Escherichia coli*.
* The position of each line indicates the relative change in the incidence of that pathogen compared with 1996–1998. The actual incidences of these infections cannot be determined from this graph.

FIGURE 2. Estimated percentage change in incidence of laboratory-confirmed bacterial and parasitic infections in 2010, compared with average annual incidence during 2006–2008, by pathogen — Foodborne Diseases Active Surveillance Network, United States



Abbreviation: STEC = Shiga toxin–producing *Escherichia coli*.

* *No significant change* = 95% confidence interval is both above and below the no change line; *significant increase* = entire 95% confidence interval is above the no change line; *significant decrease* = entire 95% confidence interval is below the no change line.

network for foodborne bacterial pathogens, can detect widely dispersed outbreaks and has greatly improved the detection and investigation of multistate outbreaks. Others include cleaner slaughter methods, microbial testing, and better inspections in ground beef processing plants (*12*); regulatory agency prohibition of contamination of ground beef with STEC O157 (resulting in 234 beef recalls since STEC O157 was declared an adulterant in ground beef in 1994);¶¶ improvements in the FDA model Food Code (*13*); and increased awareness in food service establishments and consumers' homes of the risk of consumption of undercooked ground beef (*14*).

Less progress has been made with most other infections, especially *Salmonella*, the most common infection and the most common cause of hospitalization and death tracked in FoodNet. *Salmonella* infections have not declined over the past 15 years and actually increased since 2006–2008. In 2010, the incidence was nearly three times the 2010 national health objective target. *Salmonella* causes an estimated 1.2 million U.S. illnesses annually, approximately 1 million of which are transmitted by food consumed in the United States (*2*). *Salmonella* can contaminate a wide range of foods, and different serotypes tend to have different animal reservoirs and food sources, making control challenging. Most of the decreases in the incidence of *Campylobacter*, *Listeria*, *Shigella*, and *Yersinia* infection since 1996–1998 occurred before 2004. *Vibrio* infections, though less common, have increased.

Other important pathogens transmitted commonly through food (e.g., norovirus, *Clostridium perfringens,* and *Toxoplasma*) are not tracked in FoodNet because tests to detect them are not generally available for clinical laboratories (*2*). Many of the control measures that would decrease illness caused by pathogens tracked in FoodNet would also decrease illnesses caused by pathogens not tracked presently.

Most pathogens tracked in FoodNet live in healthy animals; they contaminate meat and poultry when animals are slaughtered and processed, and they contaminate environments in which fruits, nuts, and vegetables are grown and processed. Exceptions are *Shigella*, which lives in the intestines of ill persons and can contaminate food when persons do not wash their hands after defecating, and *Vibrio*, which lives in marine waters and healthy shellfish, especially oysters.

Children aged <5 years continue to have the highest incidence of most of these infections. However, infected persons aged

¶¶ A list of recalls issued is available at http://www.fsis.usda.gov/fsis_recalls/index.asp.

Key Points

- Despite broad declines in several foodborne infections, *Salmonella* infections, which cause the largest numbers of illnesses, hospitalizations, and deaths of any pathogen under surveillance in the Foodborne Diseases Active Surveillance Network (FoodNet), have not declined during the past decade.
- In contrast, Shiga toxin–producing *Escherichia coli* (STEC) O157 infection has declined to the 2010 national health objective target of ≤1 case per 100,000.
- *Salmonella* infections can be prevented using approaches similar to those that were successful in reducing STEC O157:
  - **Monitoring food production.** This includes monitoring the safety of ingredients, reducing contamination in factories and slaughterhouses using proven measures, and maintaining refrigeration in transport.
  - **Preventing food contamination.** This includes training restaurant managers in food safety and educating consumers about preparing foods safely at home.
  - **Investigating illnesses and outbreaks.** This includes improving detection and investigation of outbreaks, so contaminated products are removed before more persons become ill and public health and food safety agencies can learn about new food safety challenges and how to address them.

≥60 years are at highest risk for hospitalization and death from most of these infections, making prompt diagnosis and treatment, as well as careful attention to food safety, especially important in this age group.

FoodNet surveillance relies on isolation of bacterial pathogens by culture of clinical specimens. However, most illnesses are not laboratory-confirmed; for example, an estimated 29 *Salmonella* illnesses occur for every one that is laboratory-confirmed, and many hospitalizations and deaths caused by *Salmonella* infection are not ascertained (*2*). In addition, changes in laboratory practices, such as increasing use of culture-independent tests for STEC (*15*) and *Campylobacter*, can affect the reported incidence of infection. These tests offer the clinical advantage of more rapid diagnosis; as they are adopted more broadly, they might have an adverse effect on current surveillance strategies (*16*).

The findings in this report are subject to at least four limitations. First, the proportion transmitted by nonfood routes differs for each pathogen, and the route usually cannot be determined for individual nonoutbreak illnesses. Second, differences in health-care–seeking behaviors between age groups might account for some of the observed differences in incidence (*17*). Third, despite broad demographic similarities between FoodNet and the U.S. population, findings in FoodNet might not be representative of the entire United States (*9*). Finally, the measure of overall incidence was calculated from data for six bacterial pathogens and was influenced strongly by early declines in *Campylobacter*, *Listeria*, and *Yersinia*; this is not a measure of all foodborne illnesses.

Reducing *Salmonella* infection and other foodborne infections will require strong action to prevent food contamination at multiple steps along the farm to the table chain, a prominent lesson from the success in reducing STEC O157 infection. Farmers, the food industry, regulatory agencies, food service, consumers, and public health authorities all have a role. New national health objectives target a 25% reduction in *Salmonella* infections by 2020 and 25%–50% reductions for five other infections and HUS (*18*). Achieving the targets could prevent an estimated 4.6 million illnesses, 68,000 hospitalizations, and 1,470 deaths by 2020.*** It also could save $421 million in direct medical costs††† associated with *Salmonella* infection alone (*9*).

Using and monitoring proven measures to reduce contamination in processing plants (e.g., through the Hazard Analysis Critical Control Point [HACCP] management system) is a successful approach. USDA-FSIS has been tightening standards aimed at preventing *Salmonella* infection, and, in July 2011, will reduce the allowable contamination of whole broiler chickens at processing plants from 20.0% to 7.5% of carcasses (*19*). FDA is implementing the new egg regulations. The Food Safety Modernization Act of 2010 gives FDA much needed authority to regulate food facilities, establish standards for safe produce, recall contaminated foods, and oversee imported foods; the act also calls on CDC and state partners to improve surveillance and response to outbreaks (*20*). Restaurants with managers trained in food safety are less likely to have outbreaks than those without; consumers can advocate for and state and local officials can require such training (*21*). Consumers can cook meat thoroughly and can follow the other food safety practices described at http://www.cdc.gov/winnablebattles/foodsafety/index.html, http://www.foodsafetyworkinggroup.gov, http://www.foodsafety.gov, and http://www.fightbac.org.

*** The total number of illnesses, hospitalizations, and deaths prevented by meeting the *Healthy People* 2020 national objective targets was estimated using the recent foodborne illness estimates as the base for 2010 (*2*) and linear extrapolation to reach the percentage reduction stated in *Healthy People* 2020, assuming stable population size.

††† Direct medical costs averted were calculated using the number of cases prevented each year and the average cost per case calculated as described previously, using an annual discounting rate of 3%.

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