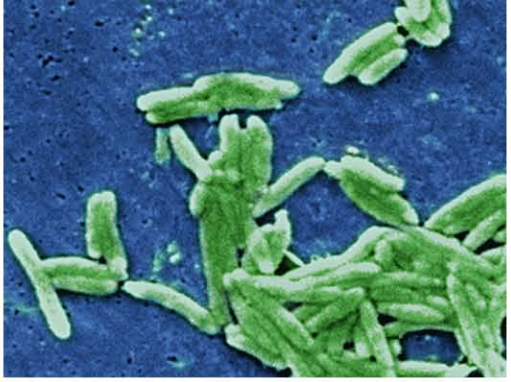


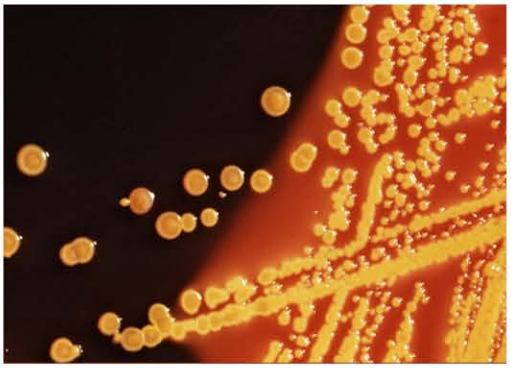
NARMS

National Antimicrobial Resistance Monitoring System: Enteric Bacteria

NARMS

2008

Human Isolates Final Report



National Center for Emerging and Zoonotic Infectious Diseases
Division of Foodborne, Waterborne, and Environmental Diseases

CS215511-A

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Information Available Online: Previous reports and additional information about NARMS are posted on the CDC NARMS website: http://www.cdc.gov/narms

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List of Abbreviations and Acronyms

ACSSuT	Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline
ACSSuTAuCf	Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline, amoxicillin-clavulanic acid, and ceftiofur
ACT/S	Resistance to at least ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole
ANT/S	Resistance to at least ampicillin, nalidixic acid and trimethoprim-sulfamethoxazole
AT/S	Resistance to at least ampicillin and trimethoprim-sulfamethoxazole
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
CLSI	Clinical and Laboratory Standards Institute
EIP	Emerging Infections Program
ELC	Epidemiology and Laboratory Capacity
FDA-CVM	Food and Drug Administration-Center for Veterinary Medicine
FoodNet	Foodborne Diseases Active Surveillance Network
MIC	Minimum inhibitory concentration
NARMS	National Antimicrobial Resistance Monitoring System for Enteric Bacteria
OR	Odds ratio
PHLIS	Public Health Laboratory Information System
USDA	United States Department of Agriculture
WHO	World Health Organization

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What is New in the NARMS Report for 2008

Salmonella ser. Paratyphi A and *Salmonella* ser. Paratyphi C Sampling

In previous reports, *Salmonella* ser. Paratyphi A and *Salmonella* ser. Paratyphi C were included in the every 20th sampling for non-Typhi *Salmonella*. Starting in 2008, NARMS requested sites to submit every *Salmonella* ser. Paratyphi A and *Salmonell*a ser. Paratyphi C isolate for susceptibility testing. *Salmonella* ser. Paratyphi A and *Salmonella* ser. Paratyphi C are reported under the typhoidal *Salmonella* section of this report.

Ceftriaxone Resistance Breakpoint

In previous reports, the resistance breakpoint for ceftriaxone was defined as MIC ≥64 µg/mL. In January 2010, the Clinical and Laboratory Standards Institute (CLSI) published revised interpretive criteria for ceftriaxone and *Enterobacteriaceae;* the revised resistance breakpoint for ceftriaxone is MIC ≥4 µg/mL. In this report, NARMS used the revised CLSI breakpoint for ceftriaxone resistance.

Blue Boxes

Blue boxes have been added to highlight trends in antimicrobial resistance and NARMS special studies. The trends in antimicrobial resistance box is in the summary section and the special studies boxes are in the results section.

Method to Assess Change in Antimicrobial Resistance

We used logistic regression to compare the prevalence of specific antimicrobial resistance patterns among *Salmonella* and *Campylobacter* isolates tested in 2008 compared with the reference, which was the average prevalence of resistance in the previous 5 years (2003–07). In previous reports that included logistic regression analysis, we compared the prevalence of resistance in the current year with the prevalence in the first year of NARMS surveillance.

Introduction

The National Antimicrobial Resistance Monitoring System (NARMS) for Enteric Bacteria is a collaboration among the Centers for Disease Control and Prevention (CDC), U.S. Food and Drug Administration's Center for Veterinary Medicine (FDA-CVM), and U.S. Department of Agriculture (USDA). The primary purpose of NARMS at CDC is to monitor antimicrobial resistance among foodborne enteric bacteria isolated from humans. Other components of the interagency NARMS program include surveillance for resistance in enteric bacterial pathogens isolated from foods, conducted by the FDA-CVM (http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/default.htm), and resistance in enteric pathogens isolated from animals, conducted by the USDA Agricultural Research Service (http://www.ars.usda.gov/main/site_main.htm?modecode=66-12-05-08).

Many NARMS activities are conducted within the framework of CDC's Emerging Infections Program (EIP), Epidemiology and Laboratory Capacity (ELC) Program, and the Foodborne Diseases Active Surveillance Network (FoodNet). In addition to surveillance of resistance in enteric pathogens, the NARMS program at CDC also includes public health research into the mechanisms of resistance, education efforts to promote prudent use of antimicrobial agents, and studies of resistance in commensal organisms.

Before NARMS was established, CDC monitored antimicrobial resistance in *Salmonella, Shigella*, and *Campylobacter* through periodic surveys of isolates from a panel of sentinel counties. NARMS at CDC began in 1996 with prospective monitoring of antimicrobial resistance among clinical non-typhoidal *Salmonella* and *Escherichia coli* O157 isolates in 14 sites. In 1997, testing of clinical *Campylobacter* isolates was initiated in the five sites participating in FoodNet. Testing of clinical *Salmonella enterica* serotype Typhi and *Shigella* isolates was added in 1999. Since 2003, all 50 states have been forwarding a representative sample of non-typhoidal *Salmonella, Salmonella* ser. Typhi, *Shigella*, and *E. coli* O157 isolates to NARMS for antimicrobial susceptibility testing, and 10 FoodNet states have been participating in *Campylobacter* surveillance.

This annual report includes CDC's surveillance data for 2008 for non-typhoidal *Salmonella*, typhoidal *Salmonella, Shigella*, *Campylobacter* and *E. coli* O157 isolates. Data for earlier years are presented in tables and graphs when appropriate. Antimicrobial classes defined by Clinical and Laboratory Standards Institute (CLSI) are used in data presentation and analysis. CLSI classes constitute major classifications of antimicrobial agents, e.g., aminoglycosides and cephems.

This report also includes the World Health Organization's categorization of antimicrobials of critical importance to human medicine (Table 1). The table includes only antimicrobials that are tested in NARMS.

Additional NARMS data and more information about NARMS activities are available at http://www.cdc.gov/narms

WHO Categorization of Antimicrobial Agents

In 2007, the World Health Organization (WHO) convened for the second time a panel of experts to develop a list of essential antimicrobial agents according to their importance to human medicine (WHO, 2007). The participants categorized antimicrobial agents as either Critically Important, Highly Important, or Important based upon two criteria: (1) sole therapies or one of the few alternatives to treat serious human diseases and (2) used to treat disease caused by organisms that may be transmitted via non–human sources or diseases caused by organisms that may acquire resistance genes from non–human sources.

- Antimicrobial agents are considered critically important if both criteria (1) and (2) are true.
- Antimicrobial agents are highly important if either criterion (1) or (2) is true.
- Antimicrobial agents are important if neither criterion is true.

Table 1. WHO categorization of antimicrobials of critical importance to human medicine

WHO Category Level	Importance	CLSI Class	Antimicrobial Agent tested in NARMS
I	Critically important	Aminoglycosides	Amikacin
			Gentamicin
			Streptomycin
		β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid
		Cephems	Ceftriaxone
		Ketolides	Telithromycin
		Macrolides	Azithromycin
			Erythromycin
		Penicillins	Ampicillin
		Quinolones	Ciprofloxacin
			Nalidixic acid
II	Highly important	Aminoglycosides	Kanamycin
		Cephems	Cefoxitin
			Cephalothin
		Folate pathway inhibitors	Sulfamethoxazole / Sulfisoxazole
			Trimethoprim-sulfamethoxazole
		Phenicols	Chloramphenicol
		Tetracyclines	Tetracycline
III	Important	Lincosamides	Clindamycin

Summary of NARMS 2008 Surveillance Data

Population

In 2008, all 50 states participated in NARMS, representing the entire U.S. population of approximately 304 million persons (Table 2). Surveillance was conducted in all states for non-typhoidal *Salmonella,* typhoidal *Salmonella, Shigella*, and *Escherichia coli* O157. For *Campylobacter*, surveillance was conducted in 10 states that comprise the Foodborne Diseases Active Surveillance Network (FoodNet), representing approximately 46 million persons (15.2% of the U.S. population).

Clinically Important Antimicrobial Resistance Patterns

In the United States, fluoroquinolones (e.g., ciprofloxacin) and third-generation cephalosporins (e.g., ceftriaxone) are commonly used to treat severe *Salmonella* infections, including *Salmonella* ser. Typhi, the organism that causes typhoid fever. In *Enterobacteriaceae*, resistance to nalidixic acid, an elementary quinolone, correlates with decreased susceptibility to ciprofloxacin (MIC ≥0.12 µg/mL) and possible fluoroquinolone treatment failure. Ceftiofur is a third-generation cephalosporin used in food animals in the United States; resistance to ceftiofur among *Enterobacteriaceae* correlates with resistance to ceftriaxone (MIC ≥4 µg/mL). A substantial proportion of *Enterobacteriaceae* isolates tested in 2008 demonstrated resistance to clinically important antimicrobial agents.

- 2.0% (47/2379) of non-typhoidal *Salmonella* isolates were resistant to nalidixic acid, including
    - 6.6% (29/439) of *Salmonella* ser. Enteritidis isolates
    - Enteritidis was the most common serotype among nalidixic acid–resistant non-typhoidal *Salmonella* isolates: 61.7% (29/47) of nalidixic acid–resistant isolates were serotype Enteritidis.
- 2.9% (70/2379) of non-typhoidal *Salmonella* isolates were resistant to ceftriaxone, including
    - 12.3% (31/252) of *Salmonella* ser. Newport isolates
    - Newport was the most common serotype among ceftriaxone–resistant non-typhoidal *Salmonella* isolates: 44.3% (31/70) of ceftiofur–resistant isolates were serotype Newport.
- 59.0% (242/410) of *Salmonella* ser. Typhi isolates were resistant to nalidixic acid.
- 2.2% (12/552) of *Shigella* isolates were resistant to nalidixic acid and 0.9% (5/552) were resistant to ciprofloxacin.
- 1.9% (3/160) of *E. coli* O157 isolates were resistant to nalidixic acid.

In *Campylobacter*, fluoroquinolones and macrolides (e.g., erythromycin) are important agents in the treatment of severe infections.

- 23.0% (267/1159) of *Campylobacter* isolates were resistant to ciprofloxacin, including
    - 30.7% (31/101) of *Campylobacter coli* isolates
    - 22.4% (236/1055) of *Campylobacter jejuni* isolates
- 3% (35/1159) of *Campylobacter* isolates were resistant to erythromycin, including
    - 10.9% (11/101) of *Campylobacter coli* isolates
    - 2.3% (24/1055) *Campylobacter jejuni* isolates

Multidrug Resistance

Multidrug resistance is described in NARMS as resistance to three or more antimicrobial classes and also by specific coresistant phenotypes. Antimicrobial classes of agents defined by the Clinical and Laboratory Standards Institute (CLSI) are used in this report (Table 3, Table 4). For non-typhoidal *Salmonella*, an important multidrug-resistant phenotype includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide (sulfamethoxazole/sulfisoxazole), and tetracycline (ACSSuT). The ACSSuT phenotype includes resistance to at least five CLSI classes. Another important phenotype includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur (ACSSuTAuCf).The ACSSuTAuCf phenotype includes resistance to at least 7 CLSI classes. With the new ceftriaxone resistance breakpoint (lowered from 64 µg/mL to 4 µg/mL), all but one isolate with this phenotype was ceftriaxone resistant. In addition, 12.4% (294/2379) of non-typhoidal *Salmonella* isolates were resistant to two or more CLSI classes, and 9.4% (223/2379) were resistant to three or more CLSI classes.

- 27.7% (110/397) of *Salmonella* ser. Typhimurium isolates were resistant to three or more classes.
- 13.5% (34/252) of *Salmonella* ser. Newport isolates were resistant to three or more classes.
- 0.2% (1/439) of *Salmonella* ser. Enteritidis isolates were resistant to three or more classes.

    - Of 223 non-typhoidal *Salmonella* resistant to three or more classes, 49.3% were *Salmonella* ser. Typhimurium.
- 5.8% (137/2379) of non-typhoidal *Salmonella* isolates had the ACSSuT resistance pattern, including
    - 22.9% (91/397) of *Salmonella* ser. Typhimurium isolates, and
    - 11.5% (29/252) of *Salmonella* ser. Newport isolates.
- 1.8% (43/2379) of non- typhoidal *Salmonella* isolates had the ACSSuTAuCf resistance pattern, including
    - 11.5% (29/252) of *Salmonella* ser. Newport isolates, and
    - 2.0% (8/397) of *Salmonella* ser. Typhimurium isolates.
- 41.3% (228/552) of *Shigella* isolates were resistant to three or more classes.
- 3.1% (5/160) of *E. coli* O157 isolates were resistant to three or more classes.

Box 1. Changes in Antimicrobial Resistance: 2008 vs. 2003–07

We used logistic regression to compare the prevalence of specific antimicrobial resistance patterns among *Salmonella* and *Campylobacter* isolates tested in 2008 with the reference, which was the average prevalence of resistance in the previous 5 years (2003–07). A description of the methods is included in this report (refer to Surveillance and Laboratory Testing Methods).

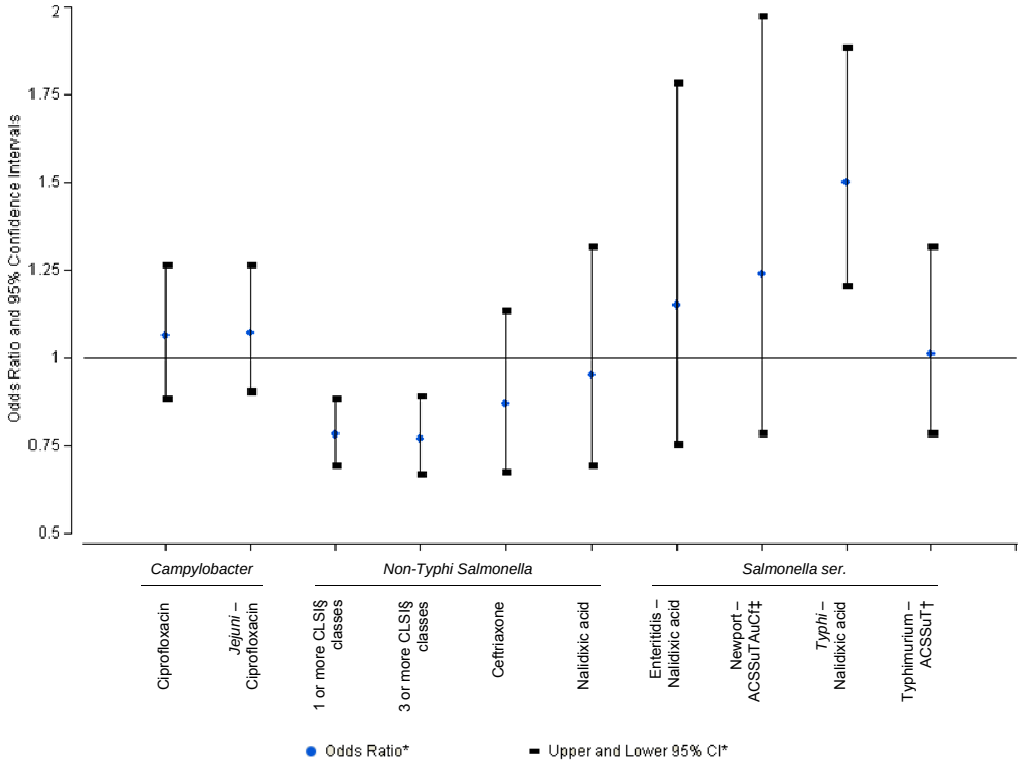
The differences between the prevalence of resistance in 2008 and the average prevalence of resistance in the previous 5 years (2003–07) (Table 1) were statistically significant for the following:

- Resistance to one or more CLSI classes in non-typhoidal *Salmonella* (NTS) (OR=0.78, 95% CI [0.69–0.88]), which was lower in 2008 compared with 2003–07
- Resistance to three or more CLSI classes in NTS (OR=0.77, 95% CI [0.66–0.89]), which was lower in 2008 compared with 2003–07
- Nalidixic acid resistance in *Salmonella* ser. Typhi (OR=1.5, 95% CI [1.20–1.88]), which was higher in 2008 compared with 2003–07

The differences between the prevalence of resistance in 2008 and the average prevalence of resistance in the previous 5 years (2003–07) (Table 1) were not statistically significant for the following:

- Nalidixic acid resistance in NTS (OR=0.95, 95% CI [0.69–1.31])
- Ceftriaxone resistance in NTS (OR=0.87, 95% CI [0.67–1.13])
- Nalidixic acid resistance in *Salmonella enterica* ser. Enteritidis (OR=1.15, 95% CI [0.75–1.78])
- ACSSuT in *Salmonella enterica* ser. Typhimurium (OR=1.01, 95% CI [0.78–1.31])
- ACSSuTAuCf in *Salmonella enterica* ser. Newport (OR=1.24, 95% CI [0.78–1.97])
- Ciprofloxacin resistance in *Campylobacter* (OR=1.07, 95% CI [0.90–1.26])
- Ciprofloxacin resistance in *Campylobacter jejuni* (OR=1.06, 95% CI [0.88–1.26])

Table 1. Summary of trend analysis of the prevalence of specific resistance patterns among *Salmonella* and *Campylobacter* isolates, 2008 compared with 2003–2007*



*The reference is the average prevalence of resistance in the previous 5 years, 2003–07. Logistic regression models adjusted for site. The odds ratios (ORs) and 95% confidence intervals (CIs) for 2008 compared with the reference were calculated using unconditional maximum likelihood estimation. ORs that do not include 1.00 in the 95% CIs are reported as statistically significant.

† ACSSuT: resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline.

‡ ACSSuTAuCf: resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur.

§ Antimicrobial classes of agents defined by the Clinical and Laboratory Standards Institute (CLSI) are used.

Antimicrobial Resistance: 1996–2008

The following figures display resistance from 1996–2008 for non-typhoidal *Salmonella*, 1999–2008 for *Salmonella* ser. Typhi, and 1997–2008 for *Campylobacter*.

Figure 1. Percentage of non-typhoidal *Salmonella* isolates resistant to nalidixic acid, by year, 1996–2008

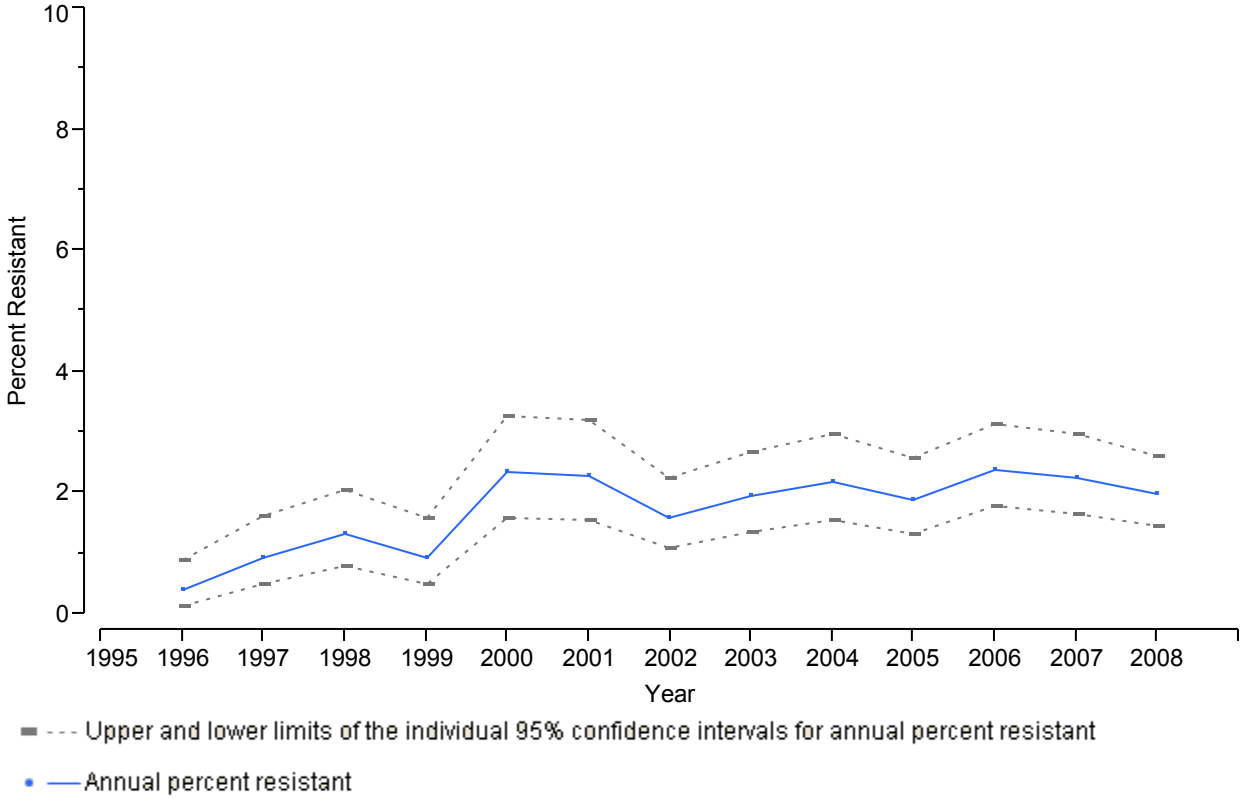


Figure 2. Percentage of non-typhoidal *Salmonella* isolates resistant to ceftriaxone, by year, 1996–2008

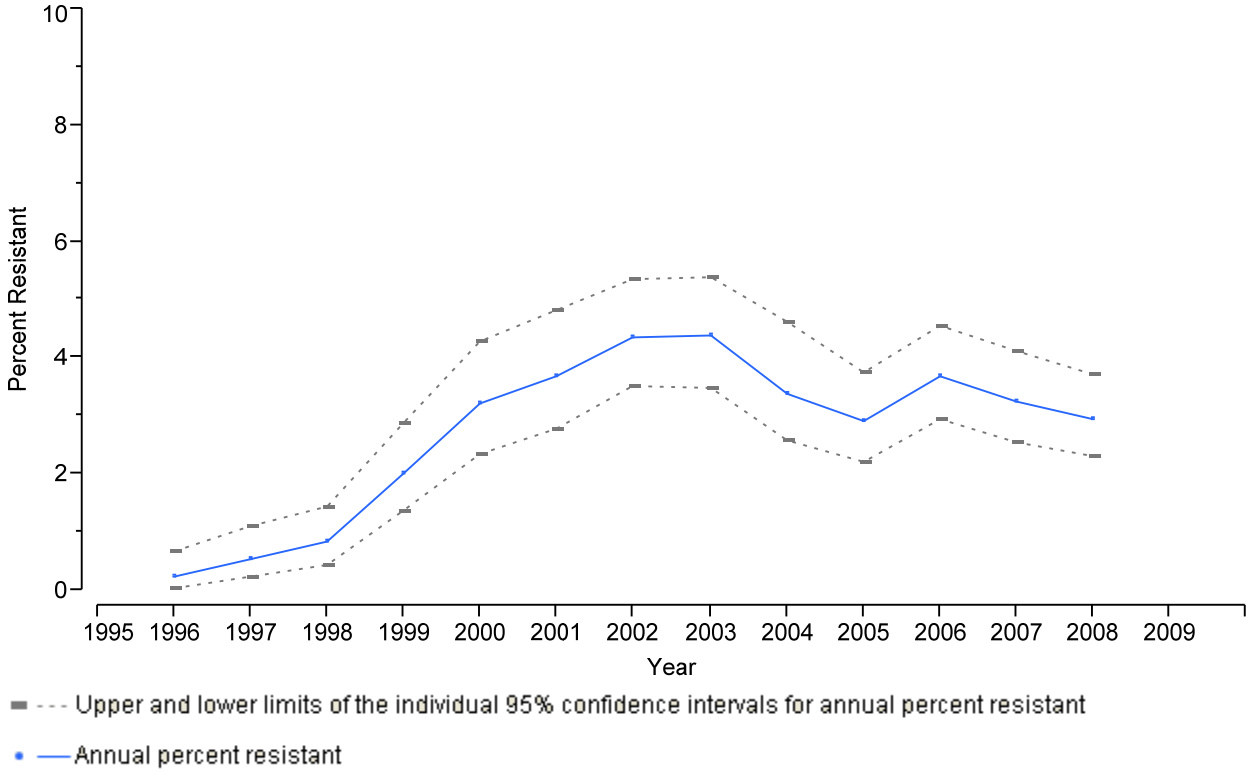


Figure 3. Percentage of *Salmonella* ser. Enteritidis isolates resistant to nalidixic acid, by year, 1996–2008

