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Narrative Report

Executive Summary

The Foodborne Diseases Active Surveillance Network (FoodNet) is the principal foodborne disease component of the Centers for Disease Control and Prevention's (CDC's) Emerging Infections Program (EIP). FoodNet is a collaborative project among CDC, the eleven EIP sites, the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA), and the Center for Food Safety and Applied Nutrition of the United States Food and Drug Administration (FDA). FoodNet augments, but does not replace, longstanding activities at CDC, USDA, FDA, and in states to identify, control, and prevent foodborne disease hazards.

FoodNet is a sentinel network that is producing more stable and accurate national estimates of the burden and sources of specific foodborne diseases in the United States through active surveillance and additional studies. Enhanced surveillance and investigation are integral parts of developing and evaluating new prevention and control strategies that can improve the safety of our food and the public's health. Ongoing FoodNet surveillance is being used to document the effectiveness of new food safety control measures, such as the USDA–FSIS Pathogen Reduction and Hazard Analysis and Critical Control Point (PR/HACCP) systems, in decreasing the number of cases of foodborne diseases that occur in the United States each year.

The following are key findings of FoodNet surveillance activities during 2002:

- After a six year decline in *Shigella* infections, FoodNet observed an increase in the number of *Shigella* infections in 2002. Many of these infections were associated with community-wide outbreaks in specialized settings (e.g., day care centers). This increase indicates the need for continued health education and intervention efforts to curb the transmission of *Shigella* in these settings.

- The lack of a sustained decline in *E. coli* O157 infections indicates a need for increased efforts to reduce the burden of these infections. Preventing *E. coli* O157 will not be a simple task because it can be transmitted through food, water, person-to-person contact, and direct animal exposure. FoodNet studies and recent outbreaks have shown that an important route of transmission is direct contact with cattle or their environment. Strategies that reduce *E. coli* O157 on farms could decrease direct contact infection and food contamination, as well as entry into the water supply.

- There has been a sustained decline in the incidence of infections caused by *Yersinia*, *Listeria*, *Campylobacter,* and *Salmonella* Typhimurium over the past six years. These declines indicate important progress toward achieving the U.S. Department of Health and Human Services Healthy People 2010 objectives of reducing the incidence of several foodborne diseases by the end of the decade. However, additional measures will be needed to further reduce the incidence of these diseases to achieve our national health objectives by 2010.

- The decline in the incidence of infections caused by *Yersinia*, *Listeria*, *Campylobacter*, and *Salmonella* Typhimurium are unlikely to be due to surveillance artifacts. FoodNet conducts several studies to monitor the surveillance factors that can influence the incidence of these laboratory-diagnosed foodborne diseases. These factors include the frequency with which persons with gastrointestinal symptoms seek medical care, the frequency with which diagnostic stool specimens are submitted to clinical laboratories, and the frequency with which the laboratories routinely test stool specimens for various pathogens. We are unaware of any changes in these factors that might explain the magnitude of the declines observed in the reported foodborne infections.

- Food animals are a major source of *Yersinia*, *Listeria*, *Campylobacter*, and *Salmonella* Typhimurium. One contributing factor to the decline in foodborne infections caused by these pathogens is likely to be a change in the industry and regulatory approach to meat and poultry safety. Beginning in 1997, the USDA-FSIS began implementing the Pathogen Reduction/Hazard Analysis Critical Control Point (PR/HACCP) systems regulations in the meat and poultry slaughter and processing plants. Additional evidence of the contribution of changes in meat processing to the decline in the incidence of *Salmonella* infections in humans described in this report is the decline in the prevalence of *Salmonella* isolated from FSIS-regulated meat and poultry products.

- Enhanced surveillance and outbreak investigations have identified new control measures and focused industry attention on foodborne illness, so that control measures are more likely to be implemented. Recent interventions include egg safety programs for the prevention of *Salmonella* Enteritidis infections, increased attention to fresh produce safety through better agricultural practices on farms and food processing, regulation of fruit and vegetable juice, industry efforts to reduce food contamination, food safety education, and increased regulation of imported food.

- Although there have been important declines in the incidence of infection for several foodborne diseases, the incidence of foodborne diseases remains high. Efforts to reduce the rate of foodborne diseases might include steps to reduce the prevalence of these pathogens in their respective important animal reservoirs; e.g., cattle (*Escherichia coli* O157), egg-laying chickens (*Salmonella* Enteritidis), and seafood, particularly oysters (*Vibrio*). Implementation of nationwide, consistent on-farm preventive controls would reduce the risk of human illness from *Salmonella* Enteritidis-contaminated eggs.

- The high incidence of foodborne diseases in infants and young children is a major concern. FoodNet studies have shown that breast-feeding of infants is important in preventing foodborne disease in infants. To determine other opportunities for prevention of foodborne diseases among children, FoodNet began a case-control study in 2002 of sporadic cases of *Salmonella* and *Campylobacter* among young children.

- The continued increase in the incidence of infections caused by *Salmonella* Newport represents an emerging challenge to public health. Many of these isolates are resistant to nine or more antimicrobial agents, including all agents approved for oral use in children. Further studies are necessary to understand and resolve these problems. FoodNet recently completed data collection in a case-control study of sporadic cases of *Salmonella* Newport to assess possible risk factors and opportunities for prevention.

Background

Foodborne infections are an important public health challenge. The Centers for Disease Control and Prevention (CDC) has estimated that in 1997, foodborne infections caused 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths. CDC, the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA), the United States Food and Drug Administration (FDA), and the Emerging Infections Program (EIP) sites are actively involved in preventing foodborne diseases. In 1997, the interagency national Food Safety Initiative was established to meet the public health challenge of foodborne diseases. CDC's principal role in the Food Safety Initiative has been to enhance surveillance and investigation of infections that are usually foodborne. FoodNet has been instrumental in accomplishing this mission.

Objectives

The objectives of FoodNet are to determine the frequency and severity of foodborne diseases; monitor trends in foodborne diseases over time; and determine the association of common foodborne diseases with eating specific foods. To address these objectives, FoodNet uses active surveillance and conducts related epidemiologic studies. By monitoring the burden of foodborne diseases over time, FoodNet can document the effectiveness of new food safety initiatives, such as the USDA Hazard Analysis and Critical Control Points (HACCP) system, in decreasing the rate of foodborne diseases in the United States each year.

Methods

In 2002, FoodNet conducted population-based active surveillance for clinical laboratory isolations of *Campylobacter*, *Cryptosporidium*, *Cyclospora*, Shiga toxin-producing *E. coli* (STEC) including *E. coli* O157, *Listeria*, *Salmonella*, *Shigella*, *Vibrio*, and *Yersinia* infections in Connecticut, Georgia, Minnesota, and Oregon, and selected counties in California, Colorado, Maryland, New York, and Tennessee (total population 40.3 million). A case was defined as isolation (for bacteria) or identification (for parasites) of an organism from a clinical specimen. For simplicity, in this report all isolations are referred to as infections, although not all strains of all pathogens have been proven to cause illness in each case. To identify cases, FoodNet personnel contact each of the more than 523 clinical laboratories serving the catchment areas either weekly or monthly, depending on the size of the clinical laboratory. FoodNet also conducts surveillance for foodborne disease outbreaks and hemolytic uremic syndrome (HUS), the latter principally through pediatric nephrologists.