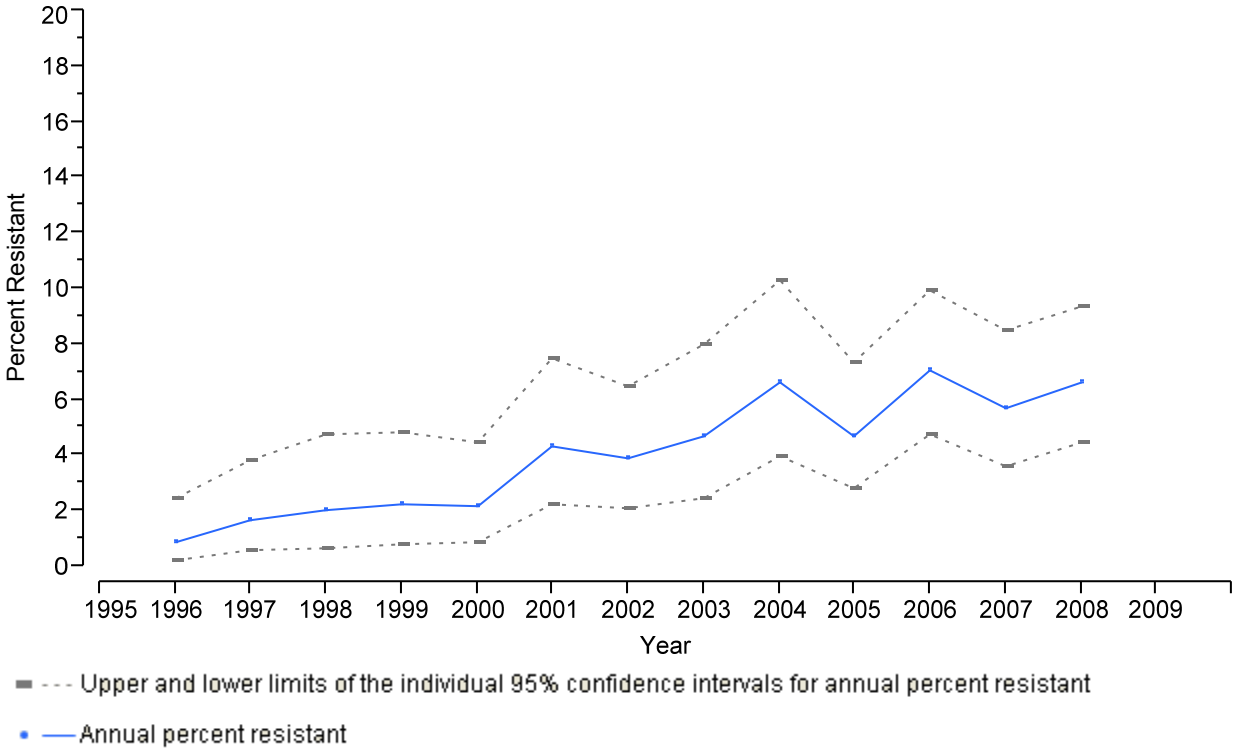


Figure 4. Percentage of *Salmonella* ser. Typhimurium isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline (ACSSuT), by year, 1996–2008

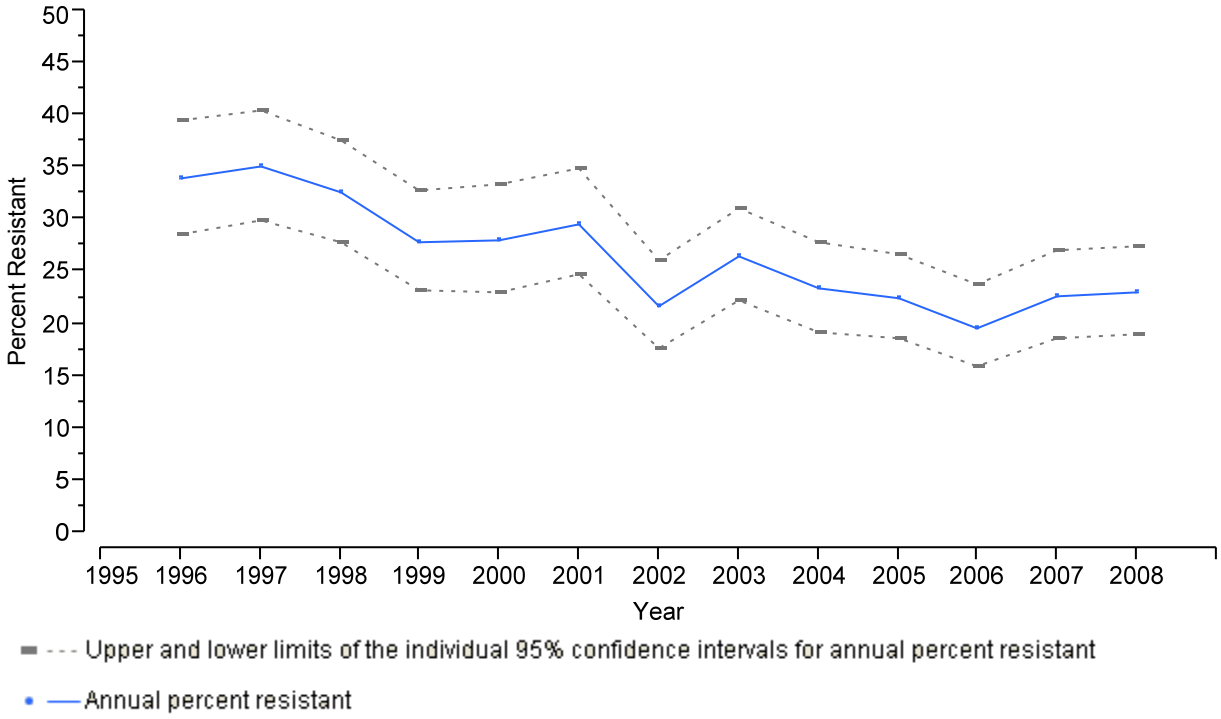


Figure 5. Percentage of *Salmonella* ser. Newport isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur (ACSSuTAuCf), by year, 1996–2008

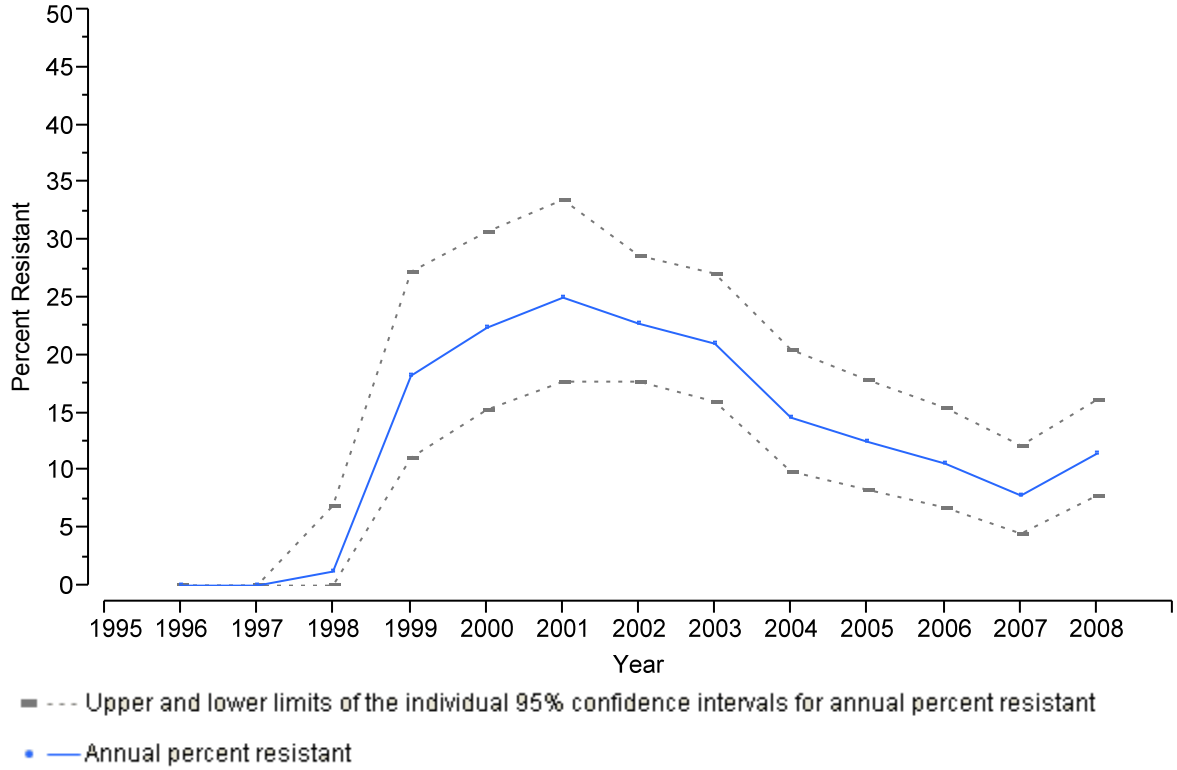


Figure 6. Percentage of non-typhoidal *Salmonella* isolates resistant to 1 or more antimicrobial classes, by year, 1996–2008

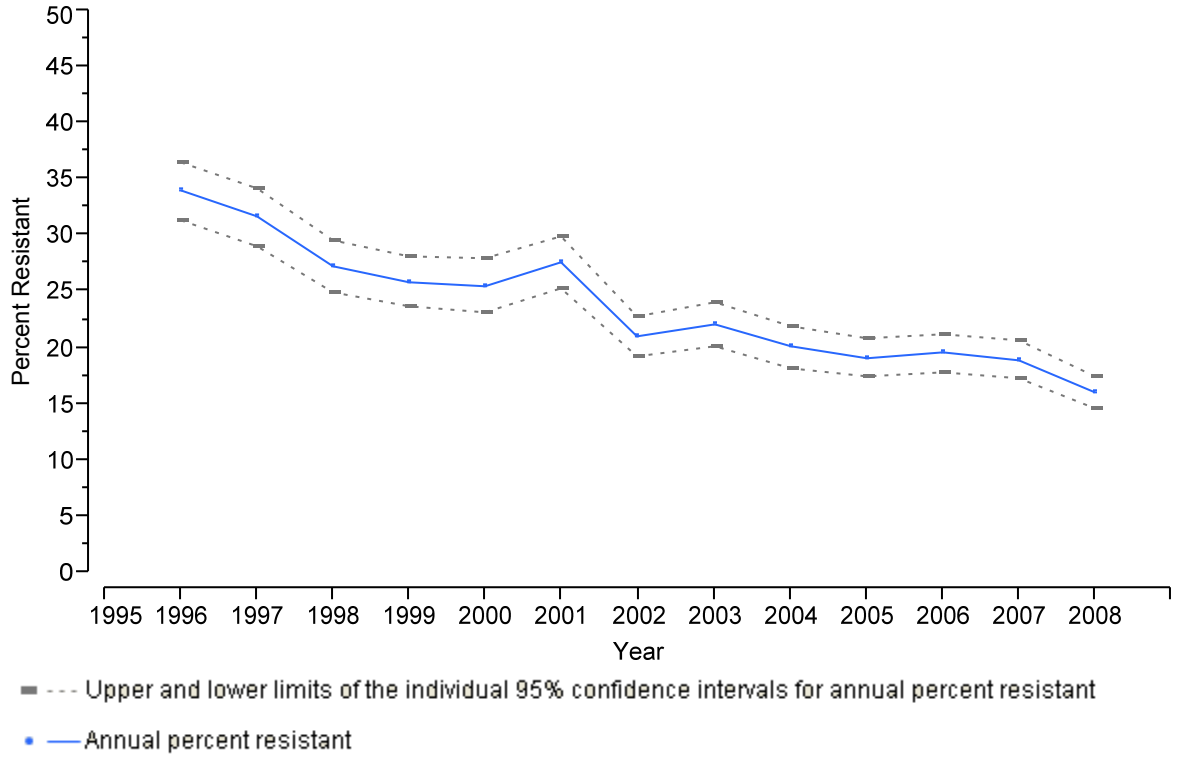


Figure 7. Percentage of non-typhoidal *Salmonella* isolates resistant to 3 or more antimicrobial classes, by year, 1996–2008

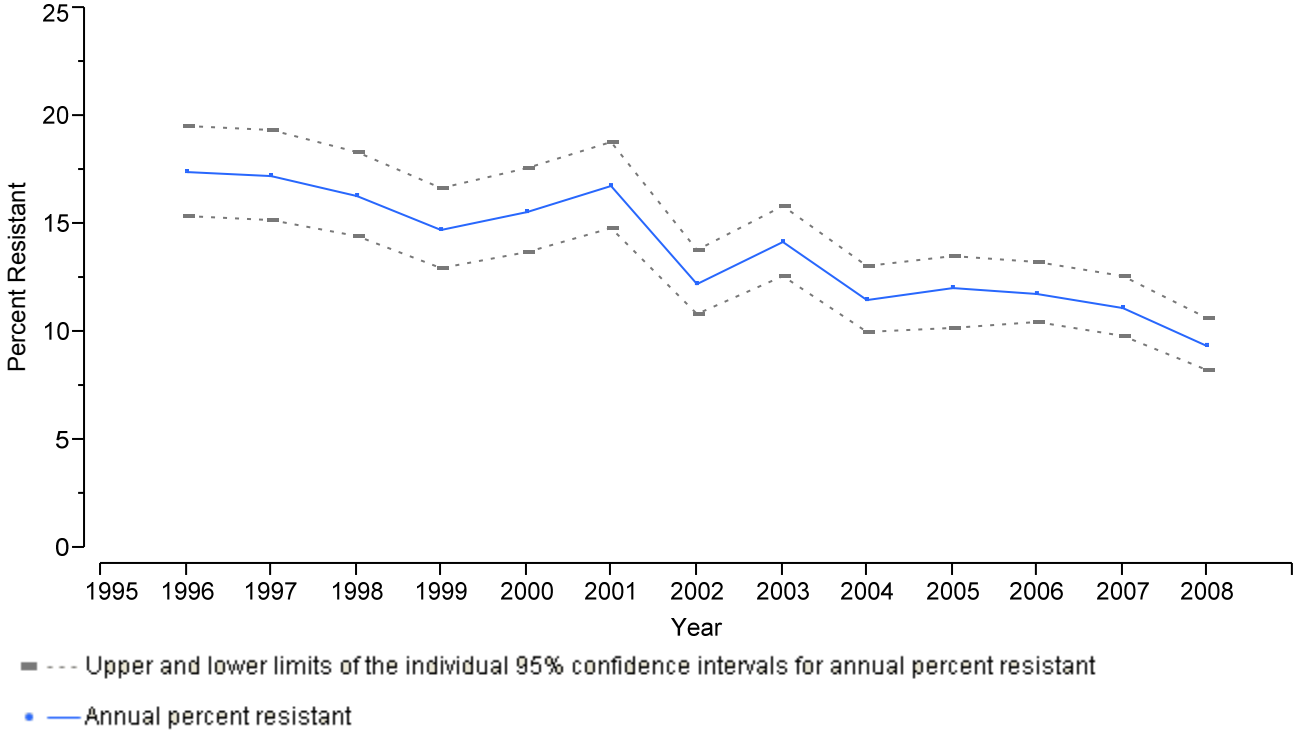


Figure 8. Percentage of *Salmonella* ser. Typhi isolates resistant to nalidixic acid, by year, 1999–2008

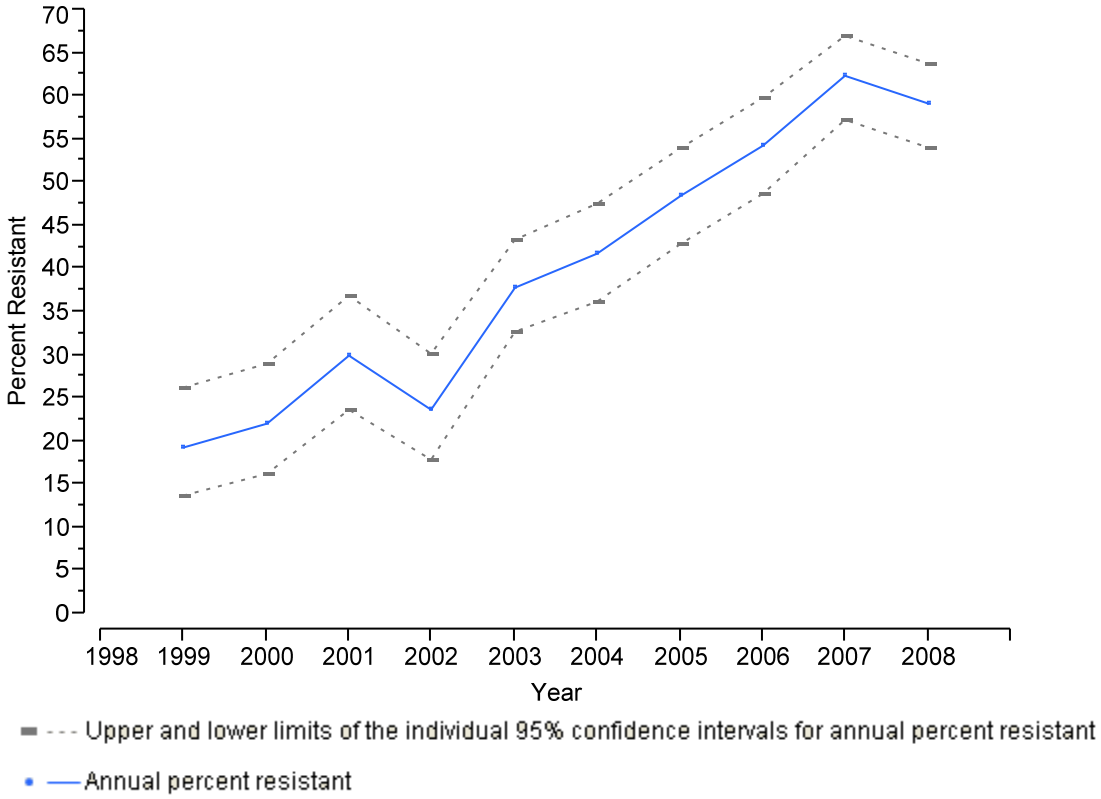


Figure 9. Percentage of *Campylobacter* isolates resistant to ciprofloxacin, by year, 1997–2008

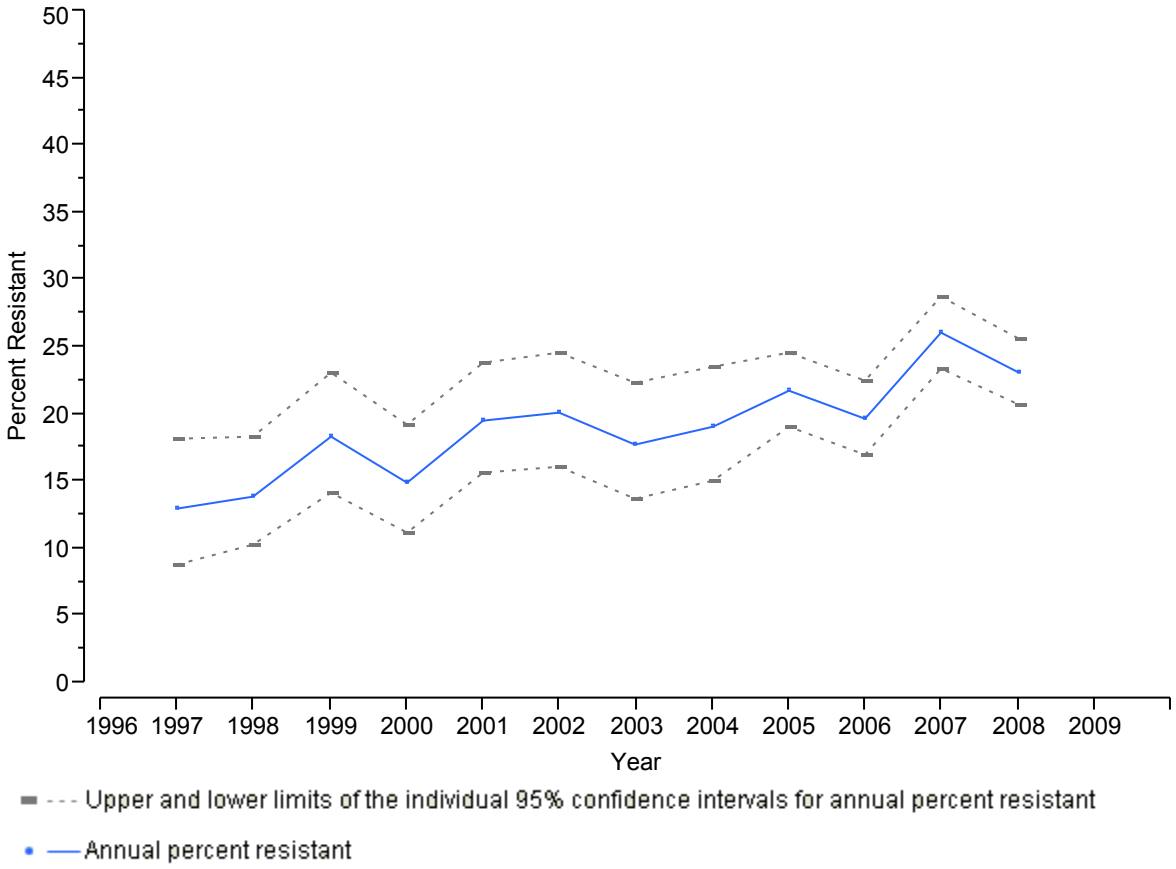


Table 2. Population size and number of isolates received and tested, NARMS, 2008

State/Site	Population Size*	Non-typhoidal *Salmonella*		Typhoidal† *Salmonella*		*Shigella*		*E. coli* O157		*Campylobacter*‡	
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Alabama	4,661,900	69	(2.9%)	3	(0.6%)	28	(5.1%)	2	(1.3%)		
Alaska	686,293	4	(0.2%)	1	(0.2%)	1	(0.2%)	1	(0.6%)		
Arizona	6,500,180	56	(2.4%)	4	(0.8%)	24	(4.3%)	1	(0.6%)		
Arkansas	2,855,390	36	(1.5%)	2	(0.4%)	16	(2.9%)	1	(0.6%)		
California§	26,894,617	198	(8.3%)	55	(11.0%)	0	(0.0%)	4	(2.5%)	41	(3.5%)
Colorado	4,939,456	41	(1.7%)	5	(1.0%)	8	(1.4%)	10	(6.3%)	65	(5.6%)
Connecticut	3,501,252	21	(0.9%)	5	(1.0%)	2	(0.4%)	2	(1.3%)	137	(11.8%)
Delaware	873,092	8	(0.3%)	5	(1.0%)	0	(0.0%)	0	(0.0%)		
District of Columbia	591,833	56	(2.4%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Florida	18,328,340	31	(1.3%)	18	(3.6%)	0	(0.0%)	0	(0.0%)		
Georgia	9,685,744	132	(5.5%)	5	(1.0%)	37	(6.7%)	6	(3.8%)	346	(29.9%)
Hawaii	1,288,198	18	(0.8%)	3	(0.6%)	3	(0.5%)	1	(0.6%)		
Houston, Texas¶	4,946,443	55	(2.3%)	15	(3.0%)	25	(4.5%)	2	(1.3%)		
Idaho	1,523,816	9	(0.4%)	1	(0.2%)	0	(0.0%)	2	(1.3%)		
Illinois	12,901,563	77	(3.2%)	16	(3.2%)	48	(8.7%)	8	(5.0%)		
Indiana	6,376,792	34	(1.4%)	1	(0.2%)	6	(1.1%)	4	(2.5%)		
Iowa	3,002,555	19	(0.8%)	6	(1.2%)	6	(1.1%)	5	(3.1%)		
Kansas	2,802,134	18	(0.8%)	2	(0.4%)	2	(0.4%)	2	(1.3%)		
Kentucky	4,269,245	23	(1.0%)	0	(0.0%)	8	(1.4%)	2	(1.3%)		
Los Angeles**	9,862,049	75	(3.2%)	16	(3.2%)	5	(0.9%)	0	(0.0%)		
Louisiana	4,410,796	26	(1.1%)	0	(0.0%)	6	(1.1%)	0	(0.0%)		
Maine	1,316,456	5	(0.2%)	0	(0.0%)	1	(0.2%)	1	(0.6%)		
Maryland	5,633,597	47	(2.0%)	13	(2.6%)	3	(0.5%)	2	(1.3%)	105	(9.1%)
Massachusetts	6,497,967	68	(2.9%)	27	(5.4%)	9	(1.6%)	4	(2.5%)		
Michigan	10,003,422	43	(1.8%)	16	(3.2%)	11	(2.0%)	5	(3.1%)		
Minnesota	5,220,393	36	(1.5%)	9	(1.8%)	14	(2.5%)	7	(4.4%)	157	(13.5%)
Mississippi	2,938,618	44	(1.8%)	0	(0.0%)	9	(1.6%)	0	(0.0%)		
Missouri	5,911,605	57	(2.4%)	4	(0.8%)	8	(1.4%)	5	(3.1%)		
Montana	967,440	6	(0.3%)	1	(0.2%)	1	(0.2%)	2	(1.3%)		
Nebraska	1,783,432	13	(0.5%)	2	(0.4%)	2	(0.4%)	3	(1.9%)		
Nevada	2,600,167	12	(0.5%)	0	(0.0%)	8	(1.4%)	1	(0.6%)		
New Hampshire	1,315,809	12	(0.5%)	4	(0.8%)	0	(0.0%)	1	(0.6%)		
New Jersey	8,682,661	65	(2.7%)	40	(8.0%)	22	(4.0%)	9	(5.6%)		
New Mexico	1,984,356	26	(1.1%)	0	(0.0%)	5	(0.9%)	1	(0.6%)	53	(4.6%)
New York††	11,126,587	77	(3.2%)	17	(3.4%)	17	(3.1%)	5	(3.1%)	121	(10.4%)
New York City‡‡	8,363,710	73	(3.1%)	76	(15.1%)	29	(5.3%)	4	(2.5%)		
North Carolina	9,222,414	81	(3.4%)	3	(0.6%)	5	(0.9%)	0	(0.0%)		
North Dakota	641,481	5	(0.2%)	3	(0.6%)	1	(0.2%)	1	(0.6%)		
Ohio	11,485,910	75	(3.2%)	13	(2.6%)	28	(5.1%)	9	(5.6%)		
Oklahoma	3,642,361	42	(1.8%)	3	(0.6%)	8	(1.4%)	0	(0.0%)		
Oregon	3,790,060	23	(1.0%)	3	(0.6%)	4	(0.7%)	4	(2.5%)	102	(8.8%)
Pennsylvania	12,448,279	94	(4.0%)	28	(5.6%)	10	(1.8%)	5	(3.1%)		
Rhode Island	1,050,788	8	(0.3%)	1	(0.2%)	1	(0.2%)	1	(0.6%)		
South Carolina	4,479,800	50	(2.1%)	3	(0.6%)	20	(3.6%)	1	(0.6%)		
South Dakota	804,194	8	(0.3%)	1	(0.2%)	1	(0.2%)	2	(1.3%)		
Tennessee	6,214,888	48	(2.0%)	3	(0.6%)	38	(6.9%)	4	(2.5%)	32	(2.8%)
Texas§§	19,380,531	150	(6.3%)	17	(3.4%)	14	(2.5%)	3	(1.9%)		
Utah	2,736,424	17	(0.7%)	1	(0.2%)	1	(0.2%)	2	(1.3%)		
Vermont	621,270	5	(0.2%)	1	(0.2%)	0	(0.0%)	1	(0.6%)		
Virginia	7,769,089	71	(3.0%)	28	(5.6%)	14	(2.5%)	4	(2.5%)		
Washington	6,549,224	34	(1.4%)	12	(2.4%)	4	(0.7%)	6	(3.8%)		
West Virginia	1,814,468	35	(1.5%)	1	(0.2%)	13	(2.4%)	5	(3.1%)		
Wisconsin	5,627,967	36	(1.5%)	9	(1.8%)	25	(4.5%)	7	(4.4%)		
Wyoming	532,668	7	(0.3%)	0	(0.0%)	1	(0.2%)	2	(1.3%)		
Total	**304,059,724**	**2379**	**(100.0%)**	**502**	**(100.0%)**	**552**	**(100.0%)**	**160**	**(100.0%)**	**1159**	**(100.0%)**

* US Census Bureau, 2008

† Typhoidal *Salmonella* includes Typhi, Paratyphi A, Paratyphi B, and Paratyphi C

‡ *Campylobacter* isolates are submitted only from FoodNet sites representing a total population 46,298,050. All *Campylobacter* isolates are received from Georgia, Maryland, New Mexico, Oregon, and Tennessee and every other isolate from California, Colorado, Connecticut, and New York; and every fifth isolate from Minnesota.