Results

Cases reported

In 2002, a total of 16,962 laboratory-confirmed infections caused by the pathogens under surveillance were identified in nine sites. Of these, 16,389 were bacterial, including 6,150 *Salmonella* infections, 5,059 *Campylobacter* infections, 4,113 *Shigella* infections, 638 *E. coli* O157 infections, 169 *Yersinia* infections, 104 *Vibrio* infections, 98 *Listeria* infections, 35 Non-O157 STEC infections, and 23 STEC O-Antigen undetermined infections (Table 1A). Of the 5,759 *Salmonella* isolates that were serotyped, the most commonly identified serotypes were Typhimurium (1,186 cases), Enteritidis (882), Newport (832), and Javiana (346). In addition, 573 cases of parasitic diseases were reported, including 531 cases of *Cryptosporidium* infection and 42 cases of *Cyclospora* infection (Table 1B).

Table 1A. Infections caused by specific bacterial pathogens, reported by FoodNet sites, 2002

Pathogen	CA	CO	CT	GA	MD	MN	NY	OR	TN	Total
Campylobacter	**1018**	**347**	**542**	**664**	**374**	**941**	**431**	**562**	**180**	**5059**
***Escherichia coli* O157**	**45**	**58**	**45**	**45**	**27**	**160**	**56**	**177**	**25**	**638**
STEC, Non-O157	**0**	**0**	**15**	**4**	**0**	**12**	**0**	**4**	**0**	**35**
STEC, O-Ant Undet*	**0**	**2**	**2**	**3**	**0**	**16**	**0**	**0**	**0**	**23**
Listeria	**12**	**3**	**16**	**16**	**21**	**4**	**15**	**8**	**3**	**98**
Salmonella	**521**	**323**	**457**	**1901**	**943**	**593**	**531**	**327**	**554**	**6150**
Shigella	**367**	**136**	**104**	**1831**	**1167**	**222**	**50**	**90**	**146**	**4113**
Vibrio	**11**	**3**	**11**	**27**	**20**	**5**	**4**	**16**	**7**	**104**
Yersinia	**17**	**3**	**16**	**47**	**15**	**19**	**21**	**16**	**15**	**169**
Total	**1991**	**875**	**1208**	**4538**	**2567**	**1972**	**1108**	**1200**	**930**	**16389**

***STEC (O-Antigen Undetermined)**

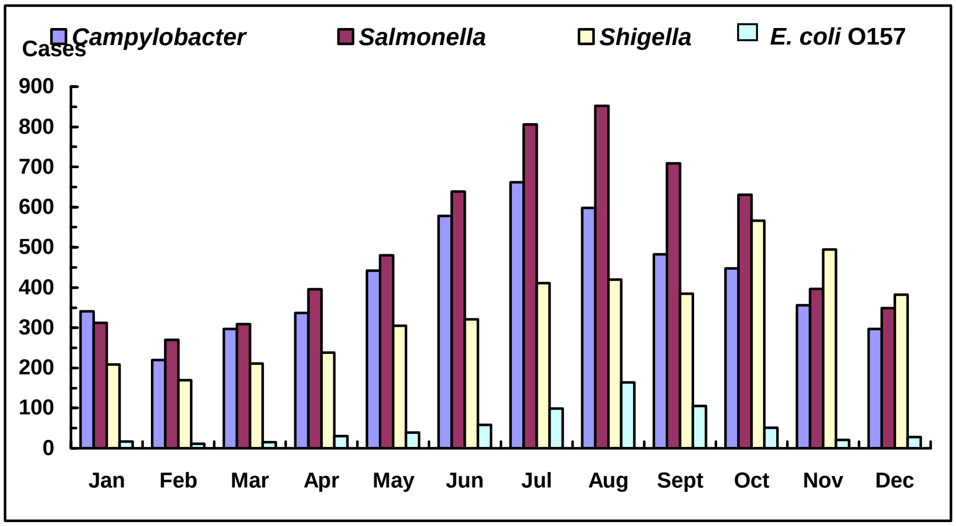
Table 1B. Infections caused by specific parasitic pathogens, reported by FoodNet sites, 2002

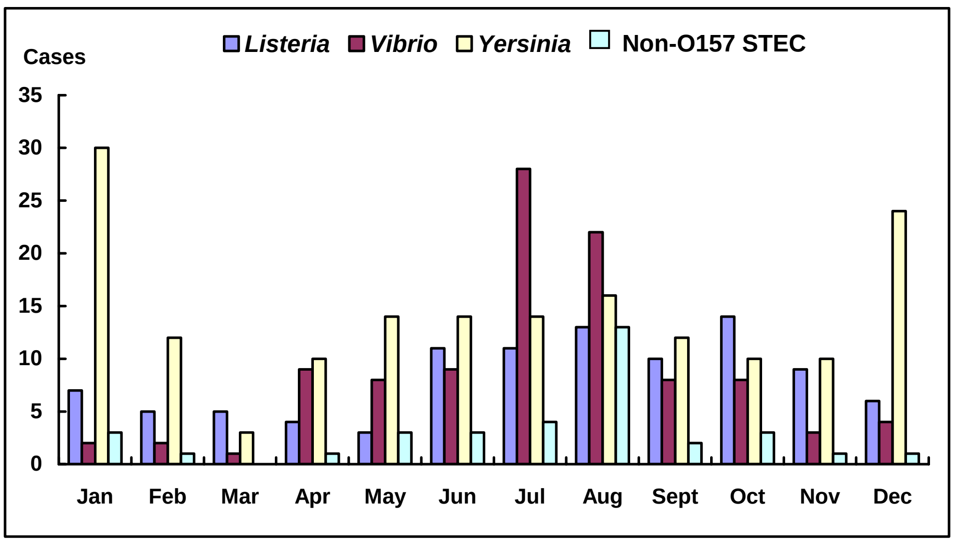
Pathogen	CA	CO	CT	GA	MD	MN	NY	OR	TN	Total
Cryptosporidium	**55**	**20**	**19**	**118**	**20**	**206**	**43**	**37**	**13**	**531**
Cyclospora	**3**	**0**	**7**	**22**	**2**	**0**	**7**	**0**	**1**	**42**
Total	**58**	**20**	**26**	**140**	**22**	**206**	**50**	**37**	**14**	**573**

Seasonality

Isolation rates for pathogens showed seasonal variation: 57% of *Vibrio*, 57% of Non-O157 STEC, 50% of *E. coli* O157, 37% of *Salmonella*, 36% of *Campylobacter*, and 28% of *Shigella* were isolated between June and August (Figure 1). *Yersinia* infections were more likely to have occurred in winter months, with 39% of cases being reported during January, February, or December (Figure 1).

Figure 1. Cases of foodborne disease caused by specific pathogens, by month, FoodNet sites, 2002

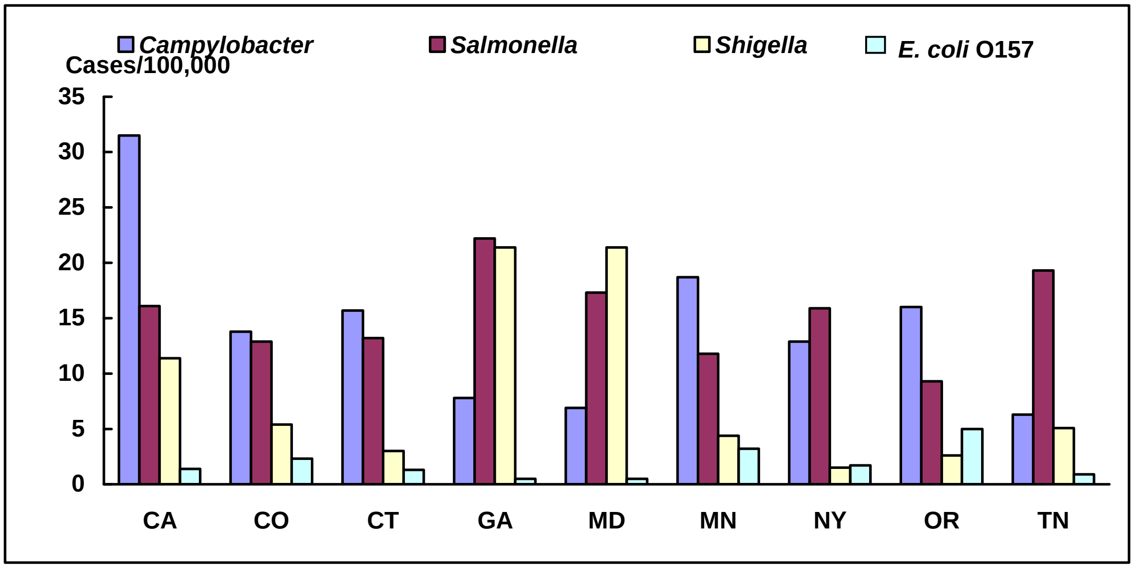


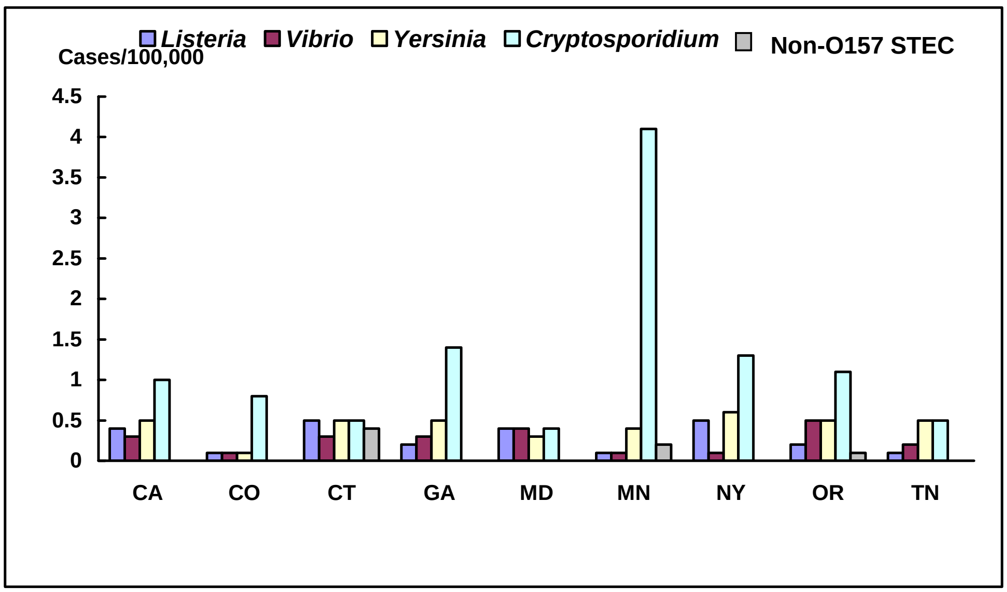


2002 Rates

To compare the number of cases among sites with different populations, annual incidence rates were calculated (incidence is the number of cases divided by the population). All 2002 rates reported here were calculated with 2002 census population counts. Overall incidence rates were highest for infections with *Salmonella* (16.2/100,000), *Campylobacter* (13.3/100,000 population), and *Shigella* (10.8/100,000). Lower overall incidence rates were reported for *E. coli* O157 (1.7/100,000), *Cryptosporidium* (1.3/100,000), *Yersinia* (0.45/100,000), *Vibrio* (0.27/100,000), *Listeria* (0.26/100,000), *Cyclospora* (0.1/100,000), and Non-O157 STEC (0.09/100,000). The rates of foodborne disease caused by specific pathogen, by FoodNet site, are shown in Figure 2.

Figure 2. Cases per 100,000 population of foodborne disease caused by specific pathogens, FoodNet sites, 2002

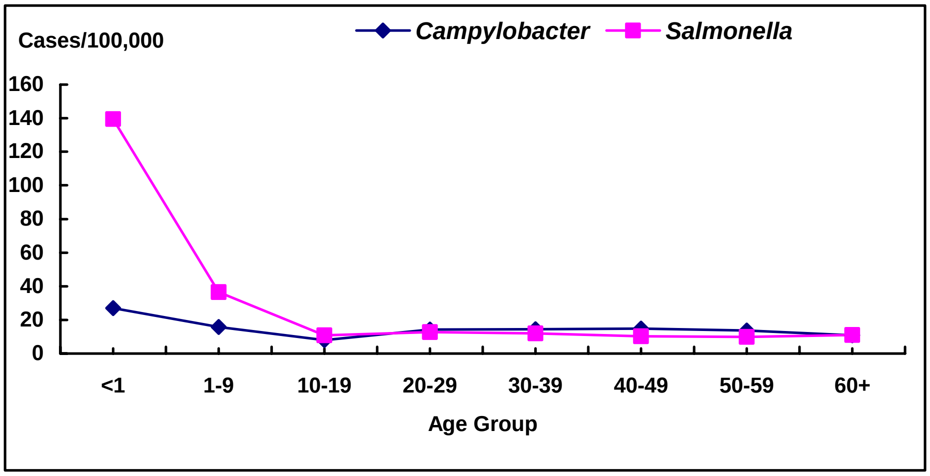




Rates by age

Annual incidence rates of foodborne illness varied by age, especially for *Salmonella* and *Campylobacter* infections (Figure 3). For children <1 year of age, the rate of *Salmonella* infection was 139.4/100,000 and the rate of *Campylobacter* infection was 27.1/100,000, substantially higher than for other age groups.

Figure 3. Incidence of *Campylobacter* and *Salmonella* infections by age group, FoodNet sites, 2002



Rates by sex

Incidence rates also varied by sex (Table 2). Overall, males were more likely than females to be infected with every pathogen except *E. coli* O157, *Shigella*, and *Yersinia*. Among males, rates of *Campylobacter* infection were 31% higher, rates of *Cryptosporidium* infection were 60% higher, rates of *Cyclospora* were 22% higher, rates of *Listeria* infection were 21% higher, and rates of *Vibrio* were 62% higher.

Table 2. Sex-specific incidence rates per 100,000 population, by pathogen, FoodNet sites, 2002

Pathogen	Male	Female
Campylobacter	15.1	11.5
Cryptosporidium	1.6	1.0
Cyclospora	0.11	0.09
***E. coli* O157**	1.6	1.7
Listeria	0.28	0.23
Salmonella	16.1	16.0
Shigella	10.7	10.9
Vibrio	0.34	0.21
Yersinia	0.44	0.45

Hospitalizations

Overall, 18.8% of persons with culture-confirmed infection were hospitalized; hospitalization rates differed markedly by pathogen. The percentage of persons hospitalized was highest for *Listeria* (86.7% of reported cases), followed by *E. coli* O157 (39.0%), *Vibrio* (34.6%), *Yersinia* (24.3%), *Salmonella* (22.2%), *Cryptosporidium* (19.2%), *Shigella* (15.5%), *Campylobacter* (13.2%), and Non-O157 STEC (5.7%).

Deaths

Eighty-four persons died; of those, 28 were infected with *Salmonella*, 18 with *Listeria*, 13 with *Vibrio*, 11 with *Campylobacter*, seven with *Shigella*, four with *E. coli* O157, two with *Cryptosporidium*, and one with *Yersinia*. The pathogen with the highest case-fatality rate was *Listeria*; 18% of persons infected with *Listeria* died.