§ Excluding Los Angeles County

¶ Houston City

** Los Angeles County

†† Excluding New York City

‡‡ Five burroughs of New York City (Bronx, Brooklyn, Manhattan, Queens, Staten Island)

§§ Excluding Houston, Texas

Surveillance and Laboratory Testing Methods

Surveillance Sites and Isolate Submissions

In 2008, NARMS conducted nationwide surveillance among approximately 304 million persons (2008 U.S. Census Bureau estimates). Public health laboratories systematically selected every 20th non-typhoidal *Salmonella, Shigella*, and *Escherichia coli* O157 isolate as well as every *Salmonella* ser. Typhi, *Salmonella* ser. Paratyphi A and *Salmonella ser.* Paratyphi C isolate received at their laboratories and forwarded these isolates to CDC for antimicrobial susceptibility testing. *Salmonella ser.* Paratyphi B was included in the every 20th sampling for non-typhoidal *Salmonella.*

Since 2005, public health laboratories of the 10 state health departments that participated in CDC's Foodborne Diseases Active Surveillance Network (FoodNet) have forwarded a representative sample of *Campylobacter* isolates to CDC for susceptibility testing. The FoodNet sites, representing approximately 46 million persons (2008 U.S. Census Bureau estimates), include California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee. Depending on the burden of *Campylobacter* in each FoodNet site, one of three following methods was used to obtain a representative sample of *Campylobacter* isolates: all isolates received by Georgia, Maryland, New Mexico, Oregon, and Tennessee; every other isolate from California, Colorado, Connecticut, and New York; and every fifth isolate from Minnesota. From 1997 to 2004, one *Campylobacter* isolate was submitted each week from participating FoodNet sites.

Testing of *Salmonella*, *Shigella*, and *Escherichia coli* O157

Antimicrobial Susceptibility Testing

Salmonella, *Shigella*, and *E. coli* O157 isolates were tested using broth microdilution (Sensititre®, Trek Diagnostics, Cleveland, OH) to determine the minimum inhibitory concentration (MIC) for each of 15 antimicrobial agents: amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole (Table 3). Before 2004, sulfamethoxazole was used instead of sulfisoxazole to represent the sulfonamides. Interpretive criteria defined by CLSI were used when available. The resistance breakpoint for amikacin, according to CLSI guidelines, is ≥64 µg/mL. In 2002 and 2003, a truncated broth microdilution series was used for amikacin testing (0.5-4 µg/mL). For isolates that grew in all amikacin dilutions on the Sensititre panel (MIC>4 µg/mL), ETest® (AB BIODISK, Solna, Sweden) was performed to determine amikacin MIC. The amikacin ETest® strip range of dilutions was 0.016-256 µg/mL. Since 2004, amikacin had a full range of dilutions (0.5-64 µg/mL) on the Sensititre panel (CMV1AGNF).

In January 2010, CLSI published revised interpretive criteria for ceftriaxone and *Enterobacteriaceae;* the revised resistance breakpoint for ceftriaxone is MIC ≥4 µg/mL. NARMS used the revised CLSI breakpoint for ceftriaxone resistance for all years in this report. In previous reports, the resistance breakpoint for ceftriaxone was ≥64 µg/mL.

Table 3. Antimicrobial agents used for susceptibility testing for *Salmonella*, *Shigella*, and *Escherichia coli* O157 isolates, NARMS, 2008

CLSI class	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	MIC Interpretive Standard (µg/mL)		
			Susceptible	Intermediate	Resistant
Aminoglycosides	Amikacin	0.5–64	≤16	32	≥64
	Gentamicin	0.25–16	≤4	8	≥16
	Kanamycin	8–64	≤16	32	≥64
	Streptomycin*	32–64	≤32		≥64
β–lactam / β–lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1/0.5–32/16	≤8/4	16/8	≥32/16
Cephems	Cefoxitin	0.5–32	≤8	16	≥32
	Ceftiofur	0.12–8	≤2	4	≥8
	Ceftriaxone†	0.25–64	≤1	2	≥4
	Cephalothin‡	2–32	≤8	16	≥32
Folate pathway inhibitors	Sulfamethoxazole§	16–512	≤256		≥512
	Sulfisoxazole	16–256	≤256		≥512
	Trimethoprim-sulfamethoxazole	0.12/2.38–4/76	≤2/38		≥4/76
Penicillins	Ampicillin	1–32	≤8	16	≥32
Phenicols	Chloramphenicol	2–32	≤8	16	≥32
Quinolones	Ciprofloxacin	0.015–4	≤1	2	≥4
	Nalidixic acid	0.5–32	≤16		≥32
Tetracyclines	Tetracycline	4–32	≤4	8	≥16

* No CLSI breakpoints; resistance breakpoint used in NARMS is ≥64 µg/mL.
† CLSI updated the ceftriaxone interpretive standards in January, 2010. Previous standards that were used for NARMS Human Isolate reports from 1996-2007 were susceptible ≤8 µg/mL , intermediate 16-32 µg/mL, and resistant ≥64 µg/mL
‡ Cephalothin has not been tested since 2003, but was tested in earlier years for *Salmonella*, *Shigella*, and *E. coli* O157.
§ Sulfamethoxazole, which was tested during 1996–2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Additional Testing of *Salmonella* Strains

Cephalosporin Retesting of Isolates from 1996-1998

Review of *Salmonella* isolates tested in NARMS during 1996 to 1998 gave conflicting cephalosporin susceptibility results. In particular, some isolates previously reported in NARMS as ceftiofur-resistant exhibited a low ceftriaxone MIC and, in some cases, did not exhibit an elevated MIC to other β-lactams. Because these findings suggested that some previously reported results were inaccurate, we retested, using the 2003 NARMS Sensititre® plate, isolates of *Salmonella* tested in NARMS during 1996 to 1998 that exhibited an MIC ≥2 µg/mL to ceftiofur or ceftriaxone. The retest results have been included in the NARMS annual reports since 2003.

Serotype Confirmation/Categorization

Salmonella serotype reported by the submitting laboratory was accepted with few exceptions. *S*erotype was confirmed by CDC for isolates that underwent subsequent molecular analysis for publication. Because of challenges associated with interpretation of tartrate fermentation assays, ability to ferment tartrate was confirmed for isolates reported as *Salmonella* ser. Paratyphi B by the submitting laboratory (serotype Paratyphi B is by definition unable to ferment L(+) tartrate). To distinguish *Salmonella* serotypes Paratyphi B and Paratyphi B var L(+) tartrate+ (formerly serotype Java), CDC performed Jordan's tartrate test and/or Kauffmann's tartrate test on all *Salmonella* ser. Paratyphi B isolates from 1996 to 2008 for which the tartrate result was not reported or was reported to be negative. Isolates negative for tartrate fermentation by both assays were categorized as serotype Paratyphi B. Isolates that were positive for tartrate fermentation by either assay were categorized as serotype Paratyphi B var L(+) tartrate+. Confirmation of other biochemical reactions or somatic and flagellar antigens was not performed at CDC.

Because of increased submissions of *Salmonella* ser. I 4,[5],12:i:- noted in previous years, and recognition of the possibility that this serotype may have been underreported in previous years, isolates reported as serogroup B and tested in NARMS during 1996 to 2008 were reviewed for additional information; isolates that could be clearly identified as serogroup B, first-phase flagellar antigen "i", second phase flagellar antigen absent were categorized in this report as *Salmonella* ser. I 4,[5],12:i:-.

Testing of *Campylobacter*

Changes in Testing Methods in 2005

Starting in 2005, there were three major changes in the methodology used for *Campylobacter*. First, a surveillance scheme for selecting a representative sample of *Campylobacter* isolates for submission by FoodNet sites was implemented in 2005, which changed from a previous scheme that selected one *Campylobacter* isolate each week for submission during 1997 to 2004. Second, from 2005 through 2008, *Campylobacter* isolates were susceptibility tested using Sensititre® (Trek Diagnostics, Cleveland, OH); isolates had been tested by Etest® (AB BIODISK, Solna, Sweden) from 1997 through 2004. Third, florfenicol replaced chloramphenicol as the phenicol subclass representative drug, and telithromycin was added to the NARMS panel of agents tested in 2005.

Identification/Speciation and Antimicrobial Susceptibility Testing

From 2005 through 2008, isolates were confirmed as *Campylobacter* by determination of typical morphology using dark-field microscopy, and reactivity to catalase and oxidase tests. Identification of *C. jejuni* was performed using the hippurate hydrolysis test. Hippurate-positive isolates were identified as *C. jejuni*. Hippurate-negative isolates were further characterized with polymerase chain reaction (PCR) assay with specific targets for C. *jejuni (mapA or hipO* gene*)* or C. *coli*-specific *ceuE* gene (Linton *et al.* 1997, Gonzales et al. 1997, Pruckler *et al*. 2006). The same methodology was used during 1997–2002.

Beginning in 2005, the broth microdilution methodology (Sensititre®,Trek Diagnostics, Cleveland, OH) was used to determine the MICs for nine antimicrobial agents: azithromycin, ciprofloxacin, clindamycin, erythromycin, florfenicol, gentamicin, nalidixic acid, telithromycin, and tetracycline (Table 4). Florfenicol replaced chloramphenicol in the NARMS panel to represent the phenicol antimicrobial subclass. Similar to the 2004 report, CLSI interpretive criteria for erythromycin, ciprofloxacin, and tetracycline (published in 2006) and revised NARMS criteria for azithromycin were used for all years in this report. In annual reports published before 2004, these CLSI interpretive criteria were not available, and NARMS used resistance breakpoints for azithromycin and

erythromycin that were lower than the new and revised breakpoints. In addition, revised NARMS interpretive criteria, adopted from the FDA-CVM arm of NARMS, have been used for clindamycin, gentamicin, and nalidixic acid since 2004. From 1997 to 2004, Etest® (AB Biomerieux, Solna, Sweden) was used for susceptibility testing of *Campylobacter* isolates.

In 2003 and 2004, putative *Campylobacter* isolates were identified as *C. jejuni* or *C. coli* using BAX® System PCR Assay according to the manufacturer's instructions (DuPont Qualicon, Wilmington, DE). Isolates not identified as *C. jejuni* or *C. coli* were further characterized by other PCR assays (Linton *et al.* 1996) or were characterized by the CDC *Campylobacter* Reference Laboratory.

Table 4. Antimicrobial agents used for susceptibility testing of *Campylobacter* isolates, NARMS, 1997–2008

CLSI class	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	MIC Interpretive Standard (µg/mL)		
			Susceptible	Intermediate	Resistant
Aminoglycosides	Gentamicin	0.12–32 0.016–256*	≤2	4	≥8
Ketolides	Telithromycin†	0.015–8	≤4	8	≥16
Lincosamides	Clindamycin	0.03–16 0.016–256*	≤2	4	≥8
Macrolides	Azithromycin	0.015–64 0.016–256*	≤2	4	≥8
	Erythromycin	0.03–64 0.016–256*	≤8	16	≥32
Phenicols	Chloramphenicol‡	0.016–256*	≤8	16	≥32
	Florfenicol§	0.03–64	≤4	N/A	N/A
Quinolones	Ciprofloxacin	0.015–64 0.002–32*	≤1	2	≥4
	Nalidixic acid	4–64 0.016–256*	≤16	32	≥64
Tetracyclines	Tetracycline	0.06–64 0.016–256*	≤4	8	≥16

* Etest dilution range used from 1997–2004.
† Telithromycin added to NARMS panel in 2005.
‡ Chloramphenicol, tested from 1997–2004, was replaced by florfenicol in 2005.
§ Currently only a susceptible breakpoint (≤4 µg/mL) has been established. In this report isolates with a MIC ≥8 µg/mL are categorized as resistant.

Retesting

Known mechanisms of quinolone resistance in *Campylobacter* are expected to confer equivalent susceptibilities to nalidixic acid and ciprofloxacin. Similarly, known mechanisms of macrolide resistance are expected to confer equivalent susceptibilities to erythromycin and azithromycin. Confirmatory testing of isolates with conflicting results was performed by broth microdilution methods (Sensititre®, Trek Diagnostics, Cleveland, OH). Totals reported here reflect the retest results.

Data Analysis

For all pathogens, MICs were categorized as resistant, intermediate (if applicable), or susceptible. Analysis was restricted to the first isolate received (per genus under surveillance) per patient in the calendar year. If two or more isolates were received for the same patient for *Salmonella* ser. Typhi, the first blood isolate collected would be included in analysis. If no blood isolates were submitted, the first isolate collected would be included in analysis. Where established, CLSI interpretive criteria were used; streptomycin resistance was defined as MIC ≥64 µg/mL (Table 3). The 95% confidence intervals (CIs) for the percentage of resistant isolates are included in the MIC distribution tables. The 95% CIs were calculated using the Clopper-Pearson exact method.

When describing results for several years, multidrug resistance for *Salmonella, Shigella,* and *E. coli* O157 isolates was limited to the eight CLSI classes tested in all years from 1996 through 2008 represented by 15 agents: amikacin, amoxicillin-clavulanic acid, ampicillin, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole. When describing multidrug resistance for several years for *Campylobacter* isolates, multidrug resistance was limited to the five CLSI classes tested in all years from 1997 through 2008, represented by ciprofloxacin, chloramphenicol/florfenicol, clindamycin, erythromycin, nalidixic acid, and tetracycline.

Logistic regression was used to compare the prevalence of antimicrobial resistance among *Salmonella* and *Campylobacter* isolates tested in 2008 with the reference, which was the average prevalence of resistance in the previous 5 years (2003–07). The analysis included the following:

1. Non-typhoidal *Salmonella*: resistance to nalidixic acid, resistance to ceftiofur, resistance to one or more CLSI classes, resistance to three more CLSI classes
2. *Salmonella* ser. Enteritidis: resistance to nalidixic acid
3. *Salmonella* ser. Typhimurium: resistance to at least ACSSuT (ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline)
4. *Salmonella* ser. Newport: resistance to at least ACSSuTAuCf (ACSSuT, amoxicillin-clavulanic acid, and ceftiofur)
5. *Salmonella* ser. Typhi: resistance to nalidixic acid
6. *Campylobacter* species: resistance to ciprofloxacin
7. *Campylobacter jejuni*: resistance to ciprofloxacin

To account for site-to-site variation in the prevalence of antimicrobial resistance, we included main effects adjustments for site in the analysis. The final regression models for *Salmonella* adjusted for the submitting site using the nine geographic regions described in the Public Health Laboratory Information System (PHLIS): East North Central, East South Central, Mid-Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central. For *Campylobacter*, the final regression models adjusted for the submitting FoodNet site. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using unconditional maximum likelihood estimation. The adequacy of model fit was assessed in several ways. The significance of the main effect of year was assessed using the likelihood ratio test. The likelihood ratio test was also used to test for significance of interaction between site and year, although the power of the test to detect a single site-specific interaction was low. The Hosmer and Lemeshow goodness-of-fit test was also used. Finally, residual analysis was performed to examine the influence of individual observations. Having assessed that the main effect of year was significant, we reported ORs with 95% CIs (for 2008 compared with reference) that did not include 1.00 as statistically significant.

MIC Distribution Tables and Proportional Figures

An explanation on "how to read a table," showing the distribution of MICs for antimicrobial agents tested, which we refer to as "squashtogram", has been provided to assist the reader with the different parts of each table (Figure 10). Proportional figures visually display data from squashtograms for an immediate comparative summary of resistance in specific pathogens and serotypes. These figures are a categorical visual aid for the interpretation of MIC values. For most antimicrobial agents tested, three categories (susceptible, intermediate, and resistant) are used to interpret MICs. The proportion representing each category is shown in a horizontal proportional bar chart (Figure 11).

Figure 10. How to read a squashtogram

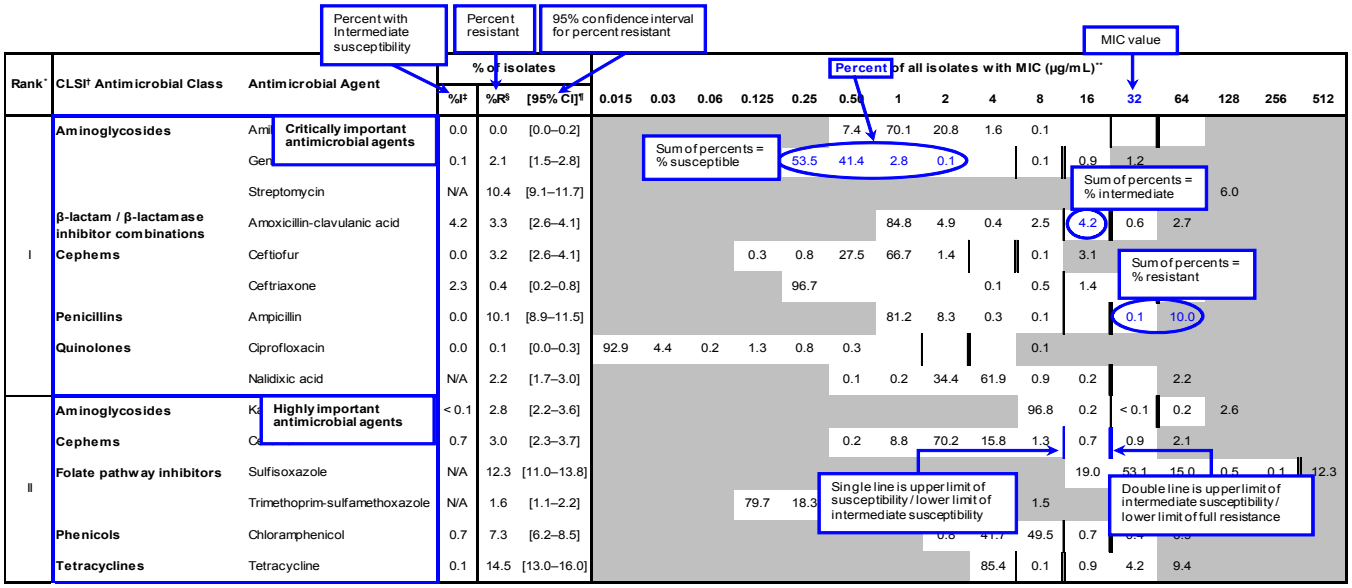
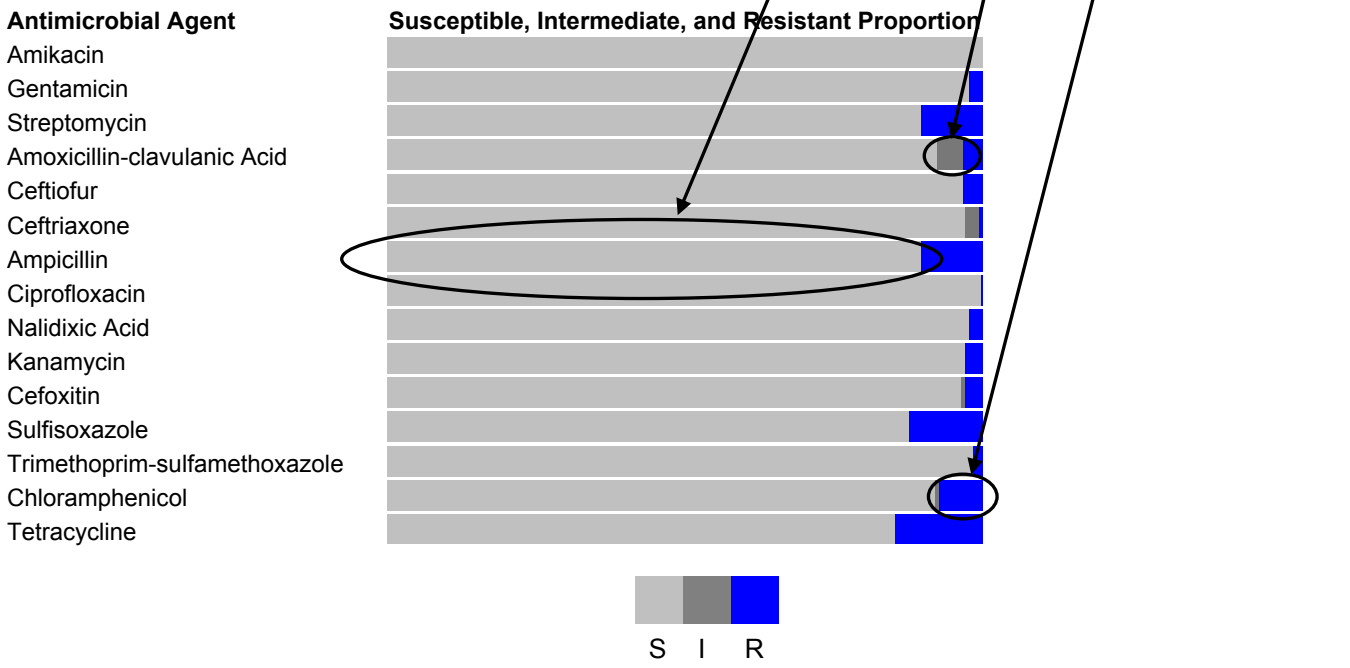


Figure 11. Proportional chart, a categorical graph of a squashtogram

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.2]						3.1	48.4	45.9	2.6	< 0.1						
		Gentamicin	0.1	1.5	[1.0 - 2.0]					33.5	61.4	3.4	0.1		0.1	0.4	1.1				
		Streptomycin	N/A	10.0	[8.8 - 11.2]												90.0	4.1	5.8		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.1	3.0	[2.3 - 3.7]							87.6	2.6	0.4	2.3	4.1	0.5	2.5			
	Cephems	Ceftiofur	0.0	2.9	[2.3 - 3.7]				0.2	0.6	32.7	62.1	1.4			2.9					
		Ceftriaxone	0.0	2.9	[2.3 - 3.7]					97.0		< 0.1			0.3	1.5	0.8	0.2	0.1		
	Penicillins	Ampicillin	< 0.1	9.6	[8.5 - 10.9]							84.2	5.8	0.3		0.1	0.1	9.5			
	Quinolones	Ciprofloxacin	< 0.1	< 0.1	[0.01 - 0.3]	92.4	5.0	0.2	0.9	0.9	0.4	< 0.1	< 0.1		< 0.1						
		Nalidixic acid	N/A	2.0	[1.5 - 2.6]						0.2	0.3	51.3	44.6	1.3	0.3	< 0.1	1.9			
II	**Aminoglycosides**	Kanamycin	< 0.1	2.1	[1.5 - 2.7]										97.6	0.3	< 0.1	< 0.1	2.0		
	Cephems	Cefoxitin	0.2	2.9	[2.3 - 3.7]						0.3	23.8	55.4	11.3	0.9	0.2	1.0	1.9			
	Folate pathway inhibitors	Sulfisoxazole	N/A	10.0	[8.9 - 11.3]											16.5	57.0	16.1	0.3	< 0.1	10.0
		Trimethoprim-sulfamethoxazole	N/A	1.6	[1.1 - 2.1]				80.8	17.2	0.3	< 0.1	< 0.1		1.6						
	Phenicols	Chloramphenicol	1.1	6.1	[5.2 - 7.1]								1.2	41.4	50.1	1.1	< 0.1	6.1			
	Tetracyclines	Tetracycline	0.2	11.5	[10.2 - 12.8]									88.3	0.2	0.3	3.5	7.7			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.