HUS

Hemolytic uremic syndrome (HUS) is a life-threatening illness characterized by hemolytic anemia, thrombocytopenia, and acute renal failure. Most cases of HUS in the United States are preceded by diarrhea caused by infection with STEC. *E. coli* O157:H7 is the most easily and frequently isolated STEC, but other serotypes of *E. coli* can also cause HUS.

Active surveillance for pediatric HUS cases was established in 1997 in five FoodNet sites (California, Connecticut, Georgia, Minnesota, and Oregon). Surveillance was expanded to include areas of Maryland and New York in 1999, Tennessee in 2000, and Colorado in 2001. Maryland, Tennessee, and Colorado submitted pilot HUS data in 1998, 1999, and 2000, respectively. These data were included, but were considered as outside the catchment area. Active surveillance is accomplished through pediatric nephrologists, who report all cases of HUS, including those from outside the FoodNet catchment area. Data on HUS cases in adults are also collected, but surveillance is passive and often incomplete. The primary objectives of HUS surveillance are to 1) determine the incidence of HUS, 2) monitor long-term trends in STEC infection using HUS as a marker, and
3) identify and monitor STEC strains that cause HUS over time. A total of 375 cases of HUS were reported between 1997 and 2001 (Table 3A). Sixty-one percent of reported cases occurred in females. The median age was 4.8 years and the median length of hospitalization was 11 days.

In 2001, 103 HUS cases were reported, and deaths occurred in nine (9%) of these cases. Among children less than 15 years of age, 82 HUS cases were reported and six (7%) died. Consistent with the seasonal distribution of 2001 *E. coli* O157:H7 infections, 47 (46%) of the HUS cases were diagnosed between June and September.

The overall rate of HUS among children under five years of age in the nine sites from 1997 to 2001 was 1.6/100,000, and among children 5 to 14 years of age it was 0.3/100,000 (Table 3B). *E. coli* O157:H7 was isolated from 56% of stools that were specifically tested for this pathogen (Table 3C). Eight patients had stool samples that tested positive for Shiga toxin, but stool cultures did not yield *E. coli* O157:H7. Only two other STEC were identified by stool culture, but it is unclear how rigorously they were sought. Serology was done on 29 cases to identify anti-O157, O111, or O126 antibodies; 16 cases (55%) had detectable antibody to O157 and three cases (10%) had detectable antibodies to O111.

Table 3A. HUS cases by site* and year, 1997–2001

State	1997		1998		1999		2000		2001	
	Age <15 years	Age ≥15 years	Age <15 years	Age ≥15 years	Age <15 years	Age ≥15 years	Age <15 years	Age ≥15 years	Age <15 years	Age ≥15 years
California	10	0	10	0	5	1	18	0	10	1
Colorado	n/a	n/a	n/a	n/a	n/a	n/a	8	0	8	3
Connecticut	1	0	0	0	8	2	11	5	3	1
Georgia	6	0	13	0	4	0	15	12	6	1
Maryland	n/a	n/a	2	0	2	0	2	0	9	1
Minnesota	9	3	17	3	9	4	12	1	19	3
New York	n/a	n/a	n/a	n/a	15	5	4	3	2	3
Oregon	6	3	6	1	3	3	6	5	12	1
Tennessee	n/a	n/a	n/a	n/a	2	0	10	7	13	7
Total	**32**	**6**	**48**	**4**	**48**	**15**	**86**	**33**	**82**	**21**

**Includes cases among persons residing outside the formal catchment area.*
n/a means not applicable.

Table 3B. Pediatric HUS cases, by site† and age, 1997–2001

State	Age < 5 years		Age 5–14 years	
	Cases	**Rate per 100,000**	**Cases**	**Rate per 100,000**
California	9	1.1	6	0.3
Colorado* **	2	1.3	4	1.3
Connecticut	13	1.2	8	0.3
Georgia	27	1.2	6	0.1
Maryland*	7	0.8	6	0.3
Minnesota	45	2.8	21	0.6
New York*	12	2.2	5	0.4
Oregon	22	2.0	9	0.4
Tennessee**	8	2.0	4	0.5
Total	**145**	**1.6**	**69**	**0.3**

†Includes cases among persons residing within catchment area only
**Based only on 1999-2001 data*
***Based only on 2000-2001 data*
****Based only on 2001 data*

Table 3C. Results of microbiologic testing for STEC infection among HUS cases, 1997–2001

Diarrhea in three weeks before HUS diagnosis/ Total patients	335/375 (89%)
Stool specimen obtained/ Total patients	334/375 (89%)
Stool cultured for *E. coli* O157:H7/ Patients with stool specimen obtained	321/334 (96%)
E. coli O157:H7 isolated from stool/ Patients with stool cultured for *E. coli* O157:H7	179/321 (56%)
Stool tested for Shiga toxin/ Patients with stool specimen obtained	116/334 (35%)
Stool Shiga toxin positive/ Patients with stool tested for Shiga toxin	77/116 (66%)
Non-O157 STEC isolated from stool/ Patients with stool tested for Shiga toxin	2/116 (2%)
Stool yielding *E. coli* O157:H7, Non-O157 STEC and/or Shiga toxin/ Total patients with stool cultured for *E. coli* O157:H7	187/321 (58%)

1996–2002 Rates

The number of sites and the population under surveillance have nearly doubled since FoodNet began in 1996 (Tables 4A and 4B). Because of substantial variation in incidence among the sites, adding new sites influences overall incidence. To account for the increased population and variation in the incidence among sites, a log-linear Poisson regression model was used to estimate the effect of time on the incidence of various pathogens, treating time (i.e., calendar year) as a categorical variable, with 1996 as the reference year. The relative change in incidence between 1996 and 2002 was estimated and confidence intervals for that change were calculated.

The bacterial pathogens with the highest relative incidence during the period between 1996 and 2002 were *Salmonella, Campylobacter,* and *Shigella* (Figure 4A). Pathogens with lower incidence were *E. coli* O157, *Yersinia,* and *Listeria,* (Figure 4B). The incidence of infection with most pathogens decreased between 1996 and 2001. For three pathogens (*Yersinia*, *Listeria*, and *Campylobacter*), this decrease was observed consistently over several years. During the period of 1996 to 2002, the estimated incidence of *Yersinia* infections decreased 43% (95% confidence interval [CI]=55% to 27% decrease), *Listeria* decreased 41% (95% CI=54% to 23% decrease), *Campylobacter* decreased 25% (95% CI=32% to 16% decrease), and *Salmonella* decreased 5% (95% CI=15% decrease to 5% increase) (Table 5A). Considerable temporal variations were observed for the five most common *Salmonella* serotypes. Between 1996 and 2002, *S*. Typhimurium decreased 29% (95% CI=40% to 16% decrease), *S*. Enteritidis decreased 3% (95% CI=33% decrease to 42% increase), *S*. Newport increased 89% (95% CI=16% to 210% increase), *S*. Heidelberg increased 14% (95% CI=15% decrease to 53% increase), and *S*. Javiana increased 233% (95% CI=66% to 566%

increase) (Table 5B). A substantial decline in the incidence of *S*. Enteritidis infection during the period of 1996 through 1999 was partially reversed by increased incidence in 2000 through 2002. Between 1996 and 2002, the estimated incidence of *E. coli* O157 infections decreased 9% (95% CI=34% decrease to 25% increase).

The incidence of *Shigella* infections showed considerable variation by year and site. The estimated incidence in 2002 was 14% higher than in 1996 (95% CI=35% decrease to 101% increase). The incidence of *Vibrio* infections was 91% higher in 1997 than it was in 1996, reflecting the emergence of *Vibrio parahaemolyticus* O3:K6, and has not shown a consistent change since; the incidence was 125% higher in 2002 than it was in 1996 (95% CI=27% to 298% increase) (Figure 4C).

Surveillance for the parasitic pathogens *Cryptosporidium* and *Cyclospora* began in 1997. Between 1997 and 2002, the incidence of *Cryptosporidium* cases decreased 43% (95% CI=59% to 22% decrease) (Figure 4D). Although the incidence of *Cyclospora* has decreased since 1997, the statistical model could not be applied to *Cyclospora* because of the rarity of cases (170 cases between 1997 and 2001).

Table 4A. Population under surveillance in FoodNet sites, 1996-2002

Site	1996	1997	1998	1999	2000	2001	2002
California	2,063,454	2,103,374	2,146,096	2,162,359	3,169,290	6,755,632	5,615,424
Colorado	-	-	-	-	-	2,155,324	2,507,484
Connecticut	1,626,366	2,450,656	3,274,069	3,282,031	3,405,565	3,434,602	3,460,503
Georgia	2,729,783	3,627,184	3,746,059	7,788,240	8,186,453	8,405,677	8,560,310
Maryland	-	-	2,444,280	2,450,566	2,512,431	4,253,665	5,458,137
Minnesota	4,657,758	4,685,549	4,725,419	4,775,508	4,919,479	4,984,535	5,019,720
New York	-	-	1,106,085	2,084,453	2,109,694	2,115,056	3,330,456
Oregon	3,203,735	3,243,487	3,281,974	3,316,154	3,421,399	3,473,441	3,521,515
Tennessee	-	-	-	-	2,818,711	2,848,426	2,874,846
TOTAL	**14,281,096**	**16,110,250**	**20,723,982**	**25,859,311**	**30,543,022**	**38,426,358**	**40,348,395**
FoodNet population as % of U.S. population	5.4	6.0	7.7	9.5	10.9	13.7	14.0

"-" Indicates state was not a FoodNet site during indicated year.

Table 4B. FoodNet sites conducting statewide versus selected county

surveillance, 1996-2002

Site	1996	1997	1998	1999	2000	2001	2002
California	SC	SC	SC	SC	SC	SC	SC
Colorado	-	-	-	-	SC	SC	SC
Connecticut	SC	SC	SW	SW	SW	SW	SW
Georgia	SC	SC	SC	SW	SW	SW	SW
Maryland	-	-	-	-	-	SW	SW
Minnesota	SW	SW	SW	SW	SW	SW	SW
New York	-	-	SC	SC	SC	SC	SC
Oregon	SW	SW	SW	SW	SW	SW	SW
Tennessee	-	-	-	-	SC	SC	SC

SC: selected counties within the state
SW: statewide, includes all counties in the state

Figure 4A. Relative rates of laboratory-diagnosed cases of *Campylobacter, Salmonella*, and *Shigella*, by year, 1996–2002

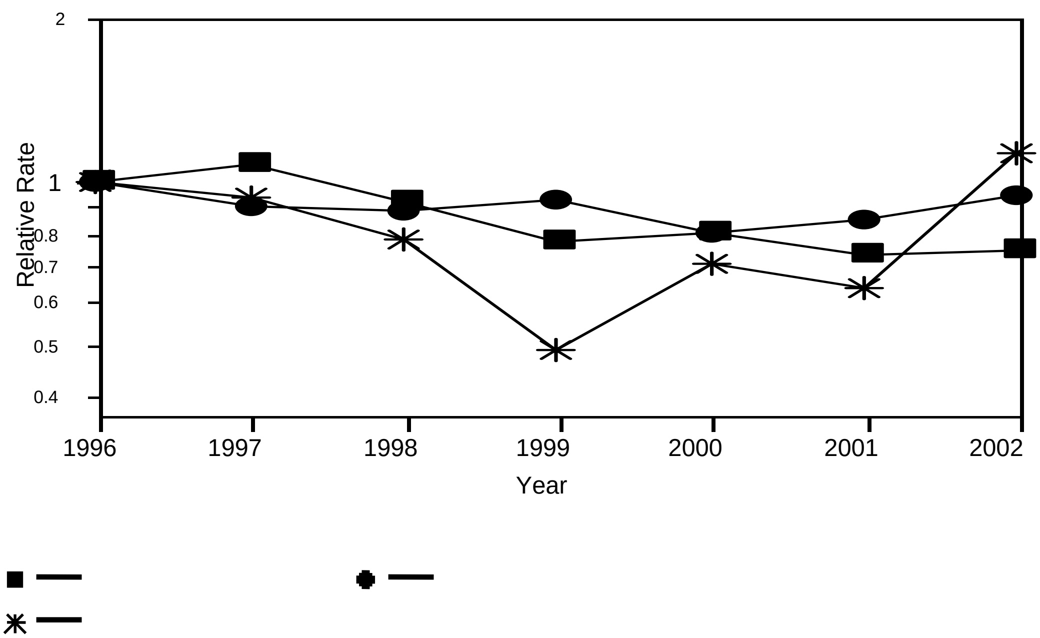


Figure 4B. Relative rates of laboratory-diagnosed cases of *E. coli* O157, *Listeria*, and *Yersinia*, by year, 1996–2002

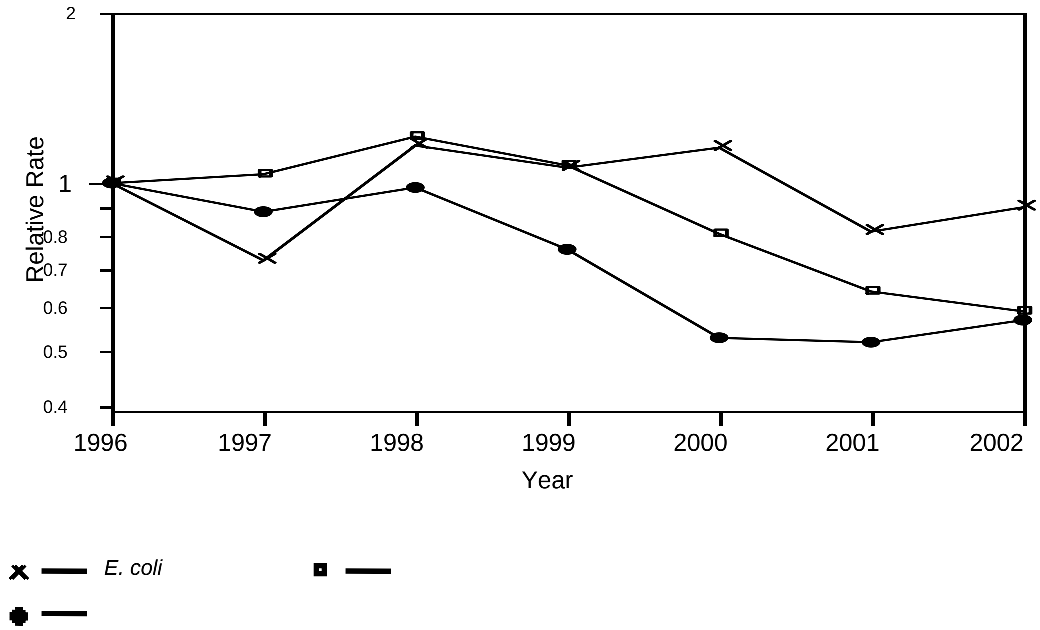


Figure 4C. Relative rates of laboratory-diagnosed cases of *Vibrio*, by year, 1996–2002