Results

1. Non-typhoidal *Salmonella*

Table 5. Minimum inhibitory concentrations (MICs) and resistance of non-typhoidal *Salmonella* isolates to antimicrobial agents, 2008 (N=2,379)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**													
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.2]						3.1	48.4	45.9	2.6	< 0.1						
		Gentamicin	0.1	1.5	[1.0 - 2.0]					33.5	61.4	3.4	0.1		0.1	0.4	1.1				
		Streptomycin	N/A	10.0	[8.8 - 11.2]												90.0	4.1	5.8		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.1	3.0	[2.3 - 3.7]							87.6	2.6	0.4	2.3	4.1	0.5	2.5			
	Cephems	Ceftiofur	0.0	2.9	[2.3 - 3.7]				0.2	0.6	32.7	62.1	1.4			2.9					
		Ceftriaxone	0.0	2.9	[2.3 - 3.7]					97.0		< 0.1			0.3	1.6	0.8	0.2	0.1		
	Penicillins	Ampicillin	< 0.1	9.6	[8.5 - 10.9]							84.2	5.8	0.3		< 0.1	0.1	9.5			
	Quinolones	Ciprofloxacin	< 0.1	< 0.1	[0.01 - 0.3]	92.4	5.0	0.2	0.9	0.9	0.4	< 0.1	< 0.1		< 0.1						
		Nalidixic acid	N/A	2.0	[1.5 - 2.6]						0.2	0.3	51.3	44.6	1.3	0.3	< 0.1	1.9			
II	**Aminoglycosides**	Kanamycin	< 0.1	2.1	[1.5 - 2.7]										97.6	0.3	< 0.1	< 0.1	2.0		
	Cephems	Cefoxitin	0.2	2.9	[2.3 - 3.7]						0.3	28.8	55.4	11.3	0.9	0.2	1.0	1.9			
	Folate pathway inhibitors	Sulfisoxazole	N/A	10.0	[8.9 - 11.3]											16.5	57.0	16.1	0.3	< 0.1	10.0
		Trimethoprim-sulfamethoxazole	N/A	1.6	[1.1 - 2.1]				80.8	17.2	0.3	< 0.1	< 0.1		1.6						
	Phenicols	Chloramphenicol	1.1	6.1	[5.2 - 7.1]								1.2	41.4	50.1	1.1	< 0.1	6.1			
	Tetracyclines	Tetracycline	0.2	11.5	[10.2 - 12.8]									88.3	0.2	0.3	3.5	7.7			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 12. Antimicrobial resistance pattern for non-typhoidal *Salmonella*, 2008

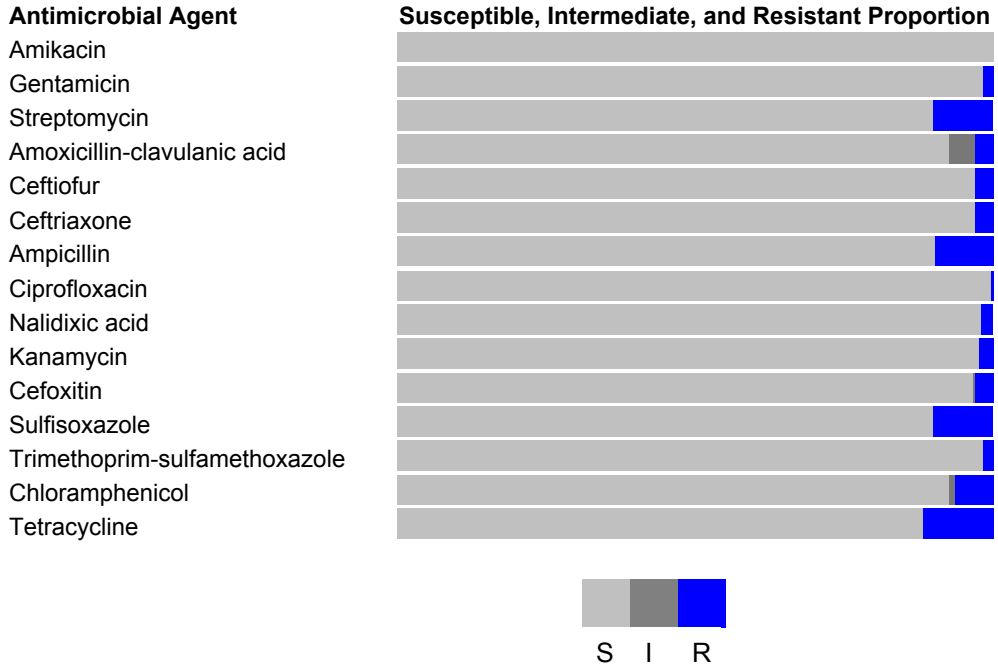


Table 6. Percentage and number of non-typhoidal *Salmonella* isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			1493	1372	1410	1998	1855	1782	2034	2173	2144	2379
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 1	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.1% 32	2.7% 37	1.9% 27	1.4% 27	1.4% 26	1.3% 24	2.2% 44	2.0% 44	2.1% 45	1.5% 35
		Streptomycin (MIC ≥ 64)	16.7% 250	16.3% 223	17.1% 241	13.2% 264	15.0% 279	11.9% 212	11.1% 225	10.7% 233	10.4% 222	10.0% 237
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	2.3% 34	3.9% 54	4.7% 66	5.3% 106	4.6% 86	3.8% 67	3.2% 65	3.7% 81	3.3% 70	3.0% 71
	Cephems	Ceftiofur (MIC ≥ 8)	2.0% 30	3.2% 44	4.1% 58	4.4% 87	4.5% 83	3.4% 61	2.9% 60	3.6% 79	3.3% 70	2.9% 70
		Ceftriaxone (MIC ≥ 4)	2.0% 30	3.2% 44	3.7% 52	4.4% 87	4.4% 81	3.4% 60	2.9% 59	3.7% 80	3.3% 70	2.9% 70
	Penicillins	Ampicillin (MIC ≥ 32)	15.5% 232	15.9% 218	17.5% 247	13.0% 259	13.6% 253	12.1% 216	11.4% 232	11.0% 238	10.1% 217	9.6% 229
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.1% 1	0.4% 5	0.2% 3	0.1% 1	0.2% 3	0.2% 4	0.0% 1	0.1% 2	0.1% 2	0.1% 2
		Nalidixic acid (MIC ≥ 32)	0.9% 14	2.3% 32	2.3% 32	1.6% 32	1.9% 36	2.2% 39	1.9% 38	2.4% 52	2.2% 48	2.0% 47
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	4.4% 65	5.6% 77	4.8% 68	3.8% 76	3.5% 64	2.8% 50	3.4% 70	2.9% 63	2.8% 61	2.1% 49
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	3.2% 44	3.4% 48	4.3% 86	4.3% 79	3.5% 62	3.0% 62	3.5% 77	2.9% 63	2.9% 70
		Cephalothin (MIC ≥ 32)	3.5% 53	4.0% 55	4.0% 57	5.1% 101	5.3% 99	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	18.0% 269	17.1% 234	17.8% 251	12.9% 258	15.1% 280	13.2% 236	12.6% 256	12.1% 263	12.3% 264	10.0% 239
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.0% 30	2.0% 28	2.0% 28	1.4% 28	1.9% 36	1.7% 31	1.7% 34	1.7% 36	1.5% 33	1.6% 37
	Phenicols	Chloramphenicol (MIC ≥ 32)	9.2% 137	10.1% 138	11.6% 164	8.6% 172	10.1% 187	7.6% 135	7.8% 159	6.4% 139	7.3% 156	6.1% 145
	Tetracyclines	Tetracycline (MIC ≥ 16)	19.4% 289	18.7% 256	19.9% 280	14.9% 298	16.3% 303	13.5% 241	13.9% 282	13.5% 293	14.5% 310	11.5% 273

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 7. Resistance patterns of non-typhoidal *Salmonella* isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	1493	1372	1410	1998	1855	1782	2034	2173	2144	2379
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	74.1% 1107	74.5% 1022	72.5% 1022	79.1% 1580	78.0% 1447	80.0% 1425	80.9% 1646	80.5% 1749	81.1% 1738	84.0% 1999
Resistance ≥ 1 CLSI class*	25.9% 386	25.5% 350	27.5% 388	20.9% 418	22.0% 408	20.0% 357	19.1% 388	19.5% 424	18.9% 406	16.0% 380
Resistance ≥ 2 CLSI classes*	20.2% 302	20.0% 275	22.1% 311	15.8% 315	17.5% 325	15.0% 267	14.8% 302	14.7% 319	14.2% 305	12.4% 294
Resistance ≥ 3 CLSI classes*	14.7% 220	15.6% 214	16.7% 236	12.3% 245	14.2% 263	11.4% 204	12.0% 244	11.8% 256	11.1% 239	9.4% 223
Resistance ≥ 4 CLSI classes*	11.9% 177	12.7% 174	13.5% 191	9.8% 195	11.4% 211	9.2% 164	9.1% 185	8.1% 177	8.2% 176	7.4% 176
Resistance ≥ 5 CLSI classes*	8.5% 127	9.5% 131	10.3% 145	8.2% 164	9.8% 182	7.9% 141	7.2% 146	6.3% 137	6.9% 149	6.6% 156
At least ACSSuT†	8.4% 125	8.9% 122	10.1% 142	7.8% 156	9.3% 173	7.2% 128	6.9% 141	5.6% 121	6.3% 136	5.8% 137
At least ACT/S‡	0.9% 14	0.9% 13	0.5% 7	1.1% 21	1.2% 23	0.6% 10	0.9% 18	0.7% 15	0.7% 16	0.5% 11
At least ACSSuTAuCf§	1.5% 23	2.6% 36	2.6% 36	3.4% 67	3.2% 60	2.4% 42	2.0% 41	2.0% 43	2.1% 46	1.8% 43
At least ceftiofur and nalidixic acid resistant	0.1% 1	0.1% 1	0.1% 2	0.2% 4	0.1% 2	0.1% 2	0.1% 2	0.1% 3	0.2% 5	0.0% 0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

Table 8. Twenty most common non-typhoidal *Salmonella* serotypes in NARMS, 2008

NARMS Rank	Serotype	Isolates n	Isolates (%)
1	Enteritidis	439	(18.5%)
2	Typhimurium	397	(16.7%)
3	Newport	252	(10.6%)
4	Javiana	118	(5.0%)
5	Saintpaul	108	(4.5%)
6	I 4,[5],12:i:-	83	(3.5%)
7	Heidelberg	75	(3.2%)
8	Montevideo	68	(2.9%)
9	Braenderup	56	(2.4%)
10	Infantis	51	(2.1%)
11	Muenchen	51	(2.1%)
12	Oranienburg	50	(2.1%)
13	Agona	39	(1.6%)
14	Thompson	32	(1.3%)
15	Mississippi	31	(1.3%)
16	Poona	26	(1.1%)
17	Schwarzengrund	24	(1.0%)
18	Litchfield	23	(1.0%)
19	Paratyphi B var. L(+) tartrate+	23	(1.0%)
20	Hadar	19	(0.8%)
	Subtotal	**1965**	**(82.6%)**
	All other serotypes	349	(14.7%)
	Unknown serotype	35	(1.5%)
	Partially serotyped	14	(0.6%)
	Rough/Nonmotile isolates	16	(0.7%)
	Subtotal	**414**	**(17.4%)**
	Grand Total	**2379**	**(100.0%)**

A. *Salmonella* ser. Enteritidis

Table 9. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Enteritidis isolates to antimicrobial agents, 2008 (N=439)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates ‡	%R§	[95% CI]¶	Percent of all isolates with MIC (µg/mL)** 0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 0.8]						8.9	77.0	13.2	0.7	0.2						
		Gentamicin	0.0	0.2	[0.00 - 1.3]					68.1	29.4	2.1	0.2				0.2				
		Streptomycin	N/A	0.5	[0.05 - 1.6]												99.5	0.2	0.2		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.5	0.0	[0.0 - 0.8]							92.9	3.2	0.2	3.2	0.5					
I	**Cephems**	Ceftiofur	0.0	0.0	[0.0 - 0.8]				0.2	0.7	6.2	91.8	1.1								
		Ceftriaxone	0.0	0.0	[0.0 - 0.8]					100.0											
	Penicillins	Ampicillin	0.2	3.6	[2.1 - 5.9]							84.1	10.9	1.1		0.2		3.6			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 0.8]	77.9	15.3	0.2	3.9	2.5	0.2										
		Nalidixic acid	N/A	6.6	[4.5 - 9.3]						0.2	0.2	21.9	69.2	1.6	0.2	0.2	6.4			
	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 0.8]										100.0						
	Cephems	Cefoxitin	0.5	0.0	[0.0 - 0.8]						0.7	17.1	78.6	2.5	0.7	0.5					
II	**Folate pathway inhibitors**	Sulfisoxazole	N/A	1.1	[0.4 - 2.6]											10.5	72.9	15.0	0.5		1.1
		Trimethoprim-sulfamethoxazole	N/A	0.9	[0.2 - 2.3]				82.2	16.6		0.2			0.9						
	Phenicols	Chloramphenicol	0.2	0.5	[0.05 - 1.6]								0.5	44.4	54.4	0.2		0.5			
	Tetracyclines	Tetracycline	0.2	1.6	[0.6 - 3.3]									98.2	0.2	0.2	0.2	1.1			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists

§ Percent of isolates that were resistant

¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).

** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 13. Antimicrobial resistance pattern for *Salmonella* ser. Enteritidis, 2008

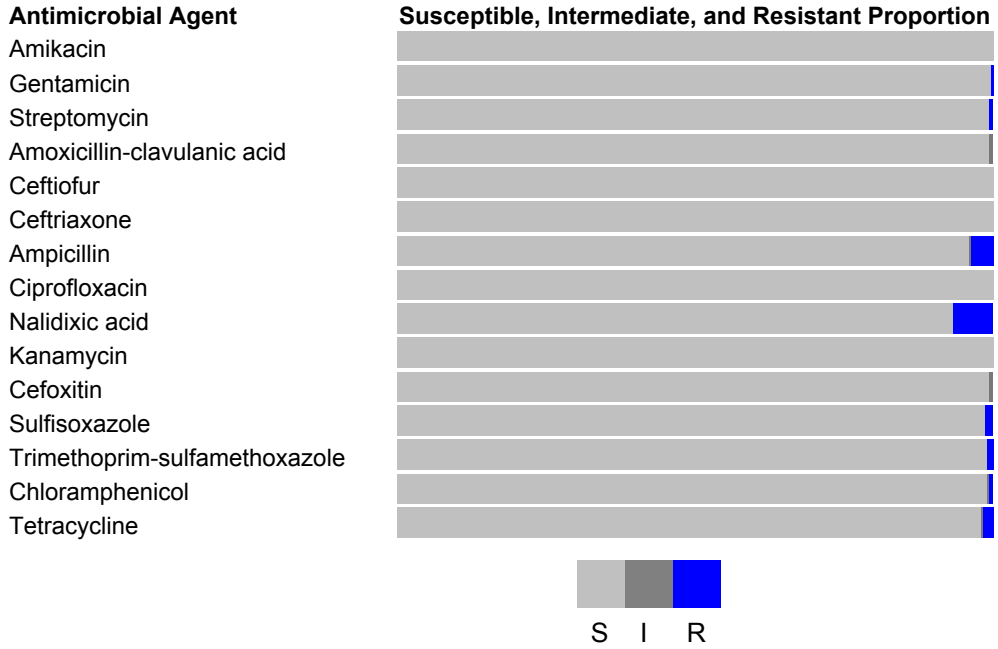


Table 10. Percentage and number of *Salmonella* ser. Enteritidis isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			269	319	277	337	257	271	384	413	385	439
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.8% 3	0.2% 1	0.0% 0	0.2% 1
		Streptomycin (MIC ≥ 64)	2.2% 6	0.0% 0	1.4% 4	1.5% 5	1.2% 3	2.2% 6	1.0% 4	1.2% 5	0.5% 2	0.5% 2
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.4% 1	0.0% 0	1.4% 4	0.6% 2	0.0% 0	0.0% 0	0.8% 3	0.5% 2	0.5% 2	0.0% 0
	Cephems	Ceftiofur (MIC ≥ 8)	0.4% 1	0.0% 0	2.2% 6	0.0% 0	0.0% 0	0.0% 0	0.5% 2	0.5% 2	0.3% 1	0.0% 0
		Ceftriaxone (MIC ≥ 4)	0.4% 1	0.0% 0	1.4% 4	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.3% 1	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	10.8% 29	7.5% 24	8.7% 24	6.8% 23	2.3% 6	4.1% 11	2.9% 11	4.4% 18	2.1% 8	3.6% 16
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	2.2% 6	2.2% 7	4.3% 12	3.9% 13	4.7% 12	6.6% 18	4.7% 18	7.0% 29	5.7% 22	6.6% 29
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.4% 1	0.3% 1	0.7% 2	0.3% 1	0.0% 0	0.7% 2	0.3% 1	0.2% 1	0.5% 2	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.0% 0	1.0% 4	0.5% 2	0.3% 1	0.0% 0
		Cephalothin (MIC ≥ 32)	1.9% 5	0.9% 3	1.1% 3	0.6% 2	1.2% 3	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	3.0% 8	0.9% 3	2.2% 6	1.5% 5	1.2% 3	1.8% 5	1.6% 6	1.5% 6	1.6% 6	1.1% 5
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.7% 2	0.0% 0	0.7% 2	0.6% 2	0.8% 2	0.0% 0	0.5% 2	0.5% 2	1.0% 4	0.9% 4
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.4% 1	0.0% 0	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.5% 2	0.0% 0	0.5% 2	0.5% 2
	Tetracyclines	Tetracycline (MIC ≥ 16)	8.2% 22	1.9% 6	1.8% 5	4.2% 14	1.6% 4	3.3% 9	2.3% 9	1.7% 7	3.9% 15	1.6% 7

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 11. Resistance patterns of *Salmonella* ser. Enteritidis isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	269	319	277	337	257	271	384	413	385	439
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	83.6%	89.0%	86.6%	87.5%	91.8%	87.1%	91.4%	88.6%	90.4%	87.9%
	225	284	240	295	236	236	351	366	348	386
Resistance ≥ 1 CLSI class*	16.4%	11.0%	13.4%	12.5%	8.2%	12.9%	8.6%	11.4%	9.6%	12.1%
	44	35	37	42	21	35	33	47	37	53
Resistance ≥ 2 CLSI classes*	8.6%	1.9%	4.7%	3.9%	2.3%	3.0%	3.6%	2.9%	3.4%	1.6%
	23	6	13	13	6	8	14	12	13	7
Resistance ≥ 3 CLSI classes*	1.1%	0.3%	2.9%	2.1%	0.4%	1.1%	1.6%	1.7%	1.0%	0.2%
	3	1	8	7	1	3	6	7	4	1
Resistance ≥ 4 CLSI classes*	0.4%	0.0%	1.1%	0.6%	0.4%	0.7%	1.0%	0.7%	0.3%	0.0%
	1	0	3	2	1	2	4	3	1	0
Resistance ≥ 5 CLSI classes*	0.4%	0.0%	0.4%	0.0%	0.4%	0.7%	0.5%	0.2%	0.3%	0.0%
	1	0	1	0	1	2	2	1	1	0
At least ACSSuT†	0.4%	0.0%	0.0%	0.0%	0.4%	0.4%	0.5%	0.0%	0.3%	0.0%
	1	0	0	0	1	1	2	0	1	0
At least ACT/S‡	0.4%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%
	1	0	0	0	1	0	0	0	0	0
At least ACSSuTAuCf§	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%
	1	0	0	0	0	0	1	0	1	0
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%
	0	0	0	0	0	0	1	0	1	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

B. *Salmonella* ser. Typhimurium

Table 12. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhimurium isolates to antimicrobial agents, 2008 (N=397)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.9]						1.0	33.2	62.7	2.8	0.3						
		Gentamicin	0.0	1.5	[0.6 - 3.3]					18.4	74.3	5.8				0.5	1.0				
		Streptomycin	N/A	28.5	[24.1 - 33.2]												71.5	13.4	15.1		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	20.9	3.3	[1.8 - 5.5]							72.3	1.5	0.3	1.8	20.9		3.3			
	Cephems	Ceftiofur	0.0	3.3	[1.8 - 5.5]						29.7	65.2	1.8			3.3					
		Ceftriaxone	0.0	3.3	[1.8 - 5.5]					96.7					1.0	1.8	0.3	0.3			
	Penicillins	Ampicillin	0.0	26.2	[21.9 - 30.8]							69.8	4.0				0.3	25.9			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 0.9]	94.0	3.3	0.3		1.0	1.5										
		Nalidixic acid	N/A	1.3	[0.4 - 2.9]						0.3		65.0	31.2	1.5	0.8		1.3			
II	**Aminoglycosides**	Kanamycin	0.0	2.3	[1.0 - 4.3]										97.7				2.3		
	Cephems	Cefoxitin	0.3	3.3	[1.8 - 5.5]							33.2	54.4	7.8	1.0	0.3	2.0	1.3			
	Folate pathway inhibitors	Sulfisoxazole	N/A	30.2	[25.7 - 35.0]											9.6	57.2	3.0			30.2
		Trimethoprim-sulfamethoxazole	N/A	1.8	[0.7 - 3.6]				72.3	25.7			0.3		1.8						
	Phenicols	Chloramphenicol	0.5	23.2	[19.1 - 27.6]								1.8	38.0	36.5	0.5		23.2			
	Tetracyclines	Tetracycline	0.3	27.5	[23.1 - 32.1]									72.3	0.3	1.0	17.6	8.8			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 14. Antimicrobial resistance pattern for *Salmonella* ser. Typhimurium, 2008

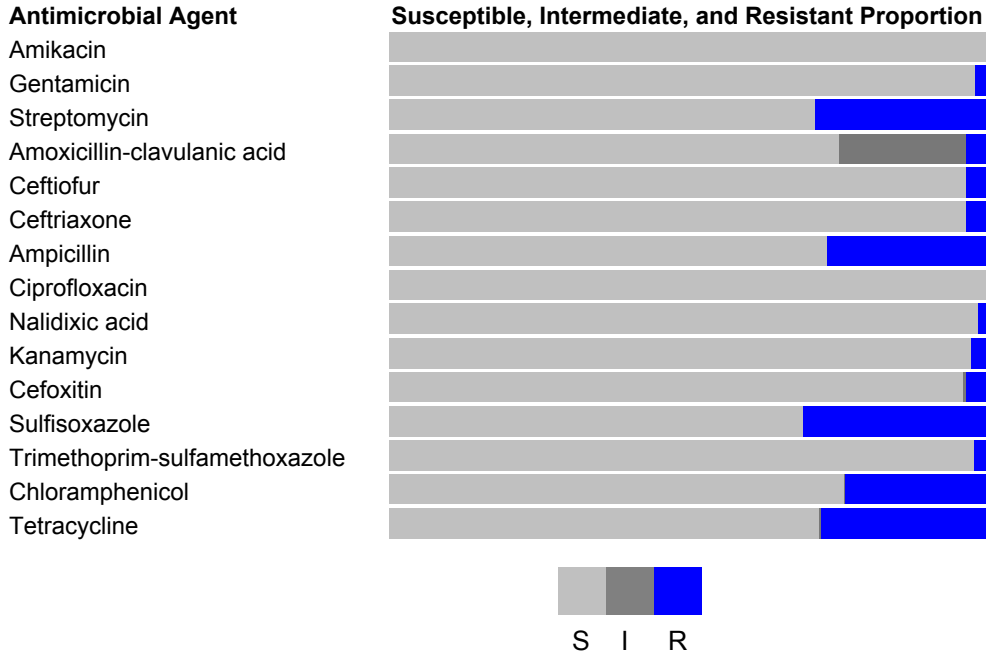


Table 13. Percentage and number of *Salmonella* ser. Typhimurium isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			363	304	325	394	408	382	438	409	403	397
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.2% 8	2.6% 8	1.5% 5	2.3% 9	2.0% 8	2.1% 8	1.8% 8	2.7% 11	2.5% 10	1.5% 6
		Streptomycin (MIC ≥ 64)	43.3% 157	39.5% 120	40.0% 130	32.0% 126	35.5% 145	31.7% 121	28.1% 123	29.3% 120	32.3% 130	28.5% 113
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	2.8% 10	6.3% 19	6.2% 20	7.6% 30	5.6% 23	4.7% 18	3.2% 14	4.4% 18	6.5% 26	3.3% 13
	Cephems	Ceftiofur (MIC ≥ 8)	1.9% 7	3.6% 11	3.1% 10	4.3% 17	4.9% 20	4.5% 17	2.5% 11	4.2% 17	6.2% 25	3.3% 13
		Ceftriaxone (MIC ≥ 4)	1.9% 7	3.3% 10	3.1% 10	4.3% 17	4.9% 20	4.5% 17	2.5% 11	4.2% 17	6.2% 25	3.3% 13
	Penicillins	Ampicillin (MIC ≥ 32)	41.3% 150	42.1% 128	42.5% 138	33.8% 133	36.3% 148	31.9% 122	29.0% 127	28.1% 115	31.5% 127	26.2% 104
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.0% 0	1.3% 4	0.6% 2	1.3% 5	1.2% 5	0.5% 2	0.9% 4	0.7% 3	1.5% 6	1.3% 5
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	12.9% 47	13.2% 40	8.3% 27	7.6% 30	7.1% 29	5.8% 22	5.7% 25	5.1% 21	5.7% 23	2.3% 9
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	3.6% 11	3.1% 10	4.3% 17	4.4% 18	4.7% 18	2.5% 11	3.9% 16	5.5% 22	3.3% 13
		Cephalothin (MIC ≥ 32)	4.4% 16	4.3% 13	3.1% 10	5.6% 22	6.1% 25	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	45.7% 166	45.4% 138	43.1% 140	32.2% 127	38.7% 158	35.9% 137	32.0% 140	33.3% 136	37.2% 150	30.2% 120
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.8% 10	3.6% 11	2.5% 8	2.3% 9	3.4% 14	2.6% 10	2.7% 12	2.2% 9	2.2% 9	1.8% 7
	Phenicols	Chloramphenicol (MIC ≥ 32)	28.9% 105	30.9% 94	31.7% 103	23.4% 92	28.2% 115	24.1% 92	24.4% 107	22.0% 90	25.3% 102	23.2% 92
	Tetracyclines	Tetracycline (MIC ≥ 16)	41.9% 152	43.4% 132	43.4% 141	32.0% 126	38.2% 156	30.1% 115	30.4% 133	31.5% 129	36.7% 148	27.5% 109

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 14. Resistance patterns of *Salmonella* ser. Typhimurium isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	363	304	325	394	408	382	438	409	403	397
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	50.4%	49.3%	49.2%	59.9%	54.7%	60.7%	65.1%	62.6%	57.6%	68.0%
	183	150	160	236	223	232	285	256	232	270
Resistance ≥ 1 CLSI class*	49.6%	50.7%	50.8%	40.1%	45.3%	39.3%	34.9%	37.4%	42.4%	32.0%
	180	154	165	158	185	150	153	153	171	127
Resistance ≥ 2 CLSI classes*	46.0%	46.4%	47.4%	36.3%	41.4%	36.9%	33.3%	34.0%	39.2%	31.2%
	167	141	154	143	169	141	146	139	158	124
Resistance ≥ 3 CLSI classes*	43.0%	43.4%	41.5%	32.5%	37.3%	31.4%	30.1%	30.3%	34.2%	27.7%
	156	132	135	128	152	120	132	124	138	110
Resistance ≥ 4 CLSI classes*	38.6%	39.8%	37.8%	28.4%	32.4%	27.5%	27.4%	26.9%	29.8%	24.7%
	140	121	123	112	132	105	120	110	120	98
Resistance ≥ 5 CLSI classes*	28.1%	29.6%	29.5%	23.1%	27.7%	24.1%	22.8%	20.8%	24.8%	23.7%
	102	90	96	91	113	92	100	85	100	94
At least ACSSuT†	27.8%	28.0%	29.5%	21.6%	26.5%	23.3%	22.4%	19.6%	22.6%	22.9%
	101	85	96	85	108	89	98	80	91	91
At least ACT/S‡	2.2%	1.6%	0.9%	2.0%	3.2%	1.6%	2.1%	0.7%	1.7%	0.5%
	8	5	3	8	13	6	9	3	7	2
At least ACSSuTAuCf§	0.6%	2.0%	1.2%	1.8%	2.2%	2.6%	1.8%	2.9%	3.5%	2.0%
	2	6	4	7	9	10	8	12	14	8
At least ceftiofur and nalidixic acid resistant	0.0%	0.3%	0.3%	0.5%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
	0	1	1	2	0	0	0	0	1	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

C. *Salmonella* ser. Newport

Table 15. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Newport isolates to antimicrobial agents, 2008 (N=252)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 1.5]						0.4	42.1	54.4	3.2							
		Gentamicin	0.0	0.4	[0.01 - 2.2]					21.4	74.2	3.6	0.4				0.4				
		Streptomycin	N/A	13.5	[9.5 - 18.3]												86.5	0.8	12.7		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.4	12.3	[8.5 - 17.0]							82.9	2.8	0.4	1.2	0.4	3.2	9.1			
	Cephems	Ceftiofur	0.0	12.3	[8.5 - 17.0]						30.6	55.6	1.6				12.3				
		Ceftriaxone	0.0	12.3	[8.5 - 17.0]					87.7					0.8	6.7	4.0	0.8			
	Penicillins	Ampicillin	0.0	14.3	[10.2 - 19.2]							81.3	4.4					14.3			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 1.5]	97.6	2.0		0.4												
		Nalidixic acid	N/A	0.4	[0.01 - 2.2]								50.8	48.0	0.8			0.4			
II	Aminoglycosides	Kanamycin	0.0	3.2	[1.4 - 6.2]										96.8				3.2		
	Cephems	Cefoxitin	0.0	12.3	[8.5 - 17.0]							34.9	48.0	4.8			2.8	9.5			
	Folate pathway inhibitors	Sulfisoxazole	N/A	13.1	[9.2 - 17.9]											3.2	52.0	31.0	0.4	0.4	13.1
		Trimethoprim-sulfamethoxazole	N/A	3.2	[1.4 - 6.2]				79.0	17.5	0.4				3.2						
	Phenicols	Chloramphenicol	0.8	11.9	[8.2 - 16.6]								2.8	59.5	25.0	0.8		11.9			
	Tetracyclines	Tetracycline	0.0	13.9	[9.9 - 18.8]									86.1			0.8	13.1			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 15. Antimicrobial resistance pattern for *Salmonella* ser. Newport, 2008

Table 16. Percentage and number of *Salmonella* ser. Newport isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			99	121	124	241	223	191	207	217	220	252
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	2.5% 3	3.2% 4	3.3% 8	3.1% 7	0.5% 1	1.0% 2	0.9% 2	0.9% 2	0.4% 1
		Streptomycin (MIC ≥ 64)	19.2% 19	24.0% 29	31.5% 39	25.3% 61	24.2% 54	15.7% 30	14.0% 29	13.8% 30	10.0% 22	13.5% 34
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	18.2% 18	22.3% 27	26.6% 33	22.8% 55	21.5% 48	15.2% 29	12.6% 26	12.4% 27	7.7% 17	12.3% 31
	Cephems	Ceftiofur (MIC ≥ 8)	18.2% 18	22.3% 27	27.4% 34	22.8% 55	22.0% 49	15.2% 29	12.6% 26	12.4% 27	7.7% 17	12.3% 31
		Ceftriaxone (MIC ≥ 4)	18.2% 18	22.3% 27	25.8% 32	22.8% 55	21.5% 48	14.7% 28	12.6% 26	12.9% 28	7.7% 17	12.3% 31
	Penicillins	Ampicillin (MIC ≥ 32)	18.2% 18	23.1% 28	29.8% 37	24.9% 60	22.9% 51	15.7% 30	14.0% 29	15.2% 33	9.5% 21	14.3% 36
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.0% 0	0.8% 1	0.0% 0	0.8% 2	0.4% 1	0.5% 1	0.0% 0	0.5% 1	0.0% 0	0.4% 1
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	1.0% 1	5.0% 6	7.3% 9	10.0% 24	4.5% 10	2.6% 5	1.9% 4	2.3% 5	0.9% 2	3.2% 8
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	22.3% 27	25.8% 32	22.4% 54	21.5% 48	15.2% 29	12.6% 26	12.9% 28	7.7% 17	12.3% 31
		Cephalothin (MIC ≥ 32)	18.2% 18	22.3% 27	26.6% 33	22.8% 55	22.4% 50	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	22.2% 22	23.1% 28	32.3% 40	25.7% 62	24.7% 55	16.8% 32	15.5% 32	15.2% 33	10.0% 22	13.1% 33
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.0% 2	4.1% 5	1.6% 2	4.1% 10	0.9% 2	2.1% 4	1.9% 4	3.2% 7	1.8% 4	3.2% 8
	Phenicols	Chloramphenicol (MIC ≥ 32)	18.2% 18	23.1% 28	28.2% 35	25.3% 61	22.4% 50	15.2% 29	13.5% 28	12.4% 27	9.1% 20	11.9% 30
	Tetracyclines	Tetracycline (MIC ≥ 16)	19.2% 19	23.1% 28	30.6% 38	25.7% 62	24.2% 54	16.8% 32	14.5% 30	14.3% 31	9.5% 21	13.9% 35

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 17. Resistance patterns of *Salmonella* ser. Newport isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	99	121	124	241	223	191	207	217	220	252
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	75.8%	75.2%	65.3%	72.2%	73.5%	82.2%	84.1%	82.9%	89.5%	85.3%
	75	91	81	174	164	157	174	180	197	215
Resistance ≥ 1 CLSI class*	24.2%	24.8%	34.7%	27.8%	26.5%	17.8%	15.9%	17.1%	10.5%	14.7%
	24	30	43	67	59	34	33	37	23	37
Resistance ≥ 2 CLSI classes*	18.2%	23.1%	32.3%	25.3%	25.1%	17.3%	15.0%	16.6%	10.5%	13.5%
	18	28	40	61	56	33	31	36	23	34
Resistance ≥ 3 CLSI classes*	18.2%	23.1%	31.5%	25.3%	23.3%	16.2%	14.5%	15.2%	10.5%	13.5%
	18	28	39	61	52	31	30	33	23	34
Resistance ≥ 4 CLSI classes*	18.2%	23.1%	31.5%	25.3%	22.9%	15.7%	14.0%	13.4%	9.1%	13.5%
	18	28	39	61	51	30	29	29	20	34
Resistance ≥ 5 CLSI classes*	18.2%	23.1%	26.6%	23.7%	22.4%	14.7%	12.6%	12.9%	8.2%	12.7%
	18	28	33	57	50	28	26	28	18	32
At least ACSSuT†	18.2%	23.1%	25.8%	23.7%	22.0%	14.7%	12.6%	12.0%	8.2%	11.5%
	18	28	32	57	49	28	26	26	18	29
At least ACT/S‡	2.0%	4.1%	0.8%	3.7%	0.9%	1.0%	1.9%	2.3%	0.5%	2.8%
	2	5	1	9	2	2	4	5	1	7
At least ACSSuTAuCf§	18.2%	22.3%	25.0%	22.8%	21.1%	14.7%	12.6%	10.6%	7.7%	11.5%
	18	27	31	55	47	28	26	23	17	29
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.4%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
	0	0	0	1	0	1	0	0	0	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

D. *Salmonella* ser. I 4,[5],12:i:-

Table 18. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. I 4,[5],12:i:- isolates to antimicrobial agents, 2008 (N=83)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 4.3]						1.2	31.3	63.9	3.6							
		Gentamicin	0.0	3.6	[0.7 - 10.2]					20.5	71.1	4.8				2.4	1.2				
		Streptomycin	N/A	10.8	[5.1 - 19.6]												89.2	2.4	8.4		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.2	3.6	[0.7 - 10.2]							90.4		2.4	2.4	1.2	1.2	2.4			
	Cephems	Ceftiofur	0.0	3.6	[0.7 - 10.2]					1.2	34.9	60.2				3.6					
		Ceftriaxone	0.0	3.6	[0.7 - 10.2]					96.4					1.2	2.4					
	Penicillins	Ampicillin	0.0	8.4	[3.4 - 16.6]							84.3	6.0	1.2				8.4			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 4.3]	98.8				1.2											
		Nalidixic acid	N/A	1.2	[0.02 - 6.5]								81.9	16.9				1.2			
II	Aminoglycosides	Kanamycin	0.0	1.2	[0.02 - 6.5]										98.8				1.2		
	Cephems	Cefoxitin	0.0	3.6	[0.7 - 10.2]							42.2	48.2	4.8	1.2		2.4	1.2			
	Folate pathway inhibitors	Sulfisoxazole	N/A	13.3	[6.8 - 22.5]											7.2	71.1	8.4			13.3
		Trimethoprim-sulfamethoxazole	N/A	4.8	[1.3 - 11.9]				72.3	22.9					4.8						
	Phenicols	Chloramphenicol	0.0	6.0	[2.0 - 13.5]									43.4	50.6			6.0			
	Tetracyclines	Tetracycline	0.0	16.9	[9.5 - 26.7]									83.1		1.2	2.4	13.3			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 16. Antimicrobial resistance pattern for *Salmonella* ser. I 4,[5],12:i:-, 2008

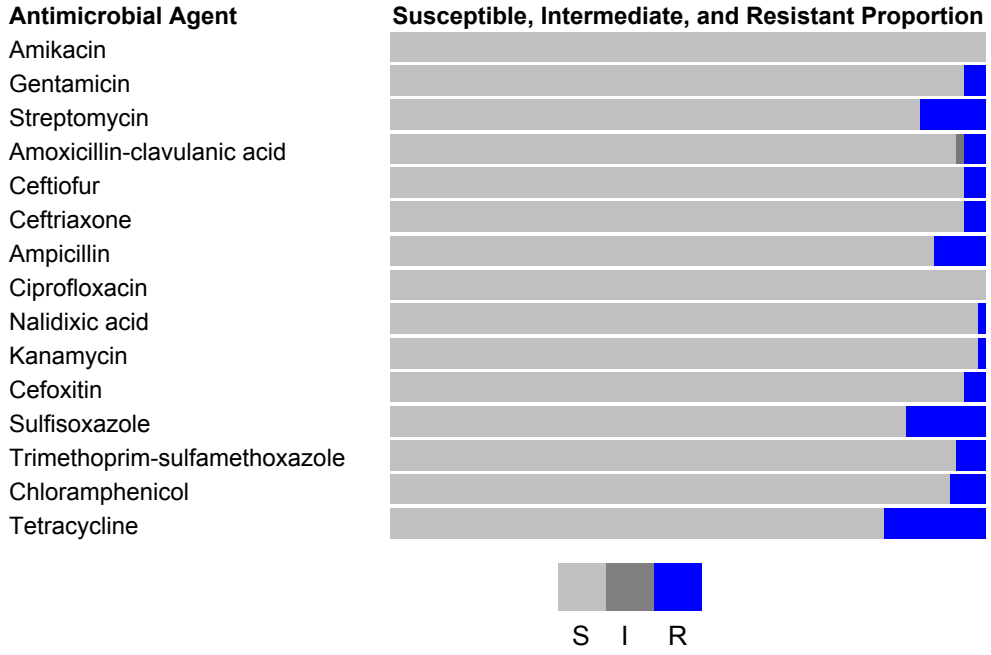


Table 19. Percentage and number of *Salmonella* ser. I 4,[5],12:i:- isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			8	13	14	35	37	36	33	105	73	83
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	7.1% 1	0.0% 0	5.4% 2	5.6% 2	0.0% 0	4.8% 5	1.4% 1	3.6% 3
		Streptomycin (MIC ≥ 64)	0.0% 0	7.7% 1	14.3% 2	2.9% 1	8.1% 3	5.6% 2	3.0% 1	3.8% 4	8.2% 6	10.8% 9
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	0.0% 0	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	1.4% 1	3.6% 3
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	7.1% 1	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	2.7% 2	3.6% 3
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	2.7% 2	3.6% 3
	Penicillins	Ampicillin (MIC ≥ 32)	0.0% 0	7.7% 1	7.1% 1	8.6% 3	8.1% 3	5.6% 2	6.1% 2	6.7% 7	5.5% 4	8.4% 7
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.7% 1	2.8% 1	0.0% 0	1.0% 1	1.4% 1	1.2% 1
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	7.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.4% 1	1.2% 1
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	1.4% 1	3.6% 3
		Cephalothin (MIC ≥ 32)	0.0% 0	0.0% 0	7.1% 1	2.9% 1	5.4% 2	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	12.5% 1	0.0% 0	14.3% 2	2.9% 1	5.4% 2	11.1% 4	0.0% 0	8.6% 9	4.1% 3	13.3% 11
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	0.0% 0	1.4% 1	4.8% 4
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	1.9% 2	1.4% 1	6.0% 5
	Tetracyclines	Tetracycline (MIC ≥ 16)	0.0% 0	7.7% 1	7.1% 1	5.7% 2	0.0% 0	11.1% 4	3.0% 1	8.6% 9	9.6% 7	16.9% 14

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 20. Resistance patterns of *Salmonella* ser. I 4,[5],12:i:- isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	8	13	14	35	37	36	33	105	73	83
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	87.5%	92.3%	78.6%	91.4%	78.4%	80.6%	87.9%	85.7%	82.2%	77.1%
	7	12	11	32	29	29	29	90	60	64
Resistance ≥ 1 CLSI class*	12.5%	7.7%	21.4%	8.6%	21.6%	19.4%	12.1%	14.3%	17.8%	22.9%
	1	1	3	3	8	7	4	15	13	19
Resistance ≥ 2 CLSI classes*	0.0%	7.7%	14.3%	8.6%	10.8%	13.9%	3.0%	11.4%	6.8%	16.9%
	0	1	2	3	4	5	1	12	5	14
Resistance ≥ 3 CLSI classes*	0.0%	7.7%	7.1%	5.7%	5.4%	8.3%	3.0%	9.5%	5.5%	9.6%
	0	1	1	2	2	3	1	10	4	8
Resistance ≥ 4 CLSI classes*	0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	3.8%	2.7%	7.2%
	0	0	1	1	0	1	0	4	2	6
Resistance ≥ 5 CLSI classes*	0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	2.9%	1.4%	4.8%
	0	0	1	1	0	1	0	3	1	4
At least ACSSuT†	0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	1.9%	1.4%	3.6%
	0	0	1	1	0	1	0	2	1	3
At least ACT/S‡	0.0%	0.0%	7.1%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	1	1	0	0	0	0	0	0
At least ACSSuTAuCf§	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
	0	0	0	0	0	0	0	0	0	2
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	0	0	0	0	0	0	0	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

E. *Salmonella* ser. Heidelberg

Table 21. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Heidelberg isolates to antimicrobial agents, 2008 (N=75)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 4.8]						6.7	56.0	34.7	2.7							
		Gentamicin	1.3	14.7	[7.5 - 24.7]					41.3	40.0	2.7			1.3	4.0	10.7				
		Streptomycin	N/A	30.7	[20.5 - 42.4]												69.3	16.0	14.7		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.0	8.0	[3.0 - 16.6]							72.0		1.3	14.7	4.0		8.0			
	Cephems	Ceftiofur	0.0	8.0	[3.0 - 16.6]						50.7	40.0	1.3			8.0					
		Ceftriaxone	0.0	8.0	[3.0 - 16.6]					92.0					1.3	5.3		1.3			
	Penicillins	Ampicillin	0.0	28.0	[18.2 - 39.6]							69.3	2.7					28.0			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 4.8]	98.7	1.3														
		Nalidixic acid	N/A	0.0	[0.0 - 4.8]							1.3	38.7	60.0							
II	Aminoglycosides	Kanamycin	0.0	26.7	[17.1 - 38.1]										69.3	4.0		1.3	25.3		
	Cephems	Cefoxitin	0.0	8.0	[3.0 - 16.6]							53.3	33.3	5.3			4.0	4.0			
	Folate pathway inhibitors	Sulfisoxazole	N/A	12.0	[5.6 - 21.6]											42.7	41.3	4.0			12.0
		Trimethoprim-sulfamethoxazole	N/A	2.7	[0.3 - 9.3]				74.7	22.7					2.7						
	Phenicols	Chloramphenicol	0.0	1.3	[0.02 - 7.2]									40.0	58.7			1.3			
	Tetracyclines	Tetracycline	1.3	36.0	[25.2 - 47.9]									62.7	1.3			36.0			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 17. Antimicrobial resistance pattern for *Salmonella* ser. Heidelberg, 2008

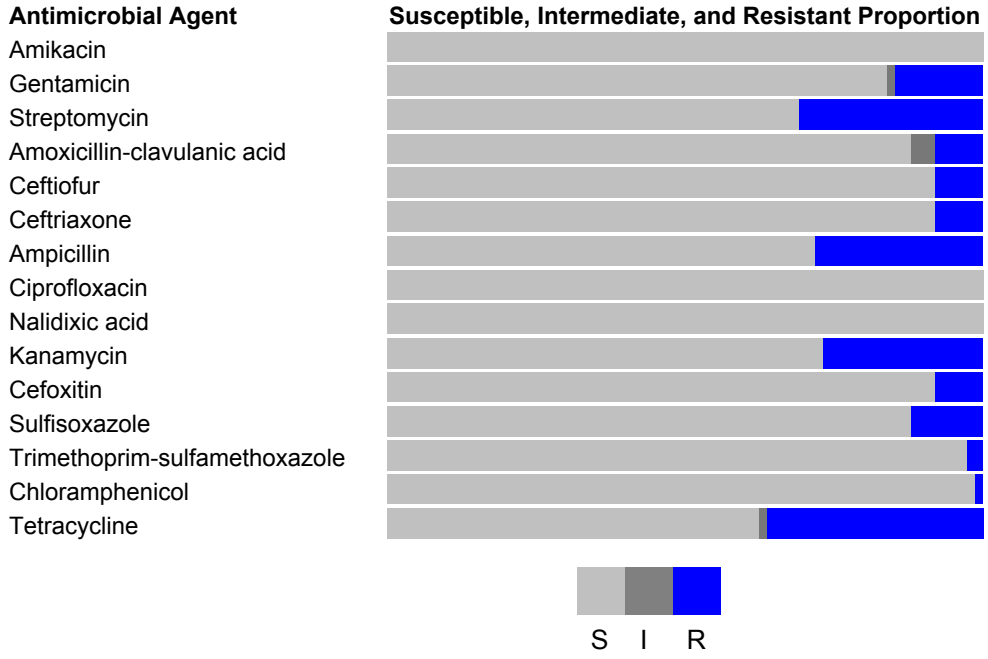


Table 22. Percentage and number of *Salmonella* ser. Heidelberg isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			88	79	102	105	96	93	125	102	98	75
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	14.8% 13	8.9% 7	7.8% 8	3.8% 4	5.2% 5	4.3% 4	6.4% 8	4.9% 5	16.3% 16	14.7% 11
		Streptomycin (MIC ≥ 64)	23.9% 21	22.8% 18	25.5% 26	17.1% 18	12.5% 12	15.1% 14	13.6% 17	11.8% 12	12.2% 12	30.7% 23
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.1% 1	3.8% 3	2.9% 3	9.5% 10	5.2% 5	10.8% 10	8.8% 11	9.8% 10	7.1% 7	8.0% 6
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	3.8% 3	2.9% 3	7.6% 8	5.2% 5	9.7% 9	8.8% 11	9.8% 10	7.1% 7	8.0% 6
		Ceftriaxone (MIC ≥ 4)	0.0% 0	3.8% 3	2.9% 3	7.6% 8	5.2% 5	9.7% 9	8.8% 11	9.8% 10	7.1% 7	8.0% 6
	Penicillins	Ampicillin (MIC ≥ 32)	6.8% 6	10.1% 8	9.8% 10	12.4% 13	10.4% 10	25.8% 24	20.0% 25	18.6% 19	18.4% 18	28.0% 21
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	1.1% 1	1.3% 1	0.0% 0	0.0% 0	1.0% 1	0.0% 0	0.8% 1	0.0% 0	0.0% 0	0.0% 0
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	9.1% 8	15.2% 12	19.6% 20	10.5% 11	8.3% 8	8.6% 8	12.8% 16	8.8% 9	11.2% 11	26.7% 20
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	2.5% 2	2.9% 3	8.6% 9	5.2% 5	8.6% 8	8.8% 11	8.8% 9	7.1% 7	8.0% 6
		Cephalothin (MIC ≥ 32)	3.4% 3	5.1% 4	3.9% 4	10.5% 11	7.3% 7	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	18.2% 16	11.4% 9	8.8% 9	6.7% 7	7.3% 7	7.5% 7	8.0% 10	4.9% 5	18.4% 18	12.0% 9
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	1.1% 1	1.3% 1	2.0% 2	1.0% 1	2.1% 2	0.0% 0	0.8% 1	0.0% 0	0.0% 0	2.7% 2
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.1% 1	1.3% 1	1.0% 1	1.0% 1	0.0% 0	1.1% 1	0.8% 1	0.0% 0	3.1% 3	1.3% 1
	Tetracyclines	Tetracycline (MIC ≥ 16)	18.2% 16	21.5% 17	24.5% 25	19.0% 20	16.7% 16	19.4% 18	18.4% 23	13.7% 14	22.4% 22	36.0% 27

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 23. Resistance patterns of *Salmonella* ser. Heidelberg isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	88	79	102	105	96	93	125	102	98	75
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	68.2%	63.3%	64.7%	67.6%	68.8%	55.9%	62.4%	67.6%	58.2%	57.3%
	60	50	66	71	66	52	78	69	57	43
Resistance ≥ 1 CLSI class*	31.8%	36.7%	35.3%	32.4%	31.3%	44.1%	37.6%	32.4%	41.8%	42.7%
	28	29	36	34	30	41	47	33	41	32
Resistance ≥ 2 CLSI classes*	26.1%	26.6%	28.4%	25.7%	17.7%	23.7%	24.8%	23.5%	28.6%	40.0%
	23	21	29	27	17	22	31	24	28	30
Resistance ≥ 3 CLSI classes*	10.2%	7.6%	7.8%	12.4%	10.4%	14.0%	15.2%	12.7%	17.3%	28.0%
	9	6	8	13	10	13	19	13	17	21
Resistance ≥ 4 CLSI classes*	3.4%	3.8%	2.0%	1.9%	0.0%	4.3%	4.8%	2.0%	5.1%	13.3%
	3	3	2	2	0	4	6	2	5	10
Resistance ≥ 5 CLSI classes*	0.0%	2.5%	1.0%	1.9%	0.0%	3.2%	1.6%	2.0%	4.1%	6.7%
	0	2	1	2	0	3	2	2	4	5
At least ACSSuT†	0.0%	1.3%	1.0%	1.0%	0.0%	1.1%	0.0%	0.0%	3.1%	1.3%
	0	1	1	1	0	1	0	0	3	1
At least ACT/S‡	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	0	1	0	0	0	0	0	0
At least ACSSuTAuCf§	0.0%	1.3%	1.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	1	1	1	0	0	0	0	0	0
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	0	0	0	0	0	0	0	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

F. Specific Drug Resistance Phenotypes

Table 24. Number and percentage of ACSSuT-, ACSSuTAuCf-, Nalidixic Acid-, and Ceftiofur-resistant isolates among the 20 most common non-typhoidal *Salmonella* serotypes isolated in NARMS, 2008

Rank	Serotype	N	ACSSuT*		ACSSuTAuCf†		Nalidixic Acid		Ceftiofur	
			n	(%)	n	(%)	n	(%)	n	(%)
1	Enteritidis	439	0	(0.0%)	0	(0.0%)	**29**	**(61.7%)**	0	(0.0%)
2	Typhimurium	397	**91**	**(66.4%)**	**8**	**(53.3%)**	**5**	**(10.6%)**	**13**	**(18.6%)**
3	Newport	252	**29**	**(21.2%)**	**1**	**(6.7%)**	**1**	**(2.1%)**	**31**	**(44.3%)**
4	Javiana	118	0	(0.0%)	0	(0.0%)	**1**	**(2.1%)**	**1**	**(1.4%)**
5	Saintpaul	108	**1**	**(0.7%)**	**1**	**(6.7%)**	0	(0.0%)	**4**	**(5.7%)**
6	I 4,[5],12:i:-	83	**3**	**(2.2%)**	**2**	**(13.3%)**	**1**	**(2.1%)**	**3**	**(4.3%)**
7	Heidelberg	75	**1**	**(0.7%)**	0	(0.0%)	0	(0.0%)	**6**	**(8.6%)**
8	Montevideo	68	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
9	Braenderup	56	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
10	Infantis	51	**1**	**(0.7%)**	0	(0.0%)	**1**	**(2.1%)**	0	(0.0%)
11	Muenchen	51	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
12	Oranienburg	50	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
13	Agona	39	0	(0.0%)	0	(0.0%)	**1**	**(2.1%)**	**4**	**(5.7%)**
14	Thompson	32	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
15	Mississippi	31	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
16	Poona	26	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
17	Schwarzengrund	24	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
18	Litchfield	23	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
19	Paratyphi B var. L(+) tartrate+	23	**1**	**(0.7%)**	0	(0.0%)	0	(0.0%)	0	(0.0%)
20	Hadar	19	0	(0.0%)	0	(0.0%)	**1**	**(2.1%)**	0	(0.0%)
	Subtotal	**1965**	**127**	**(92.7%)**	**12**	**(80.0%)**	**40**	**(85.1%)**	**62**	**(88.6%)**
	All other serotypes	349	7	(5.1%)	2	(13.3%)	5	(10.6%)	7	(10.0%)
	Unknown serotype	35	0	(0.0%)	0	(0.0%)	1	(2.1%)	0	(0.0%)
	Partially serotyped	14	2	(1.5%)	1	(6.7%)	0	(0.0%)	1	(1.4%)
	Rough/Nonmotile isolates	16	1	(0.7%)	0	(0.0%)	1	(2.1%)	0	(0.0%)
	Total	**2379**	**137**	**(100.0%)**	**15**	**(100.0%)**	**47**	**(100.0%)**	**70**	**(100.0%)**

*ACSSuT: ampicillin, chloramphenicol, streptomycin, sulfisoxazole, tetracycline

†ACSSuTAuCf = ACSSuT, amoxicillin-clavulanic acid, and ceftiofur

2. Typhoidal *Salmonella*

A. *Salmonella* ser. Typhi

Table 25. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhi isolates to antimicrobial agents, 2008 (N=410)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**													
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 0.9]						28.0	66.3	5.1	0.5							
		Gentamicin	0.0	0.0	[0.0 - 0.9]					91.2	8.8										
		Streptomycin	N/A	11.5	[8.5 - 15.0]												88.5	0.2	11.2		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.7	0.0	[0.0 - 0.9]							86.3	1.0	2.9	9.0	0.7					
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 0.9]				1.2	7.3	79.5	12.0									
		Ceftriaxone	0.0	0.0	[0.0 - 0.9]					99.8		0.2									
	Penicillins	Ampicillin	0.0	13.2	[10.1 - 16.8]							85.6	1.2					13.2			
	Quinolones	Ciprofloxacin	0.7	0.0	[0.0 - 0.9]	37.6	0.5	3.9	19.0	35.9	2.4		0.7								
		Nalidixic acid	N/A	59.0	[54.1 - 63.8]							4.4	31.7	3.4	1.5		3.4	55.6			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 0.9]										100.0						
	Cephems	Cefoxitin	0.5	0.0	[0.0 - 0.9]						7.8	40.2	9.8	36.1	5.6	0.5					
	Folate pathway inhibitors	Sulfisoxazole	N/A	13.2	[10.1 - 16.8]											61.2	19.3	4.4	1.5	0.5	13.2
		Trimethoprim-sulfamethoxazole	N/A	12.7	[9.6 - 16.3]				80.0	7.1			0.2		12.7						
	Phenicols	Chloramphenicol	0.0	12.9	[9.8 - 16.6]								5.1	73.4	8.5			12.9			
	Tetracyclines	Tetracycline	0.2	4.6	[2.8 - 7.1]									95.1	0.2			4.6			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 18. Antimicrobial resistance pattern for *Salmonella* ser. Typhi, 2008