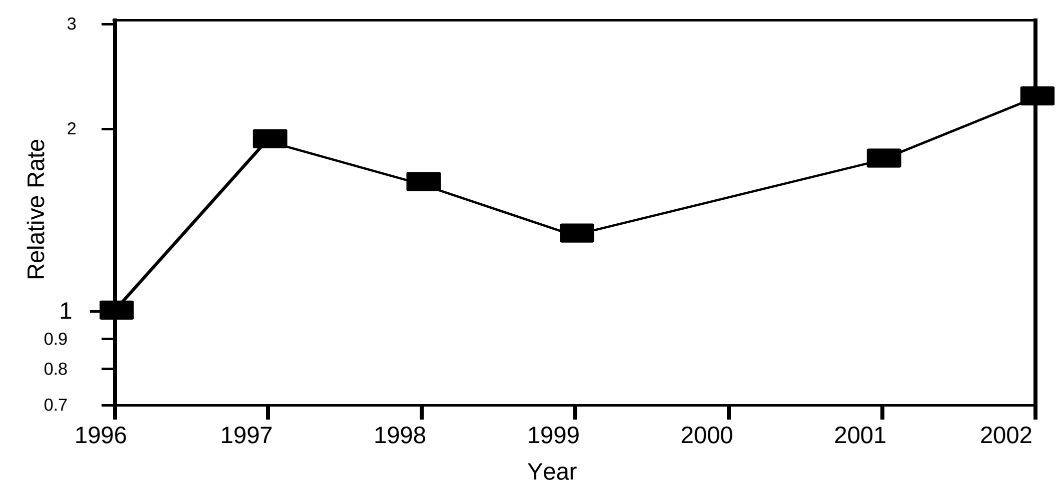


Figure 4D. Relative rates of laboratory-diagnosed cases of *Cryptosporidium*, by year, 1997-2002

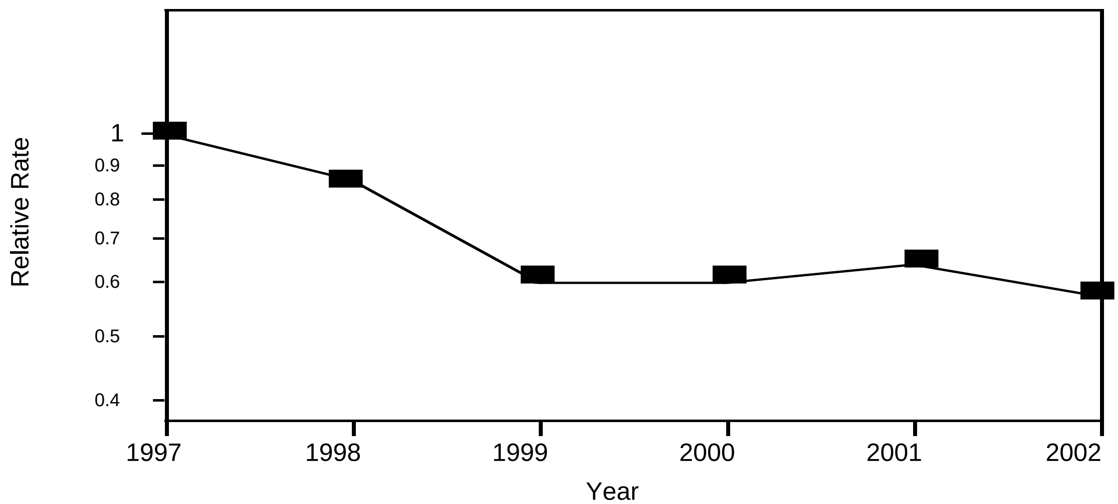


Table 5A. Percent change in incidence* of diagnosed infections for pathogens under surveillance in FoodNet, by pathogen, 1996–2002

Bacterial Pathogen	Percent Change	95% Confidence Interval
Campylobacter	-25	32% to 16% decrease
Escherichia 157	-9	34% decrease to 25% increase
Listeria	-41	54% to 23% decrease
Salmonella	-5	15% decrease to 5% increase
Shigella	+14	35% decrease to 101% increase
Vibrio	+125	27% to 298% increase
Yersinia	-43	55% to 27% decrease

*Per 100,000 population

Parasitic Pathogen	Percent Change*	95% Confidence Interval
Cryptosporidium	-43	59% to 22% decrease

*1997–2001

Table 5B. Percent change in incidence* of diagnosed infections for the five most common *Salmonella* serotypes, by serotype, 1996–2002

Pathogen	Percent Change	95% Confidence Interval
Salmonella Typhimurium	-29	40% to 16% decrease
Salmonella Enteritidis	-3	33% decrease to 42% increase
Salmonella Newport	+89	16% to 210% increase
Salmonella Heidelberg	+14	15% decrease to 53% increase
Salmonella Javiana	+233	66% to 566% increase

*Per 100,000 population

Table 6. Comparison of 2002 incidence with the Healthy People 2010 objectives

Pathogen	2002 Actual Incidence*	2010 Objective Incidence*
Campylobacter	12.61	12.3
Escherichia coli O157	1.22	1.0
Salmonella	15.09	6.8
Listeria	0.26	0.25

*Per 100,000 population

Comments

From 1996 to 2002, the incidence of *Campylobacter*, *Listeria*, and *Yersinia* has shown substantial declines. *Campylobacter* and *Listeria* incidences are approaching their respective national health objectives, indicating important progress in food safety. For infections caused by the three most common *Salmonella* serotypes, a sustained decline in incidence has occurred only for *S.* Typhimurium.

From 1996 to 2002, the incidence did not decline for *Salmonella*, *Shigella*, *Vibrio*, *Cryptosporidium*, *E. coli* O157, and HUS. Although the incidence of *Salmonella* declined initially, it has increased since 2000. *Salmonella* infections are caused by many different *Salmonella* serotypes with different animal reservoirs; therefore, changes in overall incidence of *Salmonella* are influenced strongly by the most common serotypes and their reservoirs. For example, the incidence of *S.* Enteritidis infections declined during the late 1990s but has since increased, similar to the incidence of *Salmonella* infections caused by all serotypes combined. Similarly, the largest increase in incidence of *Vibrio* infections occurred from 1996 to 1998, and this increase was associated with the emergence of a new pandemic strain of *Vibrio parahaemolyticus* (1). However, from 2000 to 2002, other *Vibrio* species have contributed substantially to the overall increase in *Vibrio* infections.

Some year-to-year variation in incidence can be attributed to outbreaks. For example, in 2002, both Georgia and Maryland experienced large community outbreaks of *Shigella sonnei* infections. Oregon experienced a large outbreak

1 Daniels NA, Ray B, Easton A, et al. Emergence of a new *Vibrio parahaemolyticus* serotype in raw oysters: a prevention quandary. JAMA 2000;284:1541--5.

of *E. coli* O157 infections, many of which were complicated by HUS, associated with a county fair. A large outbreak of multidrug-resistant *S*. Newport infections from ground beef in 2002 might be related to emergence of this strain in dairy cattle (2). In 2002, a large multistate outbreak of infections caused by pansusceptible *S*. Newport was traced to contaminated tomatoes (3).