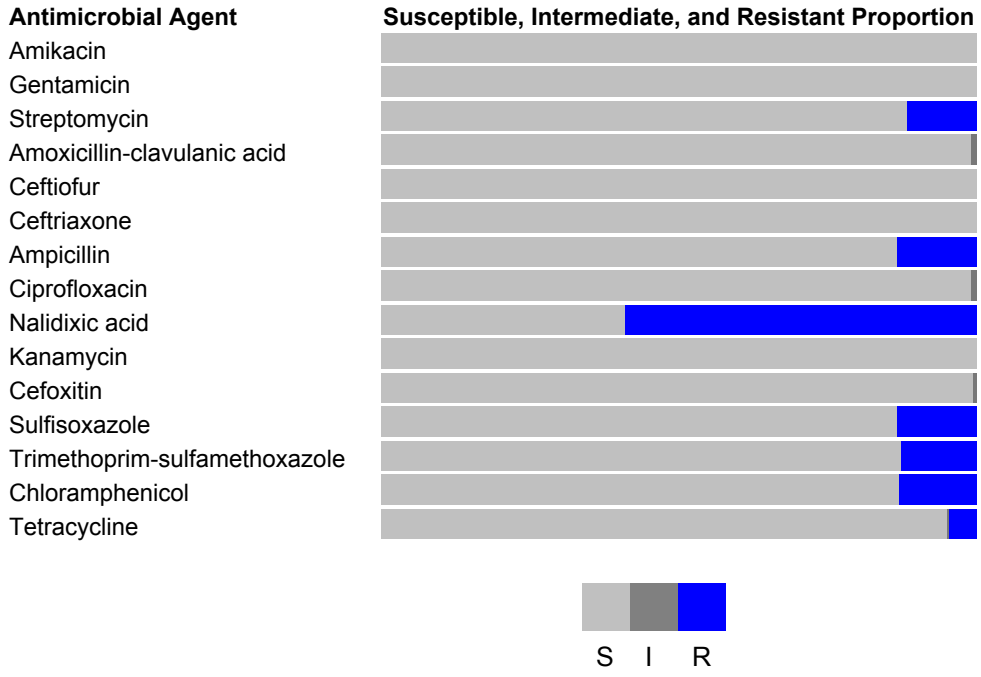


Table 26. Percentage and number of *Salmonella* ser. Typhi isolates resistant to antimicrobial agents, 1999–2008

Year / Total Isolates			1999 166	2000 177	2001 197	2002 195	2003 333	2004 304	2005 318	2006 323	2007 398	2008 410
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	13.9% 23	9.0% 16	20.3% 40	7.2% 14	14.4% 48	11.8% 36	13.2% 42	18.9% 61	15.6% 62	11.5% 47
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.3% 1	0.0% 0
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	12.7% 21	9.0% 16	20.3% 40	5.6% 11	15.9% 53	11.8% 36	13.2% 42	20.4% 66	17.1% 68	13.2% 54
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.9% 3	1.0% 4	0.0% 0
		Nalidixic acid (MIC ≥ 32)	19.3% 32	22.0% 39	29.9% 59	23.6% 46	37.8% 126	41.8% 127	48.4% 154	54.2% 175	62.3% 248	59.0% 242
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	0.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.6% 1	0.5% 1	0.0% 0	0.6% 2	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.0% 0
		Cephalothin (MIC ≥ 32)	1.8% 3	1.1% 2	0.5% 1	1.5% 3	0.3% 1	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	16.3% 27	11.3% 20	20.8% 41	6.2% 12	17.1% 57	11.8% 36	14.2% 45	20.7% 67	17.6% 70	13.2% 54
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	13.3% 22	9.0% 16	20.8% 41	6.7% 13	16.8% 56	13.2% 40	14.5% 46	20.7% 67	16.3% 65	12.7% 52
	Phenicols	Chloramphenicol (MIC ≥ 32)	12.7% 21	10.7% 19	20.8% 41	6.2% 12	16.5% 55	13.2% 40	13.2% 42	19.5% 63	15.8% 63	12.9% 53
	Tetracyclines	Tetracycline (MIC ≥ 16)	9.6% 16	9.6% 17	20.8% 41	6.7% 13	15.6% 52	8.9% 27	10.1% 32	8.4% 27	6.3% 25	4.6% 19

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 27. Resistance patterns of *Salmonella* ser. Typhi isolates, 1999–2008

Year / Total Isolates	1999 166	2000 177	2001 197	2002 195	2003 333	2004 304	2005 318	2006 323	2007 398	2008 410
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	71.7% 119	72.3% 128	58.9% 116	74.4% 145	56.5% 188	56.6% 172	48.1% 153	40.6% 131	35.4% 141	38.0% 156
Resistance ≥ 1 CLSI class*	28.3% 47	27.7% 49	41.1% 81	25.6% 50	43.5% 145	43.4% 132	51.9% 165	59.4% 192	64.6% 257	62.0% 254
Resistance ≥ 2 CLSI classes*	14.5% 24	10.7% 19	22.8% 45	7.2% 14	17.7% 59	13.2% 40	14.5% 46	21.7% 70	18.1% 72	14.4% 59
Resistance ≥ 3 CLSI classes*	12.7% 21	9.6% 17	21.8% 43	6.7% 13	16.8% 56	12.8% 39	13.8% 44	20.7% 67	17.6% 70	13.4% 55
Resistance ≥ 4 CLSI classes*	12.7% 21	9.0% 16	21.3% 42	6.2% 12	16.5% 55	12.5% 38	12.9% 41	19.2% 62	17.1% 68	12.9% 53
Resistance ≥ 5 CLSI classes*	11.4% 19	7.9% 14	16.8% 33	5.6% 11	14.1% 47	11.8% 36	11.9% 38	16.7% 54	14.8% 59	10.7% 44
At least ACSSuT†	9.6% 16	7.9% 14	16.8% 33	5.6% 11	12.6% 42	7.9% 24	9.1% 29	5.9% 19	3.8% 15	2.4% 10
At least ACT/S‡	12.7% 21	9.0% 16	17.8% 35	5.6% 11	15.6% 52	11.8% 36	12.9% 41	18.6% 60	15.3% 61	12.2% 50
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0

* CLSI: Clinical and Laboratory Standards Institute

† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline

‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

B. *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C

Table 28. Frequency of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolated in NARMS, 2007

Species	2008	
	n	(%)
Paratyphi A	90	(97.8%)
Paratyphi B	2	(2.2%)
Paratyphi C	0	(0.0%)
Total	**92**	**(100.0%)**

Table 29. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates to antimicrobial agents, 2008 (N=92)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**													
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 3.9]						90.2	3.3	6.5							
		Gentamicin	0.0	0.0	[0.0 - 3.9]					93.5	5.4	1.1								
		Streptomycin	N/A	1.1	[0.01 - 5.9]												98.9		1.1	
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	1.1	[0.01 - 5.9]							39.1	57.6	2.2				1.1		
	Cephems	Ceftiofur	0.0	1.1	[0.01 - 5.9]					1.1	3.3	92.4	2.2			1.1				
		Ceftriaxone	0.0	1.1	[0.01 - 5.9]					98.9					1.1					
	Penicillins	Ampicillin	0.0	1.1	[0.01 - 5.9]							7.6	87.0	3.3	1.1			1.1		
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 3.9]	12.0	1.1	1.1	1.1	7.6	77.2									
		Nalidixic acid	N/A	85.9	[77.0 - 92.3]								4.3	8.7		1.1	1.1	84.8		
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 3.9]										100.0					
	Cephems	Cefoxitin	1.1	1.1	[0.01 - 5.9]							1.1	7.6	69.6	19.6	1.1		1.1		
	Folate pathway inhibitors	Sulfisoxazole	N/A	1.1	[0.01 - 5.9]											50.0	46.7	2.2		1.1
		Trimethoprim-sulfamethoxazole	N/A	0.0	[0.0 - 3.9]				81.5	18.5										
	Phenicols	Chloramphenicol	18.5	1.1	[0.01 - 5.9]								1.1	3.3	76.1	18.5		1.1		
	Tetracyclines	Tetracycline	0.0	2.2	[0.2 - 7.6]									97.8				2.2		

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 19. Antimicrobial resistance pattern for *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C, 2008

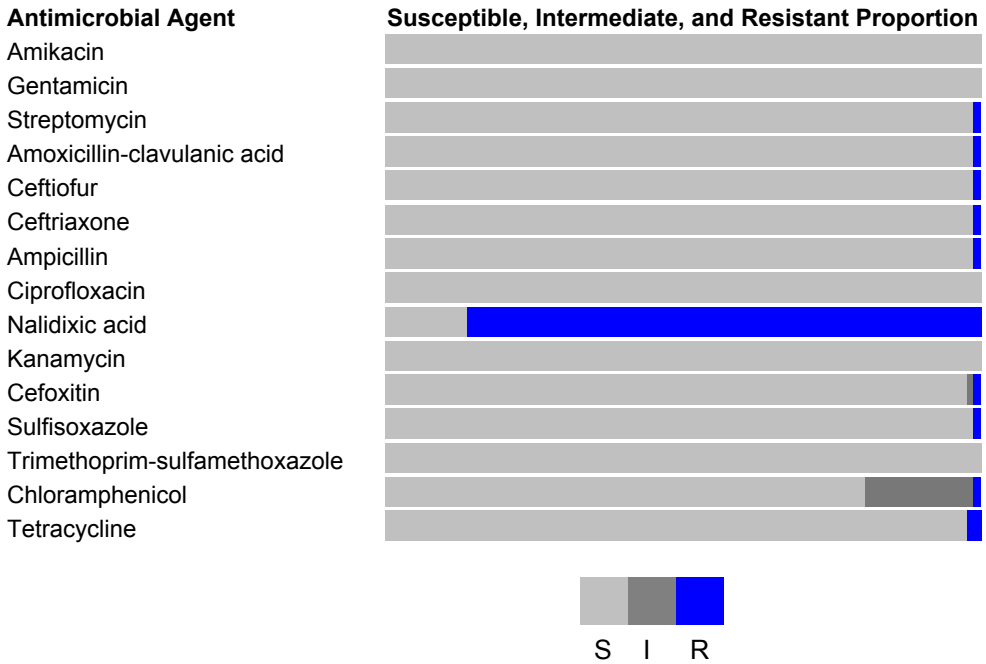


Table 30. Percentage and number of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			2	5	9	10	8	11	18	16	17	92
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	0.0% 0	20.0% 1	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
	Penicillins	Ampicillin (MIC ≥ 32)	0.0% 0	20.0% 1	0.0% 0	0.0% 0	12.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.0% 0	40.0% 2	55.6% 5	40.0% 4	75.0% 6	72.7% 8	66.7% 12	50.0% 8	94.1% 16	85.9% 79
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
		Cephalothin (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
	Tetracyclines	Tetracycline (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.2% 2

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 31. Resistance patterns of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	2	5	9	10	8	11	18	16	17	92
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	100.0% 2	40.0% 2	44.4% 4	50.0% 5	12.5% 1	27.3% 3	33.3% 6	50.0% 8	5.9% 1	12.0% 11
Resistance ≥ 1 CLSI class*	0.0% 0	60.0% 3	55.6% 5	50.0% 5	87.5% 7	72.7% 8	66.7% 12	50.0% 8	94.1% 16	88.0% 81
Resistance ≥ 2 CLSI classes*	0.0% 0	20.0% 1	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
Resistance ≥ 3 CLSI classes*	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
Resistance ≥ 4 CLSI classes*	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
Resistance ≥ 5 CLSI classes*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
At least ACSSuT†	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
At least ACT/S‡	0.0% 0	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

Box 2. Identification of the aminoglycoside resistance determinants, *armA* and *rmtC*, among human non-typhoidal *Salmonella* isolated in the United States

Aminoglycosides are an important class of antimicrobial agents for the treatment of life-threatening bacterial infections. Several mechanisms for aminoglycoside resistance have been described. Among these mechanisms, 16S rRNA methyltransferases are especially troublesome due to their wide target range and their ability to confer high levels of resistance.

From 1996-2007, 20,331 isolates of non-typhoidal *Salmonella* were collected and tested by CDC. Two isolates displayed resistance to three aminoglycosides; defined as ≥ 64 μg/ml amikacin, ≥ 16 μg/ml gentamicin, and ≥ 64 μg/ml kanamycin. AM04864 was *Salmonella enterica* serotype Stanley, submitted in 1999. Additional information from the patient was not available. AM23818 was *Salmonella enterica* serotype Virchow, submitted in 2005. The patient was an 11-month-old Asian male from Hartford, Connecticut. Prior to illness onset, he visited a farm in India and had exposure to farm animals. The patient became ill with non-bloody diarrhea in India. Upon return to the United States, he obtained medical care. Oral antibiotics were prescribed following specimen collection; the antibiotic name could not be recalled. The patient was ill with diarrhea for six weeks, during which he sought medical care two additional times.

Screening for methyltransferase genes was performed by PCR, using previously described primers for six genes; *armA*, *rmtA*, *rmtB*, *rmtC*, *rmtD*, and *npmA*. AM04864 was positive for *armA*, while AM23818 was positive for *rmtC*. Sequence analysis confirmed that *armA* was identical to that observed in *Acinetobacter baumannii* (EU014811) and *Salmonella enterica* ser. Oranienburg (DQ177329). Sequence analysis confirmed that *armA* was located between *tnpU* and *tnpD,* genes associated with the Tn*1548* transposon. Tn*1548* typically contains additional genes which confer resistance to azithromycin, streptomycin-spectinomycin, sulfonamides, and trimethoprim, which may explain the additional resistance phenotype of AM04864. Sequence analysis of the *rmtC* gene confirmed that the gene was identical to that observed in *Proteus mirabilis* (EU144360). At the time of this report, *rmtC* has not been identified outside of *P. mirabilis*. Upstream of the *rmtC* sequence, we identified the 3' end of the IS*Ecp1* element along with one of the inverted repeat regions (IRR). IS*Ecp1* has been shown to promote expression and transposition of *rmtC*.

Although ArmA is one of the most widespread methyltransferases in the world, it has only been identified in *A. baumannii* in the United States. RmtC has not previously been observed in the United States. All of the *rmtC*-positive isolates reported have been *Proteus mirabilis* isolates from patients in Japan, with the exception of a single isolate in Australia. The patient infected with *Salmonella* with the *rmtC* gene recently traveled to India, suggesting that the infection originated in India. Identification of methyltransferase genes among non-typhoidal *Salmonella* isolated from humans in the United States suggests the existence of a potential reservoir for these resistance mechanisms.

Box 3. Plasmid-Mediated Quinolone Resistance among non-Typhi *Salmonella* isolated in the United States

Although gastroenteritis due to *Salmonella* often is self-limited, antibiotic therapy is necessary for the management of invasive infections. The recommended regimen used to include either amoxicillin or trimethoprim-sulfamethoxazole, but due to increased resistance levels to these drugs, current recommendations suggest an extended-spectrum cephalosporin, such as ceftriaxone, or a fluoroquinolone, such as ciprofloxacin.

Endogenous topoisomerase mutations are an important source of fluoroquinolone resistance in *Enterobacteriaceae*. However, three plasmid-mediated mechanisms have recently been described to confer decreased susceptibility to ciprofloxacin; QNR proteins, QepA efflux and AAC(6')-Ib-cr. The first *qnr* gene described, *qnrA*, was found on a conjugative plasmid of a clinical *Klebsiella pneumoniae* isolate in 1998. This gene encodes a protein protecting type II topoisomerases and is associated with low-level ciprofloxacin resistance. Since the discovery of *qnrA* several *qnr*-variants have been identified, including *qnrB*, *S*, *C* and *D*. The QepA protein is an efflux pump that originally was described in a clinical isolate of *Escherichia coli*. Finally, the AAC(6')-Ib-cr is a mutant aminoglycoside acetyltransferase (AAC(6')-Ib) which modifies ciprofloxacin and norfloxacin. Here we summarize the prevalence of *aac(6')-Ib-cr, qepA* and *qnr* genes among non-Typhi *Salmonella* submitted to NARMS 1996-2006.

A study by Gay et al reported ten (0.08%) *qnr*-positive *Salmonella* among isolates submitted to NARMS in 1996-2003. Among isolates submitted to NARMS in 2004 to 2006, Sjolund-Karlsson et al reported 17 (0.3%) *qnr*-positive isolates; 11 isolates harbored *qnrS,* five *qnrB* and one isolate *qnrA*. The fact that 14 of these were collected in 2006 and originated from ten different states suggests *qnr* genes may be increasing among *Salmonella* in the United States. This is further supported by the expansion of serotypes carrying *qnr* genes; among the ten *qnr*-positive isolates from 1996-2003, four serotypes were represented (Berta, Mbandaka, Bovismorbificans, Anatum) whereas in 2004-2006 nine additional serotypes were detected (Typhimurium, Corvallis, Saintpaul, Montevideo, Telelkebir, Kiambu, Enteritidis, Aqua, Cubana).

Among all non-Typhi *Salmonella* submitted to NARMS 1996-2006, a single isolate harbored the *aac(6')-Ib-cr* gene. This isolate was a Typhimurium var O:5- submitted in 2005. The *qepA* gene has not yet been detected among NARMS *Salmonella* isolates.

Plasmid-mediated quinolone resistance in *Salmonella* has important public health implications since patients infected with resistant isolates may respond poorly to therapy. In order to limit further spread of plasmid-mediated quinolone resistance among *Enterobacteriaceae,* judicious use of antimicrobial agents in both human and veterinary medicine will be crucial.

3. *Shigella*

Table 32. Frequency of *Shigella* species isolated in NARMS, 2008

Species	2008	
	n	(%)
Shigella sonnei	496	(89.9%)
Shigella flexneri	48	(8.7%)
Shigella boydii	5	(0.9%)
Other	3	(0.5%)
Total	**552**	**(100.0%)**

Table 33. Minimum inhibitory concentrations (MICs) and resistance of *Shigella* isolates to antimicrobial agents, 2008 (N=552)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 0.7]						0.4	2.2	48.9	45.3	3.1	0.2					
		Gentamicin	0.0	0.5	[0.1 - 1.6]					2.4	26.3	66.3	4.5			0.2	0.4				
		Streptomycin	N/A	80.6	[77.1 - 83.8]												19.4	44.0	36.6		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	31.5	3.4	[2.1 - 5.3]							1.8	2.0	31.5	29.7	31.5	3.3	0.2			
	Cephems	Ceftiofur	0.0	0.2	[0.00 - 1.0]				6.0	83.2	10.3	0.4				0.2					
		Ceftriaxone	0.0	0.2	[0.00 - 1.0]					99.8								0.2			
	Penicillins	Ampicillin	0.4	62.5	[58.3 - 66.6]							3.4	26.1	7.2	0.4	0.4	0.2	62.3			
	Quinolones	Ciprofloxacin	0.0	0.9	[0.3 - 2.1]	96.4	1.1	0.5	0.4	0.7				0.5	0.4						
		Nalidixic acid	N/A	2.2	[1.1 - 3.8]						6.2	79.5	11.2	0.7	0.2		0.5	1.6			
II	Aminoglycosides	Kanamycin	0.0	0.5	[0.1 - 1.6]										99.3	0.2		0.2	0.4		
	Cephems	Cefoxitin	0.2	0.0	[0.0 - 0.7]						0.4	9.1	75.4	14.5	0.5	0.2					
	Folate pathway inhibitors	Sulfisoxazole	N/A	28.8	[25.1 - 32.8]											66.1	4.2	0.9			28.8
		Trimethoprim-sulfamethoxazole	N/A	41.1	[37.0 - 45.4]				9.2	4.3	6.7	25.2	13.4	6.3	34.8						
	Phenicols	Chloramphenicol	0.2	7.2	[5.2 - 9.7]								18.3	71.9	2.4	0.2	1.1	6.2			
	Tetracyclines	Tetracycline	0.0	24.3	[20.8 - 28.1]									75.7		0.2	8.9	15.2			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists

§ Percent of isolates that were resistant

¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).

** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 20. Antimicrobial resistance pattern for *Shigella*, 2008

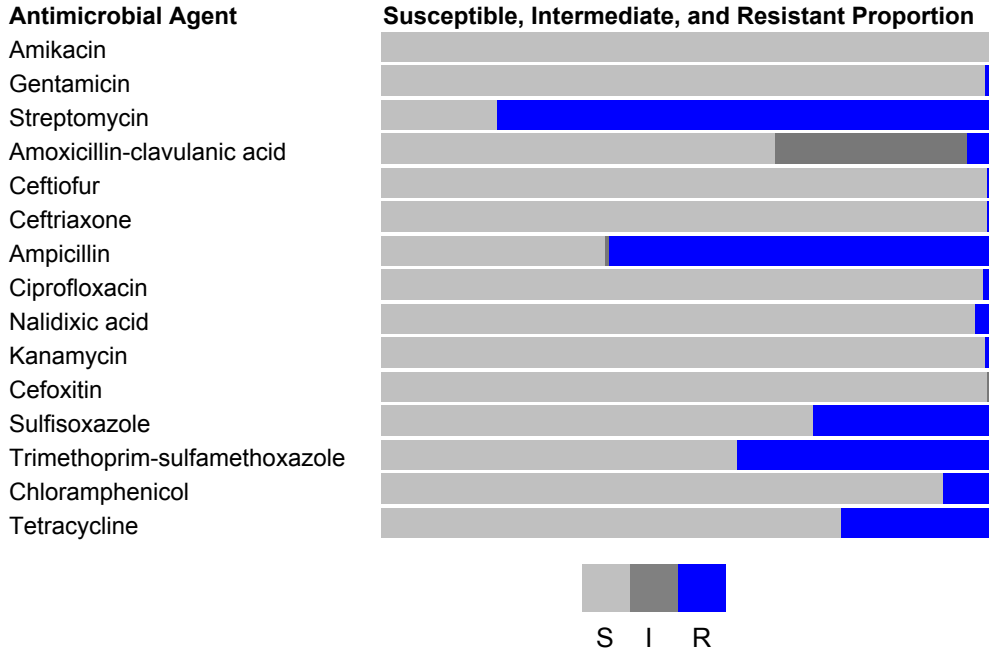


Table 34. Percentage and number of *Shigella* isolates resistant to antimicrobial agents, 1999–2008

Year Total Isolates			1999 375	2000 450	2001 344	2002 620	2003 495	2004 316	2005 396	2006 402	2007 482	2008 552
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.3% 1	0.2% 1	0.0% 0	0.2% 1	0.0% 0	0.0% 0	1.0% 4	0.2% 1	0.8% 4	0.5% 3
		Streptomycin (MIC ≥ 64)	55.7% 209	57.1% 257	53.2% 183	54.4% 337	57.0% 282	60.8% 192	68.7% 272	60.7% 244	73.0% 352	80.6% 445
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.1% 4	2.2% 10	4.4% 15	2.6% 16	1.4% 7	1.6% 5	1.0% 4	1.5% 6	0.4% 2	3.4% 19
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.3% 1	0.5% 2	0.2% 1	0.0% 0	0.2% 1
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.3% 1	0.5% 2	0.2% 1	0.0% 0	0.2% 1
	Penicillins	Ampicillin (MIC ≥ 32)	77.6% 291	79.1% 356	79.7% 274	76.6% 475	79.4% 393	77.5% 245	70.7% 280	62.2% 250	63.5% 306	62.5% 345
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.9% 5
		Nalidixic acid (MIC ≥ 32)	1.6% 6	0.9% 4	1.7% 6	1.6% 10	1.0% 5	1.6% 5	1.5% 6	3.5% 14	1.9% 9	2.2% 12
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.5% 2	1.3% 6	0.6% 2	0.8% 5	0.4% 2	0.0% 0	0.8% 3	0.0% 0	0.2% 1	0.5% 3
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.2% 1	1.2% 4	0.3% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0
		Cephalothin (MIC ≥ 32)	3.2% 12	8.0% 36	9.0% 31	6.6% 41	9.3% 46	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	56.0% 210	55.8% 251	56.4% 194	31.8% 197	33.9% 168	52.5% 166	57.6% 228	40.3% 162	25.7% 124	28.8% 159
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	51.5% 193	52.9% 238	46.8% 161	37.3% 231	38.6% 191	51.6% 163	58.6% 232	58.2% 234	34.6% 167	41.1% 227
	Phenicols	Chloramphenicol (MIC ≥ 32)	17.3% 65	14.0% 63	21.5% 74	7.6% 47	8.5% 42	15.2% 48	10.9% 43	10.9% 44	8.3% 40	7.2% 40
	Tetracyclines	Tetracycline (MIC ≥ 16)	57.3% 215	44.9% 202	59.3% 204	30.6% 190	29.1% 144	49.4% 156	38.4% 152	34.6% 139	25.5% 123	24.3% 134

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 35. Resistance patterns of *Shigella* isolates, 1999–2008