The changes in the incidence of these infections occurred in the context of several control measures, including implementation by the U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS) of the Pathogen Reduction/Hazard Analysis and Critical Control Point (HACCP) systems regulations in meat and poultry slaughter and processing plants beginning in 1997. The decline in the rate of *S.* Typhimurium infections in humans coincided with a decline in the prevalence of *Salmonella* isolated from FSIS-regulated products to levels below baseline levels before HACCP was implemented (4). The Food and Drug Administration has introduced additional interventions to prevent foodborne diseases. These interventions include increased attention to fresh produce safety through better agricultural practices, regulations requiring the refrigeration and safety labeling of shell eggs, implementation of HACCP in the seafood and juice industries, food safety education, increased regulation of imported food, and industry efforts, including new intervention technologies, to reduce food contamination.

Prevention

Additional control and prevention efforts from farm to table are needed to reduce the incidence of these infections, including measures outlined in the recent National Academy of Science Report (5). Targeted efforts to reduce the rate of foodborne illnesses could include steps to reduce the prevalence of pathogens in their respective important animal reservoirs and the foods derived from them: cattle and ground beef (*E. coli* O157), egg-laying chickens (*S.* Enteritidis), and seafood, particularly oysters (*Vibrio*). Implementation of nationwide, mandatory, on-farm preventive controls would reduce the risk for human illness from *S.* Enteritidis-contaminated eggs; such controls have been effective in reducing *S.* Enteritidis contamination of eggs where implemented

2 CDC. Outbreak of multidrug-resistant *Salmonella* Newport---United States, January--April 2002. MMWR 2002;51:545--8.

3 Kretsinger K, Noviello S, Moll M, et al. Tomatoes sicken hundreds: multistate outbreak of *Salmonella* Newport. Presented at the 52nd Annual Epidemic Intelligence Service Conference. Atlanta, Georgia, April 2003.

4 U.S. Department of Agriculture. Pathogen reduction/HACCP & HACCP implementation. Available from: http://www.fsis.usda.gov/oa/haccp/imphaccp.htm.

5 National Academy of Sciences. 2003. *Scientific Criteria to Ensure Safe Food.* Available from: http://books.nap.edu/books/030908928X/html/index.html

6 Hogue A, White P, Guard-Petter J, et al. Epidemiology and control of egg-associated *Salmonella* Enteritidis in the United States of America. Rev Sci Tech 1997;16:542-53.

(6). Greater use of foods processed for safety, including pasteurized eggs and irradiated meats, could also reduce the incidence of infection. Educating consumers and food handlers in good food handling practices is also important.

Limitations

The findings in this report are subject to at least three limitations. First, FoodNet data are limited to diagnosed illnesses; however, the majority of foodborne illnesses are neither laboratory-diagnosed nor reported to state health departments. Second, some illnesses are acquired through non-foodborne routes (e.g., contaminated water, person-to-person contact, and direct animal exposure); reported rates do not represent foodborne sources exclusively. Finally, although FoodNet data provide the most comprehensive information available for these infections, the findings might not be generalizable to the entire U.S. population.

Database Differences and Rearchiving of 1996-2001 Data

In August 2002, FoodNet personnel, in cooperation with state partners, identified discrepancies in some of the age values for FoodNet cases reported in years 1999-2000. FoodNet personnel compared records contained in selected state-based Public Health Laboratory Information System (PHLIS) datasets to the same records contained in the CDC-based PHLIS database. Of these, 375 (14%) records had discrepant age values (e.g., one patient had age recorded as seven years in the CDC database and seven months in the state database).

Discussions with personnel familiar with the internal structure of PHLIS led to the hypothesis that the hierarchical structure of PHLIS might be causing these discrepancies. This structure preserves ownership of demographic data for local health departments and ownership of laboratory-specific data (e.g., species and serotype) for state health departments that enter or import data into PHLIS. The fundamental issue was that, after initial reports were transmitted for any given case, corrections or other data edits made in the site for that same case were not reliably transmitted to or corrected in the CDC database.

To resolve this issue, FoodNet requested that each FoodNet site export all of their FoodNet data for calendar years 1996-2001 to CD-ROM and ship each CD-ROM to CDC. CDC FoodNet then reprocessed all of those data in an identical fashion to previous years to create a newly archived dataset. For 2002, data were exported for systems residing in the states and transferred to a secure website at CDC where FoodNet personnel downloaded those data for processing.

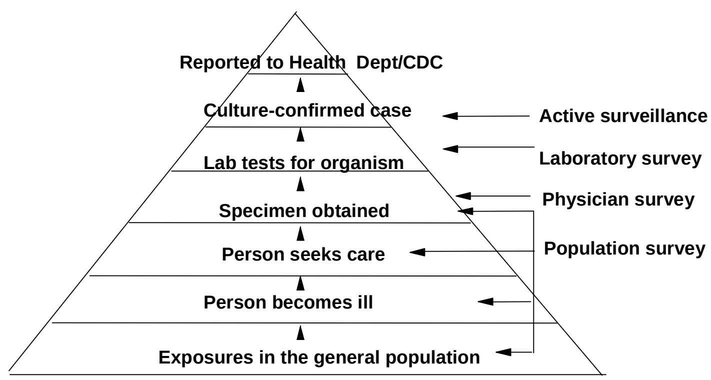
Other FoodNet Data Sources

Burden of Illness

Cases reported through active surveillance represent only a fraction of the number of cases in the community. To better estimate the number of cases of foodborne disease in the community, FoodNet conducts surveys of laboratories, physicians, and the general population in the participating EIP sites (Figure 5). Using these data, we can determine the proportion of people in the general population with a diarrheal illness, and from among those, the number who seek medical care for the illness. We can estimate the proportion of physicians who ordered a bacterial stool culture for patients with diarrhea, and we can evaluate how variations in laboratory testing for bacterial pathogens influence the number of culture-confirmed cases. Using FoodNet and other data, CDC estimated that 76 million foodborne illnesses, 325,000 hospitalizations, and 5,000 deaths occurred in 1997 in the United States (7).

This model can be used for developing estimates of the burden of illness caused by each foodborne pathogen. For example, data from this model suggest that in 1997 there were 1,400,000 *Salmonella* infections, resulting in 113,000 physician office visits and 37,200 culture-confirmed cases in this country. Laboratory-diagnosed cases alone resulted in an estimated 8,500 hospitalizations and 300 deaths; additional hospitalizations and deaths occur among persons whose illness is not laboratory diagnosed.

Figure 5. Burden of Illness Pyramid



Routes of Transmission of Foodborne Pathogens

FoodNet conducts case-control studies to determine the proportion of foodborne diseases that are caused by specific foods or food preparation and handling practices. To date, FoodNet has conducted case-control studies of *E. coli* O157; *Salmonella* serotypes Enteritidis, Heidelberg, Typhimurium, and Newport; infant salmonellosis; *Campylobacter*; *Cryptosporidium*; and *Listeria*. Case-control studies of infant *Salmonella* and *Campylobacter* infections were launched in 2002. By determining the contribution to these foodborne diseases made by specific foods or food preparation and handling practices, prevention efforts can be made more specific and their effectiveness documented.

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7 Mead P, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. Emerging Infectious Disease 1999;5:607-25. Available at http://www.cdc.gov/ncidod/eid/vol5no5/mead.htm

Other FoodNet Activities in 2002

case-control study data collection phase was completed, enrolling 174 cases and 378 controls. Analysis will be completed in 2004.

- *Salmonella* Newport and *Salmonella* Enteritidis case-control studies were launched. The *S*. Newport study was designed to identify behavioral, dietary, and medical risk factors for and medical consequences of *S*. Newport infections, including multidrug-resistant strains of *S*. Newport. The *S*. Enteritidis study was designed to identify behavioral, dietary, and medical risk factors for and medical consequences of *S*. Enteritidis infections.
- The infant salmonellosis and campylobacteriosis case-control study was launched to identify behavioral, dietary, and medical risk factors for infections of infants with *Salmonella* or *Campylobacter*.
- A retrospective cohort study was launched to evaluate the impact *Salmonella* Typhi infection with reduced susceptibility to fluoroquinolones have on clinical outcomes.