Year Total Isolates	1999 375	2000 450	2001 344	2002 620	2003 495	2004 316	2005 396	2006 402	2007 482	2008 552
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	9.1% 34	7.3% 33	4.9% 17	8.2% 51	8.5% 42	4.4% 14	4.5% 18	5.2% 21	7.3% 35	4.3% 24
Resistance ≥ 1 CLSI class*	90.9% 341	92.7% 417	95.1% 327	91.8% 569	91.5% 453	95.6% 302	95.5% 378	94.8% 381	92.7% 447	95.7% 528
Resistance ≥ 2 CLSI classes*	63.2% 237	64.7% 291	68.6% 236	55.2% 342	57.8% 286	66.8% 211	74.0% 293	70.6% 284	68.5% 330	71.7% 396
Resistance ≥ 3 CLSI classes*	59.7% 224	61.3% 276	60.2% 207	41.6% 258	40.2% 199	62.3% 197	61.4% 243	48.5% 195	33.2% 160	41.3% 228
Resistance ≥ 4 CLSI classes*	44.5% 167	31.8% 143	45.3% 156	24.4% 151	24.8% 123	32.9% 104	19.4% 77	15.4% 62	11.6% 56	10.9% 60
Resistance ≥ 5 CLSI classes*	9.9% 37	6.7% 30	8.4% 29	2.9% 18	3.6% 18	7.0% 22	4.8% 19	5.2% 21	4.6% 22	3.1% 17
At least ACSSuT†	8.5% 32	5.6% 25	6.4% 22	1.8% 11	3.2% 16	6.0% 19	4.0% 16	5.0% 20	3.7% 18	2.4% 13
At least ACT/S‡	9.9% 37	6.9% 31	7.0% 24	2.7% 17	3.6% 18	6.6% 21	6.3% 25	6.0% 24	3.9% 19	3.3% 18
At least AT/S§	44.3% 166	44.4% 200	37.5% 129	29.8% 185	33.7% 167	37.7% 119	39.9% 158	34.1% 137	18.9% 91	22.8% 126
At least ANT/S¶	0.3% 1	0.0% 0	0.6% 2	0.3% 2	0.8% 4	0.6% 2	0.5% 2	0.5% 2	0.8% 4	0.4% 2
At least ACSSuTAuCf**	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.3% 1	0.3% 1	0.2% 1	0.0% 0	0.2% 1

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

Table 36. Minimum inhibitory concentrations (MICs) and resistance of *Shigella sonnei* isolates to antimicrobial agents, 2008 (N=498)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.7]						0.4	1.8	52.2	42.6	2.8	0.2					
		Gentamicin	0.0	0.6	[0.1 - 1.7]					1.8	25.9	66.9	4.8			0.2	0.4				
		Streptomycin	N/A	82.5	[78.9 - 85.8]												17.5	47.0	35.5		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	29.5	3.4	[2.0 - 5.4]							1.6	0.8	33.1	31.5	29.5	3.2	0.2			
	Cephems	Ceftiofur	0.0	0.2	[0.00 - 1.1]				3.0	85.5	10.8	0.4				0.2					
		Ceftriaxone	0.0	0.2	[0.00 - 1.1]					99.8								0.2			
	Penicillins	Ampicillin	0.4	61.6	[57.2 - 65.9]							2.0	27.7	7.8	0.4	0.4	0.2	61.4			
	Quinolones	Ciprofloxacin	0.0	0.8	[0.2 - 2.0]	97.0	1.0	0.6	0.4	0.2				0.6	0.2						
		Nalidixic acid	N/A	2.0	[1.0 - 3.7]						6.2	80.9	10.2	0.6			0.6	1.4			
II	**Aminoglycosides**	Kanamycin	0.0	0.6	[0.1 - 1.7]										99.2	0.2		0.2	0.4		
	Cephems	Cefoxitin	0.2	0.0	[0.0 - 0.7]						0.2	10.0	78.7	10.6	0.2	0.2					
	Folate pathway inhibitors	Sulfisoxazole	N/A	25.3	[21.5 - 29.4]											69.1	4.6	1.0			25.3
		Trimethoprim-sulfamethoxazole	N/A	40.4	[36.0 - 44.8]				7.2	2.6	7.2	27.9	14.7	7.0	33.3						
	Phenicols	Chloramphenicol	0.0	1.4	[0.6 - 2.9]								16.5	79.7	2.4		0.2	1.2			
	Tetracyclines	Tetracycline	0.0	17.5	[14.2 - 21.1]									82.5			8.8	8.6			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 21. Antimicrobial resistance pattern for *Shigella sonnei*, 2008

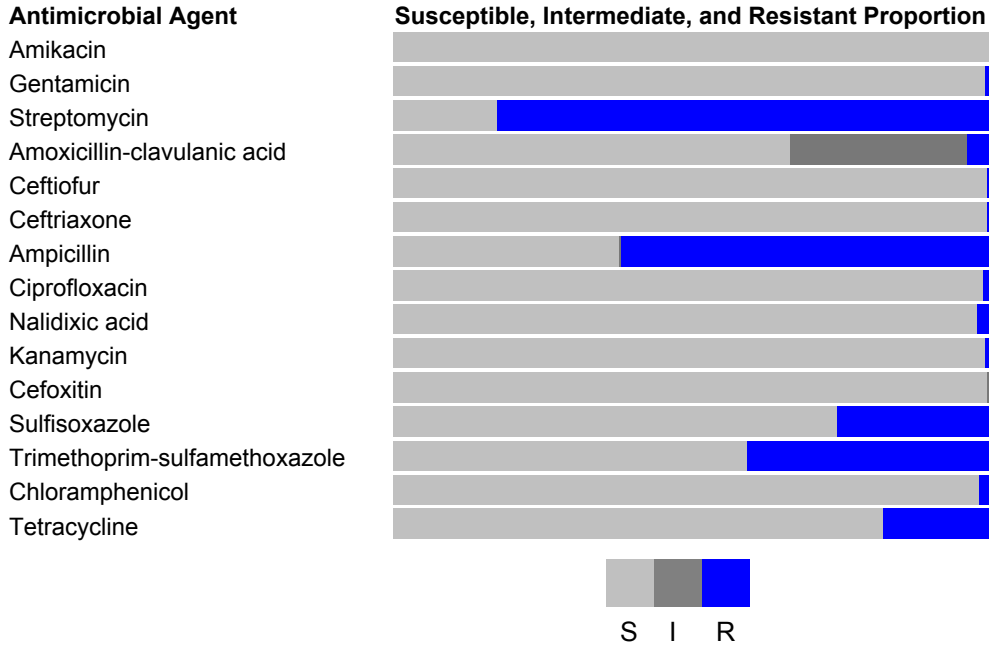


Table 37. Percentage and number of *Shigella sonnei* isolates resistant to antimicrobial agents, 1999–2008

Year Total Isolates			1999 275	2000 366	2001 239	2002 536	2003 434	2004 241	2005 340	2006 321	2007 416	2008 498
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.2% 4	0.0% 0	1.0% 4	0.6% 3
		Streptomycin (MIC ≥ 64)	52.0% 143	56.0% 205	54.0% 129	55.4% 297	56.5% 245	58.1% 140	70.3% 239	61.7% 198	76.4% 318	82.5% 411
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.4% 1	1.9% 7	4.6% 11	2.2% 12	1.4% 6	1.7% 4	1.2% 4	1.9% 6	0.5% 2	3.4% 17
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2	0.0% 0	0.0% 0	0.2% 1
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2	0.0% 0	0.0% 0	0.2% 1
	Penicillins	Ampicillin (MIC ≥ 32)	79.6% 219	80.6% 295	82.8% 198	77.6% 416	79.7% 346	79.3% 191	70.6% 240	62.3% 200	63.7% 265	61.6% 307
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.8% 4
		Nalidixic acid (MIC ≥ 32)	1.5% 4	1.1% 4	0.8% 2	1.5% 8	0.5% 2	1.7% 4	1.2% 4	2.8% 9	1.4% 6	2.0% 10
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.7% 2	1.6% 6	0.4% 1	0.4% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.6% 3
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.3% 1	1.7% 4	0.4% 2	0.0% 0	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0
		Cephalothin (MIC ≥ 32)	2.9% 8	8.7% 32	12.6% 30	7.3% 39	10.1% 44	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	54.5% 150	56.0% 205	54.4% 130	29.9% 160	31.3% 136	49.0% 118	57.9% 197	33.3% 107	20.0% 83	25.3% 126
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	53.1% 146	54.9% 201	50.6% 121	37.9% 203	38.5% 167	53.1% 128	61.2% 208	57.9% 186	32.2% 134	40.4% 201
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.8% 5	2.7% 10	1.3% 3	0.2% 1	1.2% 5	2.5% 6	2.4% 8	0.9% 3	1.2% 5	1.4% 7
	Tetracyclines	Tetracycline (MIC ≥ 16)	46.2% 127	34.4% 126	44.8% 107	23.5% 126	22.1% 96	36.1% 87	29.4% 100	22.7% 73	16.1% 67	17.5% 87

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 38. Resistance patterns of *Shigella sonnei* isolates, 1999–2008

Year Total Isolates	1999 275	2000 366	2001 239	2002 536	2003 434	2004 241	2005 340	2006 321	2007 416	2008 498
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	10.5% 29	7.7% 28	5.4% 13	7.1% 38	8.5% 37	5.0% 12	4.4% 15	4.7% 15	7.0% 29	4.4% 22
Resistance ≥ 1 CLSI class*	89.5% 246	92.3% 338	94.6% 226	92.9% 498	91.5% 397	95.0% 229	95.6% 325	95.3% 306	93.0% 387	95.6% 476
Resistance ≥ 2 CLSI classes*	55.6% 153	60.7% 222	59.8% 143	51.9% 278	54.1% 235	59.8% 144	72.9% 248	67.3% 216	66.6% 277	69.7% 347
Resistance ≥ 3 CLSI classes*	53.1% 146	56.8% 208	51.9% 124	36.6% 196	35.3% 153	54.8% 132	58.5% 199	41.7% 134	27.6% 115	36.7% 183
Resistance ≥ 4 CLSI classes*	39.3% 108	25.4% 93	37.7% 90	19.8% 106	20.5% 89	25.7% 62	12.4% 42	8.1% 26	5.0% 21	6.2% 31
Resistance ≥ 5 CLSI classes*	0.7% 2	1.6% 6	1.3% 3	0.7% 4	0.5% 2	0.8% 2	0.9% 3	0.0% 0	1.2% 5	0.8% 4
At least ACSSuT†	0.4% 1	0.8% 3	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.3% 1	0.0% 0	0.5% 2	0.4% 2
At least ACT/S‡	1.8% 5	1.9% 7	0.8% 2	0.2% 1	0.9% 4	1.7% 4	2.4% 8	0.9% 3	0.5% 2	1.2% 6
At least AT/S§	45.1% 124	46.2% 169	41.0% 98	30.2% 162	33.6% 146	39.4% 95	40.6% 138	32.1% 103	16.3% 68	21.9% 109
At least ANT/S¶	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.8% 2	0.3% 1	0.0% 0	0.7% 3	0.4% 2
At least ACSSuTAuCf**	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.2% 1

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

Table 39. Minimum inhibitory concentrations and resistance of *Shigella flexneri* isolates to antimicrobial agents, 2008 (N=46)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 7.7]							6.5	21.7	67.4	4.3						
		Gentamicin	0.0	0.0	[0.0 - 7.7]					8.7	34.8	54.3	2.2								
		Streptomycin	N/A	60.9	[45.4 - 74.9]												39.1	17.4	43.5		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	54.3	4.3	[0.5 - 14.8]							4.3	15.2	8.7	13.0	54.3	4.3				
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 7.7]				34.8	58.7	6.5										
		Ceftriaxone	0.0	0.0	[0.0 - 7.7]					100.0											
	Penicillins	Ampicillin	0.0	73.9	[58.9 - 85.7]							19.6	6.5					73.9			
	Quinolones	Ciprofloxacin	0.0	2.2	[0.03 - 11.5]	95.7				2.2					2.2						
		Nalidixic acid	N/A	4.3	[0.5 - 14.8]						6.5	67.4	21.7					4.3			
II	**Aminoglycosides**	Kanamycin	0.0	0.0	[0.0 - 7.7]										100.0						
	Cephems	Cefoxitin	0.0	0.0	[0.0 - 7.7]						2.2		41.3	52.2	4.3						
	Folate pathway inhibitors	Sulfisoxazole	N/A	60.9	[45.4 - 74.9]											39.1					60.9
		Trimethoprim-sulfamethoxazole	N/A	47.8	[32.9 - 63.1]				26.1	21.7	2.2		2.2		47.8						
	Phenicols	Chloramphenicol	2.2	67.4	[52.0 - 80.5]								28.3		2.2	2.2	10.9	56.5			
	Tetracyclines	Tetracycline	0.0	84.8	[71.1 - 93.7]									15.2		2.2	6.5	76.1			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 22. Antimicrobial resistance pattern for *Shigella flexneri*, 2008

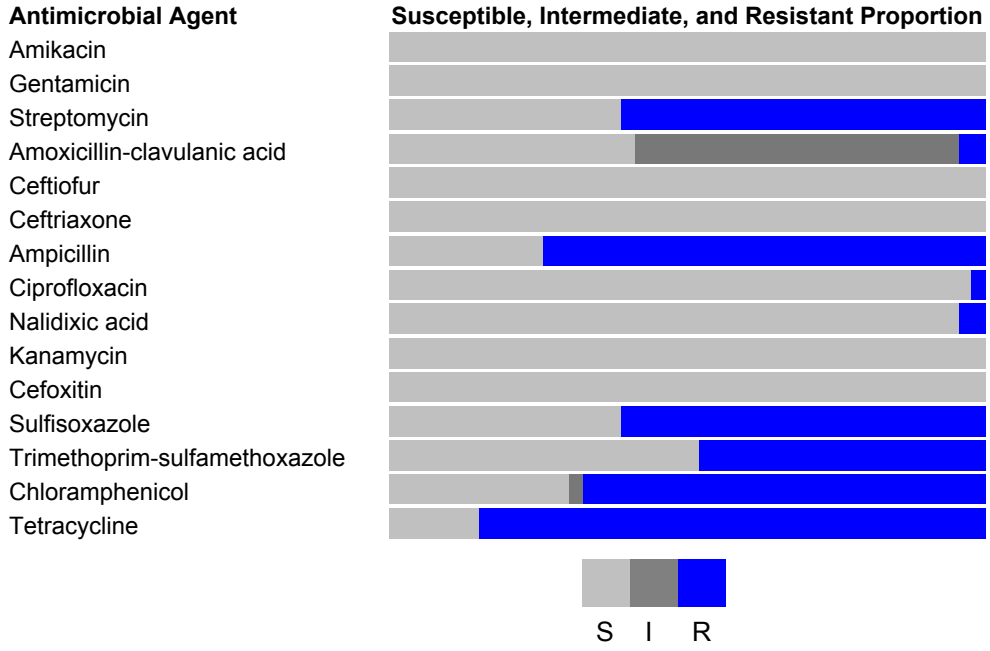


Table 40. Percentage and number of *Shigella flexneri* isolates resistant to antimicrobial agents, 1999–2008

Year Total Isolates			1999 87	2000 75	2001 91	2002 73	2003 51	2004 62	2005 52	2006 74	2007 61	2008 46
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	63.2% 55	61.3% 46	47.3% 43	43.8% 32	60.8% 31	71.0% 44	57.7% 30	58.1% 43	52.5% 32	60.9% 28
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	3.4% 3	4.0% 3	4.4% 4	5.5% 4	2.0% 1	1.6% 1	0.0% 0	0.0% 0	0.0% 0	4.3% 2
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	1.4% 1	2.0% 1	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	1.4% 1	2.0% 1	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	77.0% 67	77.3% 58	72.5% 66	75.3% 55	84.3% 43	80.6% 50	75.0% 39	63.5% 47	63.9% 39	73.9% 34
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	1.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.4% 1	1.6% 1	2.2% 1
		Nalidixic acid (MIC ≥ 32)	1.1% 1	0.0% 0	3.3% 3	2.7% 2	5.9% 3	1.6% 1	3.8% 2	5.4% 4	4.9% 3	4.3% 2
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	1.1% 1	4.1% 3	3.9% 2	0.0% 0	3.8% 2	0.0% 0	0.0% 0	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Cephalothin (MIC ≥ 32)	4.6% 4	2.7% 2	1.1% 1	2.7% 2	3.9% 2	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	58.6% 51	53.3% 40	57.1% 52	41.1% 30	52.9% 27	66.1% 41	55.8% 29	68.9% 51	62.3% 38	60.9% 28
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	48.3% 42	42.7% 32	34.1% 31	28.8% 21	39.2% 20	46.8% 29	44.2% 23	59.5% 44	49.2% 30	47.8% 22
	Phenicols	Chloramphenicol (MIC ≥ 32)	64.4% 56	69.3% 52	74.7% 68	63.0% 46	68.6% 35	61.3% 38	65.4% 34	54.1% 40	55.7% 34	67.4% 31
	Tetracyclines	Tetracycline (MIC ≥ 16)	92.0% 80	92.0% 69	94.5% 86	78.1% 57	82.4% 42	95.2% 59	94.2% 49	83.8% 62	83.6% 51	84.8% 39

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 41. Resistance patterns of *Shigella flexneri* isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	87	75	91	73	51	62	52	74	61	46
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	4.6%	4.0%	3.3%	15.1%	7.8%	0.0%	5.8%	5.4%	9.8%	4.3%
	4	3	3	11	4	0	3	4	6	2
Resistance ≥ 1 CLSI class*	95.4%	96.0%	96.7%	84.9%	92.2%	100.0%	94.2%	94.6%	90.2%	95.7%
	83	72	88	62	47	62	49	70	55	44
Resistance ≥ 2 CLSI classes*	83.9%	82.7%	89.0%	76.7%	86.3%	93.5%	80.8%	85.1%	80.3%	91.3%
	73	62	81	56	44	58	42	63	49	42
Resistance ≥ 3 CLSI classes*	79.3%	81.3%	79.1%	75.3%	80.4%	90.3%	78.8%	75.7%	68.9%	82.6%
	69	61	72	55	41	56	41	56	42	38
Resistance ≥ 4 CLSI classes*	63.2%	64.0%	62.6%	57.5%	62.7%	64.5%	65.4%	47.3%	55.7%	56.5%
	55	48	57	42	32	40	34	35	34	26
Resistance ≥ 5 CLSI classes*	37.9%	32.0%	25.3%	19.2%	31.4%	29.0%	30.8%	28.4%	27.9%	28.3%
	33	24	23	14	16	18	16	21	17	13
At least ACSSuT†	33.3%	29.3%	22.0%	15.1%	29.4%	27.4%	28.8%	27.0%	26.2%	23.9%
	29	22	20	11	15	17	15	20	16	11
At least ACT/S‡	34.5%	32.0%	23.1%	21.9%	27.5%	24.2%	32.7%	28.4%	26.2%	26.1%
	30	24	21	16	14	15	17	21	16	12
At least AT/S§	44.8%	38.7%	25.3%	27.4%	37.3%	35.5%	38.5%	43.2%	36.1%	32.6%
	39	29	23	20	19	22	20	32	22	15
At least ANT/S¶	1.1%	0.0%	1.1%	1.4%	5.9%	0.0%	1.9%	2.7%	1.6%	0.0%
	1	0	1	1	3	0	1	2	1	0
At least ACSSuTAuCf**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	0	0	0	0	0	0	0	0
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	1.4%	0.0%	0.0%
	0	0	0	0	1	0	0	1	0	0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

Box 4. Identification and characterization of CTX-M-producing *Shigella* isolates in the United States

Shigellosis is a major source of gastroenteritis throughout the world. Extended-spectrum β-lactamases (ESBLs), including cefotaximases (CTX-M), confer resistance to extended-spectrum cephalosporins (ESC) and significantly compromise the treatment options for shigellosis. Numerous ESBL's have been described among *Enterobacteriaceae*, however, only a single CTX-M-producing *Shigella* isolate has been reported in the United States.

From 1999 to 2007, 3880 *Shigella* isolates were screened for antimicrobial susceptibility to 14-17 antimicrobials by broth microdilution (Sensititre®, Trek Diagnostics, Westlake, OH). Six isolates displayed decreased susceptibility (MIC≥2 μg/ml) to ceftriaxone. The six case-patients included three males and two females and the median age was 3 years (range 1 to 8 years). Additional details were available for five patients. Three of the five (60%) were hospitalized, and one was admitted twice. One patient had an adopted sibling from Russia but had not traveled herself. The second patient traveled to a neighboring state prior to illness onset and the third reported no travel. Of the non-hospitalized patients, one was an asymptomatic adoptee from China and the second reported no travel. Two patients received antimicrobial therapy; ceftriaxone, cefotaxime and trimethoprim-sulfamethoxazole for one patient, azithromycin for the other patient.

PCR analysis was used to screen the six isolates for 13 different classes or groups of β-lactamase genes, and PCR results were confirmed by DNA sequencing. Four isolates were positive for the $bla_{\text{CTX-M-15}}$ gene while two were positive for the $bla_{\text{CTX-M-14}}$ gene. All four $bla_{\text{CTX-M-15}}$ isolates were PCR positive for non-ESBL $bla_{\text{TEM-1}}$ genes. Both $bla_{\text{CTX-M-14}}$ isolates were PCR positive for non-ESBL $bla_{\text{OXA-1}}$ genes and a single isolate was positive for both $bla_{\text{TEM-1}}$ and $bla_{\text{OXA-1}}$. By pulsed-field gel electrophoresis (PFGE) analysis, all three *S. sonnei* and all three *S. flexneri* demonstrated distinct patterns.

All six $bla_{\text{CTX-M}}$ genes were determined to be plasmid encoded. The non-ESBL β-lactamases (OXA-1, TEM-1) did not transfer and were not encoded by the same CTX-M plasmids. All three *S. sonnei* plasmids and two of the *flexneri* plasmids harbored only the CTX-M-associated resistance. The remaining *S. flexneri* plasmid contained additional determinants conferring resistance to trimethoprim-sulfamethoxazole and gentamicin.

All three *S. sonnei* plasmids were incompatibility type IncI1 and approximately 90 kb in size (plasmid pulsed-field gel electrophoresis). Plasmid multi-locus sequence typing (pMLST) identified them as novel sequence types designated as ST31 complex. The plasmid from AM22451 contained several point mutations in one allele necessitating the ST32 designation within the ST31 clonal complex (http://pubmlst.org/plasmid). Of the three *S. flexneri* plasmids, the $bla_{\text{CTX-M-15}}$-positive was a 165 kb IncA/C plasmid, while the two $bla_{\text{CTX-M-14}}$-positive plasmids were identical 75 kb IncFII plasmids. CTX-M-14 and CTX-M-15 are the most common types of cefotaximases identified among *Shigella* isolates and IncI1 plasmids carrying CTX-M-15 have been already described in *Escherichia coli* and *Salmonella* from Australia, France and the UK.

The emergence of CTX-M-producing *Shigella* isolates in the United States is concerning and necessitates continued resistance surveillance.

4. *Escherichia coli* O157

Table 42. Minimum inhibitory concentrations (MICs) and resistance of *Escherichia coli* O157 isolates to antimicrobial agents, 2008 (N=160)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 2.3]						3.8	26.3	65.6	3.8	0.6						
		Gentamicin	0.0	1.3	[0.1 - 4.4]					15.6	78.1	4.4	0.6			0.6	0.6				
		Streptomycin	N/A	1.9	[0.4 - 5.4]												98.1		1.9		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	0.6	[0.01 - 3.4]							2.5	10.0	81.3	5.6			0.6			
	Cephems	Ceftiofur	0.0	0.6	[0.01 - 3.4]				1.3	13.8	81.3	2.5	0.6			0.6					
		Ceftriaxone	0.0	1.3	[0.1 - 4.4]					98.1	0.6				0.6	0.6					
	Penicillins	Ampicillin	0.0	3.8	[1.4 - 8.0]							3.8	70.0	21.9	0.6		0.6	3.1			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 2.3]	96.3	1.3	0.6		1.3	0.6										
		Nalidixic acid	N/A	1.9	[0.4 - 5.4]						0.6		87.5	8.8	1.3			1.9			
II	**Aminoglycosides**	Kanamycin	0.0	0.0	[0.0 - 2.3]										100.0						
	Cephems	Cefoxitin	1.3	1.3	[0.1 - 4.4]						0.6	1.9	7.5	73.8	13.8	1.3	0.6	0.6			
	Folate pathway inhibitors	Sulfisoxazole	N/A	3.8	[1.4 - 8.0]											84.4	10.6	0.6		0.6		3.8
		Trimethoprim-sulfamethoxazole	N/A	1.3	[0.1 - 4.4]				90.0	8.8					1.3						
	Phenicols	Chloramphenicol	1.3	0.6	[0.01 - 3.4]								3.1	27.5	67.5	1.3		0.6			
	Tetracyclines	Tetracycline	0.0	2.5	[0.7 - 6.3]									97.5		0.6	0.6	1.3			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 23. Antimicrobial resistance pattern for *Escherichia coli* O157, 2008

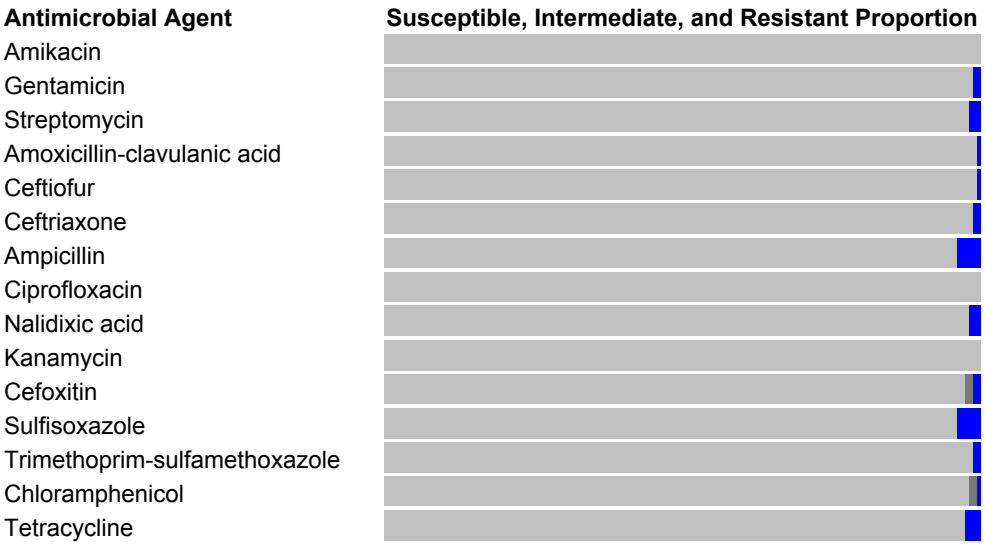


Table 43. Percentage and number of *Escherichia coli* O157 isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			292	407	277	399	158	169	194	233	190	160
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.3% 1	0.5% 2	0.4% 1	0.0% 0	0.0% 0	0.6% 1	0.5% 1	0.0% 0	0.0% 0	1.3% 2
		Streptomycin (MIC ≥ 64)	2.7% 8	5.2% 21	1.8% 5	2.3% 9	1.9% 3	1.8% 3	2.1% 4	2.6% 6	2.1% 4	1.9% 3
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.3% 1	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.5% 1	0.6% 1
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	1.0% 4	1.1% 3	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.0% 0	0.6% 1
		Ceftriaxone (MIC ≥ 4)	0.0% 0	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.0% 0	1.3% 2
	Penicillins	Ampicillin (MIC ≥ 32)	1.4% 4	2.7% 11	2.2% 6	1.5% 6	3.2% 5	1.2% 2	4.1% 8	2.6% 6	2.1% 4	3.8% 6
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.5% 1	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.7% 2	0.5% 2	1.1% 3	1.0% 4	0.6% 1	1.8% 3	1.5% 3	2.1% 5	2.1% 4	1.9% 3
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.7% 2	1.0% 4	0.0% 0	0.5% 2	0.0% 0	0.0% 0	0.5% 1	0.4% 1	0.0% 0	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.6% 1	0.0% 0	1.3% 3	0.0% 0	1.3% 2
		Cephalothin (MIC ≥ 32)	0.7% 2	1.2% 5	1.4% 4	1.5% 6	3.2% 5	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	8.2% 24	5.9% 24	5.1% 14	3.5% 14	3.8% 6	1.8% 3	6.7% 13	3.0% 7	2.6% 5	3.8% 6
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	1.4% 4	0.7% 3	0.7% 2	0.5% 2	0.6% 1	0.0% 0	0.5% 1	0.4% 1	1.1% 2	1.3% 2
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	3.7% 15	1.4% 4	1.3% 5	1.3% 2	0.6% 1	1.0% 2	1.3% 3	0.5% 1	0.6% 1
	Tetracyclines	Tetracycline (MIC ≥ 16)	3.4% 10	7.1% 29	5.4% 15	3.0% 12	5.7% 9	1.8% 3	8.8% 17	4.7% 11	4.7% 9	2.5% 4