- The *Listeria*

Publications and Abstracts, 2002

Publications

1. Buzby JC. Older Adults at Risk of Complications from Microbial Foodborne Illness. USDA Economic Research Service (ERS) FoodReview 2002;25(2):30-5.

2. Herikstad H, Yang S, Van Gilder TJ, Vugia D, Hadler J, Blake P, Deneen V, Shiferaw B, Angulo FJ, and the FoodNet Working Group. A Population-Based Estimate of the Burden of Diarrheal Illness in the United States: FoodNet, 1996-1997. Epidemiology and Infection 2002;129:9-17.

3. Jones T, Kellum M, Porter S, Bell M, Schaffner W. An Outbreak of Community-Acquired Foodborne Illness Caused by Methicillin-Resistant *Staphylococcus aureus*. Emerging Infectious Diseases 2002;8(1):82-4.

4. Preliminary FoodNet Data on the Incidence of Foodborne Illnesses ---Selected Sites, United States, 2001. Centers for Disease Control and Prevention. MMWR 2002;51(15): 325-9.

Abstracts

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3. Braden CR, Lay JC, Boothe E, Vugia DJ, Dumas N, Shiferaw B, Wagstrom E, Tong S, Burnite S, Thomas SM, Hurd S, and the EIP FoodNet Working Group. Microbiologic Testing to Identify Shiga Toxin-producing *E. coli* in HUS Patients: FoodNet 1997-2001. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

4. Charles LE, Mølbak K, Hadler JL, Jones TF, Vugia DJ, Smith K, Hawkins MA, Shillam PJ, Cieslak P, Segler SD, Morse DL, Angulo FJ, and the EIP FoodNet Working Group. Decline in Major Bacterial Foodborne Illnesses in the United States: FoodNet, 1996-2001. Infectious Diseases Society of America. Chicago, IL, October 2002.

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7. Garman RL, Jones TF, Bulens SN, Tong SF, Myers RA, Gettner SS, Mead PM, Parashar UD, and the EIP FoodNet Working Group. A Pilot Study in FoodNet of the Use of Stool Collection Kits Delivered

to the Home to Improve Confirmation of Etiology in Gastroenteritis Outbreak Investigations. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

8. Garman RL, Vugia DJ, Marcus R, Segler SD, Hawkins MA, Bogard A, Anderson BJ, Jones TF, Kirchhoff L, and the EIP FoodNet Working Group. Restaurant-Associated Behavior from the FoodNet Population Survey 1998-99. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

9. Hadler JL, Chan A, Chan M, Chemerynski S, Hahn J, Marshall K, Phan Q, McCarthy T, Rabatsky-Ehr, T. Knowledge, Attitudes and Practices Regarding Use of Irradiated Meats and Pasteurized Eggs in Healthcare Institutions, Universities, and Restaurants in Connecticut. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

10. Hardnett FP, Hoekstra RM, Kennedy MH, Angulo, FJ, and the EIP FoodNet Working Group. Comparability of FoodNet and United States Populations. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

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22. Shiferaw B, Steingraber K, Chapin W, Finnegan C, Kennedy M, Cieslak P, and the EIP FoodNet Working Group. Surveillance for Guillain-Barré Syndrome in Oregon. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

23. Torpey D, Golden N, Hawkins MA, Ruark J, Acheson D, Morris JG. Isolation and Characterization of *Campylobacter jejuni* Isolates Obtained from Asymptomatic Human Volunteers. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

24. Varma JK, Mølbak K, Rossiter S, Hawkins MA, Jones TF, Mauvais SH, Rabatsky-Ehr T, Stenzel S, Vugia DJ, Park M, Joyce K, Stamey K, Chang H, Angulo FJ, and the EIP FoodNet Working Group. Antimicrobial Resistance in *Salmonella* is Associated with Increased Hospitalization: NARMS 1996-2000. International Conference on Emerging Infectious Diseases. Atlanta, GA, March 2002.

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Materials Available On-Line

The following reports are available on the FoodNet Web site:
http://www.cdc.gov/foodnet
CDC. 1996 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 1998.
CDC. 1997 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 1998.
CDC. 1998 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 1998.
CDC. 1999 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 2000.
CDC. 2000 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 2002.
CDC. 2001 Final FoodNet Surveillance Report. Atlanta: Centers for Disease Control and Prevention; 2003.

The following *MMWR* articles about FoodNet are available at this Web site:
http://www.cdc.gov/epo/mmwr/mmwr.html
CDC. The Foodborne Diseases Active Surveillance Network**,** 1996. Morbidity and Mortality Weekly Report. 1997; 46:258-61.
CDC. Incidence of foodborne illness-FoodNet**,** 1997. Morbidity and Mortality Weekly Report. 1998; 47:782-86.
CDC. Incidence of foodborne illness: Preliminary data from the Foodborne Diseases Active Surveillance Network (FoodNet) – United States, 1998. Morbidity and Mortality Weekly Report. 1999; 48:189-94.
CDC. Preliminary FoodNet data on the incidence of foodborne illnesses – selected sites, United States, 1999. Morbidity and Mortality Weekly Report. 2000; 49: 201-5.
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CDC. Preliminary FoodNet data on the incidence of foodborne illnesses – selected sites, United States, 2001. Morbidity and Mortality Weekly Report. 2002; 51: 325-29.
CDC. Preliminary FoodNet data on the incidence of foodborne illnesses – selected sites, United States, 2002. Morbidity and Mortality Weekly Report. 2003; 52: 340-43.

The following *FoodNet News* newsletters are available at the FoodNet Web site:
http://www.cdc.gov/foodnet
FoodNet News. Volume 1, No. 1, Fall 1998
FoodNet News. Volume 1, No. 3, Fall 1999
FoodNet News. Volume 1, No. 2, Winter 1999
FoodNet News. Volume 3, No. 1, Spring 2000
FoodNet News. Volume 3, No. 2, Winter 2000
FoodNet News. Volume 4, No. 1, Fall 2002
FoodNet News. Volume 4, No. 2, Spring 2003

A list of FoodNet publications and presentations is available at the following FoodNet Web site:
http://www.cdc.gov/foodnet/pub.htm

Additional information about the pathogens under FoodNet surveillance is available at the following Web sites:
http://www.cdc.gov/ncidod/dbmd/diseaseinfo/foodborneinfections_g.htm
http://www.cdc.gov/health/diseases.htm

Further information concerning FoodNet, including previous surveillance reports, *MMWR* articles, and other FoodNet publications, can be obtained by contacting the Foodborne and Diarrheal Diseases Branch at 404.371.5465.

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Part II
Summary Tables and Graphs

Part II:
Listing of Summary Tables and Graphs

Tables

Graphs

Rates per 100,000 by pathogen per month
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Cryptosporidium
Cyclospora
Escherichia coli O157
Listeria
Salmonella
Salmonella Enteritidis
Salmonella Typhimurium
Salmonella Heidelberg
Salmonella Newport
Salmonella Montevideo
Salmonella Agona
Shigella
Shigella sonnei
Shigella flexneri
Shigella dysentariae
Vibrio
Yersinia

Age-specific rates per 100,000 distribution by pathogen for all sites
Campylobacter
Cryptosporidium
Cyclospora
Escherichia coli O157
Listeria
Salmonella
Shigella
Vibrio
Yersinia