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 44. Resistance patterns of *Escherichia coli* O157 isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	292	407	277	399	158	169	194	233	190	160
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	89.7% 262	90.4% 368	91.3% 253	94.0% 375	90.5% 143	94.7% 160	87.6% 170	91.8% 214	92.1% 175	91.3% 146
Resistance ≥ 1 CLSI class*	10.3% 30	9.6% 39	8.7% 24	6.0% 24	9.5% 15	5.3% 9	12.4% 24	8.2% 19	7.9% 15	8.8% 14
Resistance ≥ 2 CLSI classes*	3.4% 10	6.6% 27	5.4% 15	3.8% 15	5.1% 8	2.4% 4	6.7% 13	4.7% 11	3.2% 6	3.8% 6
Resistance ≥ 3 CLSI classes*	2.7% 8	4.7% 19	2.2% 6	2.0% 8	3.2% 5	1.2% 2	5.2% 10	3.4% 8	2.1% 4	3.1% 5
Resistance ≥ 4 CLSI classes*	0.7% 2	3.4% 14	1.4% 4	0.8% 3	1.3% 2	0.6% 1	1.0% 2	2.1% 5	1.1% 2	1.9% 3
Resistance ≥ 5 CLSI classes*	0.0% 0	1.2% 5	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.9% 2	0.5% 1	0.0% 0
At least ACSSuT†	0.0% 0	1.2% 5	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.9% 2	0.0% 0	0.0% 0
At least ACT/S‡	0.0% 0	0.2% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.6% 1
At least ACSSuTAuCf§	0.0% 0	1.0% 4	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.0% 0

* CLSI: Clinical and Laboratory Standards Institute
† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole
§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

5. *Campylobacter*

Table 45. Frequency of *Campylobacter* species isolated in NARMS, 2008

Species	2008	
	N	(%)
Campylobacter jejuni	1055	(91.0%)
Campylobacter coli	101	(8.7%)
Other	3	(0.3%)
Total	**1159**	**(100.0%)**

Table 46. Minimum inhibition concentrations (MICs) and resistance of *Campylobacter* isolates to antimicrobial agents, 2008 (N=1159)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**													
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Gentamicin	0.0	1.1	[0.6 - 1.9]				2.9	35.8	53.7	6.3	0.2					1.1			
	Ketolide	Telithromycin	0.6	2.5	[1.7 - 3.6]				0.5	7.4	27.8	38.1	19.5	3.6	0.6	2.5					
	Macrolides	Azithromycin	0.0	3.0	[2.1 - 4.2]	0.8	17.6	43.6	26.8	7.9	< 0.1	< 0.1	0.2						3.0		
		Erythromycin	0.0	3.0	[2.1 - 4.2]			0.2	2.2	22.4	40.9	23.2	6.9	1.2					3.0		
	Quinolones	Ciprofloxacin	< 0.1	23.0	[20.6 - 25.6]		2.4	34.4	31.8	6.9	1.2	< 0.1	< 0.1	0.8	9.3	7.6	3.5	1.1	0.7		
		Nalidixic acid	< 0.1	23.6	[21.1 - 26.1]									63.4	11.0	1.9	< 0.1	3.3	20.3		
II	**Phenicols**	Florfenicol††	0.0	0.5	[0.0 - 0.3]				< 0.1	0.3	19.1	65.2	12.3	2.5	0.5						
	Tetracyclines	Tetracycline	0.4	43.7	[40.9 - 46.7]			4.6	24.8	16.8	6.0	3.2	0.3	< 0.1	0.4	0.8	2.5	10.3	30.2		
III	**Lincosamides**	Clindamycin	0.5	2.8	[1.9 - 3.9]		1.5	16.5	43.6	24.8	7.4	2.6	0.4	0.5	0.9	0.9	0.9				

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.
† Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Figure 24. Antimicrobial resistance pattern for *Campylobacter*, 2008

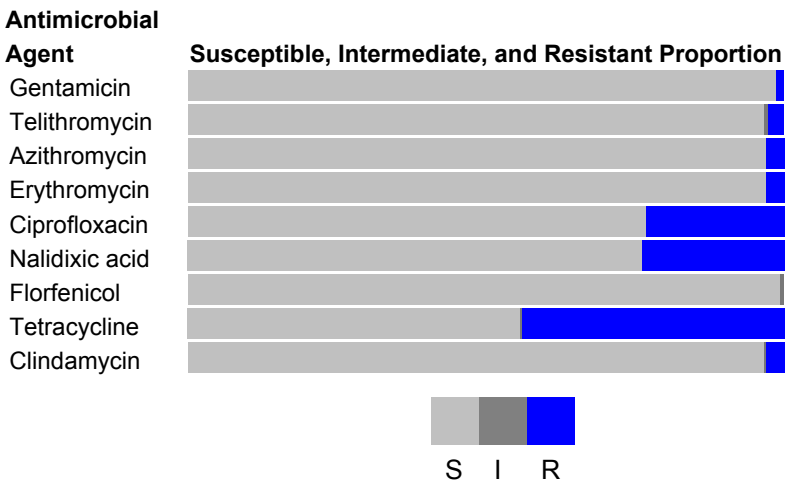


Table 47. Percentage and number of *Campylobacter* isolates resistant to antimicrobial agents, 1999–2008

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates			317	324	384	354	328	347	890	816	1100	1159
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.3% 1	0.7% 6	0.1% 1	0.6% 7	1.1% 13
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 9	1.6% 13	1.5% 16	2.5% 29
	Macrolides	Azithromycin (MIC ≥ 8)	2.2% 7	1.9% 6	2.1% 8	2.0% 7	0.9% 3	0.6% 2	1.9% 17	1.7% 14	2.0% 22	3.0% 35
		Erythromycin (MIC ≥ 32)	1.9% 6	1.2% 4	2.1% 8	1.4% 5	0.9% 3	0.3% 1	1.8% 16	1.7% 14	2.0% 22	3.0% 35
	Quinolones	Ciprofloxacin (MIC ≥ 4)	18.3% 58	14.8% 48	19.5% 75	20.1% 71	17.7% 58	19.0% 66	21.7% 193	19.6% 160	26.0% 286	23.0% 267
		Nalidixic acid (MIC ≥ 64)	21.1% 67	16.7% 54	20.3% 78	20.6% 73	18.9% 62	19.6% 68	22.4% 199	20.1% 164	26.5% 291	23.6% 273
II	Phenicols	Chloramphenicol (MIC ≥ 32)	0.6% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.4% 5	Not Tested	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5	0.0% 0	0.0% 0	0.5% 6
	Tetracyclines	Tetracycline (MIC ≥ 16)	43.8% 139	38.3% 124	40.9% 157	41.2% 146	38.4% 126	46.1% 160	40.6% 361	46.0% 375	44.4% 488	43.7% 507
III	Lincosamides	Clindamycin (MIC ≥ 8)	1.3% 4	0.9% 3	2.1% 8	2.0% 7	0.6% 2	2.0% 7	1.5% 13	2.0% 16	1.7% 19	2.8% 32

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Table 48. Resistance patterns of *Campylobacter* isolates, 1999–2008

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Isolates	317	324	384	354	328	347	890	816	1100	1159
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	47.3% 150	52.2% 169	49.2% 189	48.3% 171	50.9% 167	46.1% 160	48.4% 431	43.9% 358	45.2% 497	45.8% 531
Resistance ≥ 1 CLSI class*	52.7% 167	47.8% 155	50.8% 195	51.7% 183	49.1% 161	53.9% 187	51.6% 459	56.1% 458	54.8% 603	54.2% 628
Resistance ≥ 2 CLSI classes*	13.6% 43	8.0% 26	13.3% 51	12.7% 45	8.5% 28	14.1% 49	13.6% 121	12.0% 98	17.5% 192	15.6% 181
Resistance ≥ 3 CLSI classes*	1.6% 5	0.9% 3	1.6% 6	1.1% 4	0.9% 3	1.2% 4	1.5% 13	1.5% 12	1.7% 19	2.5% 29
Resistance ≥ 4 CLSI classes*	0.9% 3	0.3% 1	0.3% 1	0.0% 0	0.3% 1	0.3% 1	0.3% 3	0.5% 4	0.9% 10	1.1% 13
Resistance ≥ 5 CLSI classes*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 3

* CLSI: Clinical and Laboratory Standards Institute

Table 49. Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter jejuni* isolates to antimicrobial agents, 2008 (N=1055)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Gentamicin	0.0	1.1	[0.6 - 2.0]				3.2	37.3	53.6	4.6	< 0.1					1.1			
	Ketolide	Telithromycin	4.5	2.2	[1.4 - 3.3]				0.6	7.2	28.9	39.4	19.6	1.9	0.2	2.2					
	Macrolides	Azithromycin	0.0	2.3	[1.5 - 3.4]	0.9	18.8	46.2	25.9	5.7	< 0.1	< 0.1	0.2						2.3		
		Erythromycin	0.0	2.3	[1.5 - 3.4]			0.2	2.3	24.3	42.4	23.0	5.0	0.6					2.3		
	Quinolones	Ciprofloxacin	< 0.1	22.4	[19.9 - 25.0]		2.7	36.3	31.8	6.0	0.8	< 0.1	< 0.1	0.8	9.3	6.9	3.6	1.0	0.8		
		Nalidixic acid	< 0.1	22.8	[20.3 - 25.5]									65.5	10.1	1.4	< 0.1	2.9	19.9		
II	**Phenicols**	Florfenicol††	0.6	0.0	[0.0 - 0.3]				< 0.1	0.3	20.3	66.1	10.3	2.4	0.6						
	Tetracyclines	Tetracycline	0.5	44.3	[41.2 - 47.3]			4.8	25.9	15.8	5.4	2.8	0.4	< 0.1	0.5	0.8	2.7	10.9	29.9		
III	**Lincosamides**	Clindamycin	0.3	2.1	[1.3 - 3.1]		1.6	17.7	46.8	24.4	5.6	1.3	0.2	0.3	0.7	0.6	0.9				

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists

§ Percent of isolates that were resistant

¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).

** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

† Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Figure 25. Antimicrobial resistance pattern for *Campylobacter jejuni*, 2008

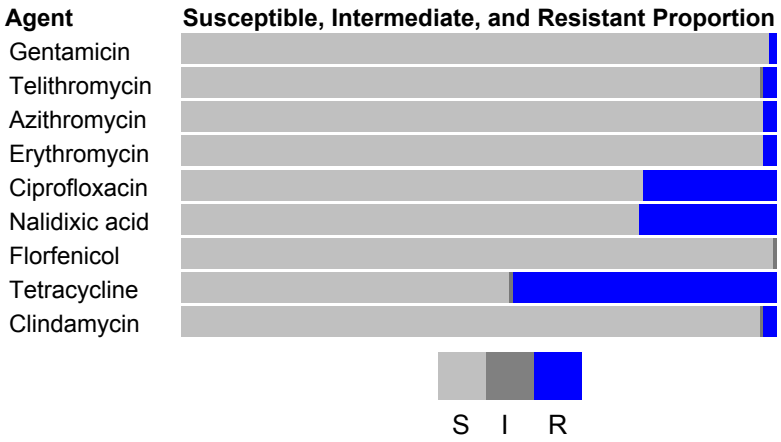


Table 50. Percentage and number of *Campylobacter jejuni* isolates resistant to antimicrobial agents, 1999–2008

Year Total Isolates			1999 293	2000 306	2001 365	2002 329	2003 303	2004 320	2005 791	2006 709	2007 992	2008 1055
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 4	0.0% 0	0.7% 7	1.1% 12
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5	0.8% 6	1.0% 10	2.2% 23
	Macrolides	Azithromycin (MIC ≥ 8)	1.7% 5	1.6% 5	1.9% 7	1.8% 6	0.3% 1	0.6% 2	1.8% 14	0.8% 6	1.6% 16	2.3% 24
		Erythromycin (MIC ≥ 32)	1.4% 4	1.0% 3	1.9% 7	1.2% 4	0.3% 1	0.3% 1	1.6% 13	0.8% 6	1.6% 16	2.3% 24
	Quinolones	Ciprofloxacin (MIC ≥ 4)	17.7% 52	14.7% 45	18.4% 67	20.7% 68	17.2% 52	18.1% 58	21.5% 170	19.5% 138	25.8% 256	22.4% 236
		Nalidixic acid (MIC ≥ 64)	20.1% 59	16.0% 49	18.9% 69	21.3% 70	17.8% 54	18.4% 59	21.9% 173	19.0% 135	26.1% 259	22.8% 241
II	Phenicols	Chloramphenicol (MIC ≥ 32)	0.7% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.6% 5	Not Tested	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.5% 4	0.0% 0	0.0% 0	0.6% 6
	Tetracyclines	Tetracycline (MIC ≥ 16)	45.4% 133	39.2% 120	40.3% 147	41.3% 136	38.3% 116	46.9% 150	41.8% 331	47.4% 336	44.8% 444	44.3% 467
III	Lincosamides	Clindamycin (MIC ≥ 8)	0.7% 2	0.7% 2	1.9% 7	1.8% 6	0.0% 0	2.2% 7	1.1% 9	1.0% 7	1.3% 13	2.1% 22

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Table 51. Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter coli* isolates to antimicrobial agents, 2008 (N=101)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Gentamicin	0.0	1.0	[0.01 - 5.4]					19.8	54.5	23.8	1.0					1.0			
	Ketolide	Telithromycin	16.8	5.9	[2.2 - 12.5]					9.9	16.8	22.8	18.8	20.8	5.0	5.9					
	Macrolides	Azithromycin	0.0	10.9	[5.6 - 18.7]		5.9	16.8	36.6	29.7									10.9		
		Erythromycin	0.0	10.9	[5.6 - 18.7]				1.0	4.0	26.7	23.8	25.7	7.9					10.9		
	Quinolones	Ciprofloxacin	0.0	30.7	[21.9 - 40.7]			15.8	31.7	15.8	5.9			1.0	9.9	14.9	3.0	2.0			
		Nalidixic acid	0.0	30.7	[21.9 - 40.7]									41.6	20.8	6.9		6.9	23.8		
II	**Phenicols**	Florfenicol††	0.0	0.0	[0.0 - 3.6]						6.9	56.4	32.7	4.0							
	Tetracyclines	Tetracycline	0.0	39.6	[30.0 - 49.8]			2.0	13.9	26.7	11.9	5.9				1.0		4.0	34.7		
III	**Lincosamides**	Clindamycin	3.0	9.9	[4.8 - 17.5]			4.0	9.9	29.7	24.8	15.8	3.0	3.0	4.0	5.0	1.0				

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists
§ Percent of isolates that were resistant
¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.
† Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Figure 26. Antimicrobial resistance pattern for *Campylobacter coli*, 2008

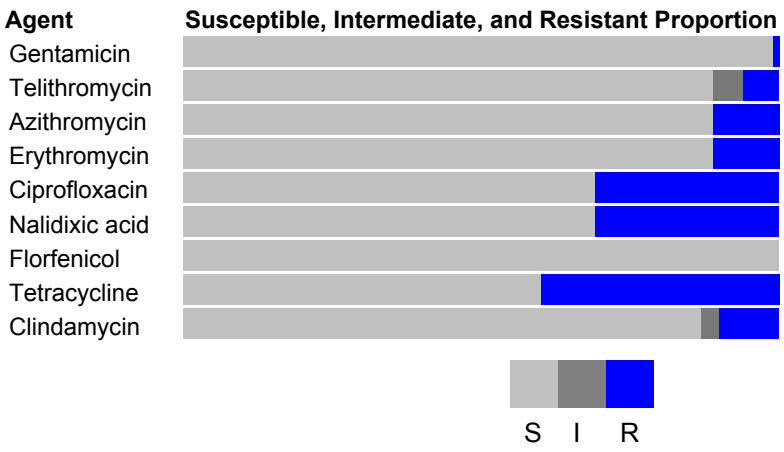


Table 52. Percentage and number of *Campylobacter coli* isolates resistant to antimicrobial agents, 1999–2008

Year Total Isolates			1999 20	2000 12	2001 17	2002 25	2003 22	2004 26	2005 98	2006 97	2007 105	2008 101
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.0% 0	8.3% 1	0.0% 0	0.0% 0	4.5% 1	0.0% 0	2.0% 2	1.0% 1	0.0% 0	1.0% 1
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	4.1% 4	7.2% 7	5.7% 6	5.9% 6
	Macrolides	Azithromycin (MIC ≥ 8)	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3	8.2% 8	5.7% 6	10.9% 11
		Erythromycin (MIC ≥ 32)	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3	8.2% 8	5.7% 6	10.9% 11
	Quinolones	Ciprofloxacin (MIC ≥ 4)	30.0% 6	25.0% 3	47.1% 8	12.0% 3	22.7% 5	30.8% 8	23.5% 23	21.6% 21	28.6% 30	30.7% 31
		Nalidixic acid (MIC ≥ 64)	30.0% 6	25.0% 3	47.1% 8	12.0% 3	22.7% 5	34.6% 9	26.5% 26	23.7% 23	30.5% 32	30.7% 31
II	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 1	0.0% 0	0.0% 0	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	30.0% 6	25.0% 3	58.8% 10	40.0% 10	45.5% 10	38.5% 10	30.6% 30	39.2% 38	41.9% 44	39.6% 40
III	Lincosamides	Clindamycin (MIC ≥ 8)	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	4.1% 4	9.3% 9	5.7% 6	9.9% 10

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

References

CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): 2005 Human Isolates Final Report. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2007.

Clinical and Laboratory Standards Institute. Methods for Antimicrobial Dilution and Disk Susceptibility Testing of Infrequently Isolated or Fastidious Bacteria: Approved Guideline. CLSI Document M45-A. CLSI, Wayne, Pennsylvania, 2006.

Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; Nineteenth Informational Supplement. CLSI Document M100-S19. CLSI, Wayne, Pennsylvania, 2010.

Clinical and Laboratory Standards Institute. Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria that Grow Aerobically; Approved Standard-Eighth Edition. CLSI Document M07-A8. CLSI, Wayne, Pennsylvania, 2009.

Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals; Approved Standard-Third Edition. CLSI Document M31-A3. CLSI, Wayne, Pennsylvania, 2008.

Fleiss JL, Levin B, Paik MC. Statistical Methods in for Rates and Proportions. In: Shewart WA, Wilks SS, eds. Wiley Series in Probability and Statistics. Published Online; 2004.

Folster JP, Pecic G, Krueger A, Rickert R, Burger K, Carattoli A, Whichard JM. Identification and characterization of CTX-M-producing *Shigella* isolates in the United States. Antimicrobial Agents and Chemotherapy 2010; Mar 8. [Epub ahead of print]

Folster JP, Rickert R, Barzilay EJ, Whichard JM. Identification of the Aminoglycoside resistance determinants *armA* and *rmtC* among non-Typhi *Salmonella* isolates from humans in the United States. Antimicrobial Agents and Chemotherapy 2009;53:4563-4.

Gonzalez, I, Grant KA, Richardson PT, Park SF, Collins MD. Specific identification of the enteropathogens *Campylobacter jejuni* and *Campylobacter coli* by using a PCR test based on the *ceuE* gene encoding a putative virulence determinant. Journal of Clinical Microbiology 1997;35:759-63.

Linton D, Lawson AJ, Owen RJ, Stanley J. PCR detection, identification to species level, and fingerprinting of *Campylobacter jejuni* and *Campylobacter coli* direct from diarrheic samples. Journal of Clinical Microbiology 1997;35:2568-72.

Linton D, Owen RJ, Stanley J. Rapid Indentification by PCR of the genus Campylobacter and of five Campylobacter species enteropathogenic for man and animals. Research in Microbiology 1996;147:707-718.

Pruckler, J., et al., Comparison of four real-time PCR methods for the identification of the genus Campylobacter and speciation of C. jejuni and C. coli. ASM 106th General meeting; Poster C282.

Sjolund-Karlsson M, Folster JP, Pecic G, Joyce K, Medalla F, Rickert R, Whichard JM. Emergence of plasmid-mediated quinolone resistance among non-Typhi *Salmonella* enterica isolates from humans in the United States. Antimicrobial Agents and Chemotherapy 2009;53:2142-4.

World Health Organization (WHO). Critically Important Antimicrobials for Human Medicine. Report of the Second WHO Expert Meeting. Switzerland, 2007.

NARMS Publications in 2008

Crump JA, Kretsinger K, Gay K, Hoekstra RM, Vugia DJ, Hurd S, Segler SD, Megginson M, Luedeman LJ, Shiferaw B, Hanna SS, Joyce KW, Mintz ED, Angulo FJ; Emerging Infections Program FoodNet and NARMS Working Groups. Clinical response and outcome of infectionwith *Salmonella* enterica serotype Typhi with decreased susceptibility to fluoroquinolones: a United States foodnet multicenter retrospective cohort study. J Antimicrob Chemother 2008 Apr;52(4): 1278-84.

Egorova S, Timinouni M, Demartin M, Granier SA, Whichard JM, Sangal V, Fabre L, Delaune A, Pardos M, Millemann Y, Espie E, Achtman M, Grimont PA, Weill FX. Ceftriaxone-resistant *Salmonella* enterica serotype Newport, France. Emerg Infect Dis. 2008 June;14(6):954-7.

Greene SK, Stuart AM, Medalla FM, Whichard JM, Hoekstra RM, and Chiller TM. Distribution of Multidrug-Resistant Human Isolates of MDR-ACSSuT *Salmonella* Typhimurium and MDR-AmpC *Salmonella* Newport in the United States, 2003–2005. Foodborne Pathogens and Disease 2008 Oct; 5(5): 669-680.

Gupta SK, Medalla F, Omondi MW, Whichard JM, Fields PI, Gerner-Smidt P, Patel NJ, Cooper KL, Chiller TM, Mintz ED. Laboratory-based surveillance of paratyphoid fever in the United States: travel and antimicrobial resistance. Clinical Infectious Diseases 2008 June;46(11):1656-63.

Petrov P, Hendriksen RS, Kantardjiev T, Asseva G, Sorensen G, Fields P, Mikoleit M, Whichard J, McQuiston JR, Torpdahl M, Aarestrup FM, Angulo FJ. Occurrence and characterization of *Salmonella enterica* serovar 9,12,l,v:- strains from Bulgaria, Denmark and the United States. European Journal of Clinical Microbiology & Infectious Diseases 2008 Nov 8; [Epub ahead of print].

Sjölund M, Yam J, Schwenk J, Joyce K, Medalla F, Barzilay E, Whichard JM. Human *Salmonella* infection yielding CTX-M beta-lactamase, United States. Emerg Infect Dis. 2008 Dec;14(12):1957-9.

Zioga, A., J.M. Whichard, K.Joyce, E. Tzelepi, L.S. Tzouvelekis, V. Miriagou. Evidence for chromosomal and plasmid location of CMY-2 cephalosporinase gene in *Salmonella* serotype Typhimurium. J Antimicrob Chemother 2008 61(6):1389-90.

Appendix A
Summary of *Escherichia coli* Resistance Surveillance Pilot Study, 2008

***E. COLI* WORKING GROUP**

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INTRODUCTION

Escherichia coli is a Gram–negative coccobacillus bacterium that is part of the intestinal flora of humans and other animals. Because antimicrobial resistance genes commonly reside in mobile genetic elements that can be transferred horizontally to other bacteria, antimicrobial–resistant bacteria of the intestinal flora, including *E. coli*, constitute an important reservoir of resistance genes for pathogenic bacteria of humans and other animals. Furthermore, when introduced into a normally sterile site, *E. coli* is an important cause of infections, including septicemia, urinary tract infections, and wound infections. The human intestinal tract is the predominant source of *E. coli* causing these infections. Antimicrobial resistance among *E. coli* causing such infections complicates treatment options.

The use of antimicrobial agents creates a selective pressure for the emergence and dissemination of resistant bacteria. Use of antimicrobial agents in food animals selects resistant bacteria, including resistant *E. coli* in the intestinal tract of food animals. These resistant bacteria can be transmitted to humans through the food supply. Therefore, monitoring resistance in *E. coli* isolated from the intestinal flora of humans and animals is important to determining the role of these bacteria as human pathogens and as reservoirs of resistance determinants for human pathogens. The *E. coli* Resistance Surveillance Pilot is designed to determine the prevalence of resistance to clinically important antimicrobial agents among *E. coli* isolated from persons in the community.

SUMMARY OF 2008 SURVEILLANCE DATA

Background

Beginning in 2004, NARMS began to prospectively monitor the prevalence of antimicrobial resistance of *E. coli* isolated from human stool samples in two sites: Maryland and Michigan.

SURVEILLANCE AND LABORATORY TESTING METHODS

In 2008, Michigan was the sole participant in the study. Michigan cultured 10 human stool samples, from outpatients, each month for *E. coli* using Eosin Methylene Blue agar. One *E. coli* isolate, if present, from each

stool sample was sent to CDC for susceptibility testing to antimicrobial agents using broth microdilution (Sensititre®) to determine the minimum inhibitory concentration (MIC) for each of 15 antimicrobial agents: amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfonamides, tetracycline, and trimethoprim-sulfamethoxazole (Table 53).

Interpretive criteria from the Clinical and Laboratory Standards Institiute (CLSI) were used when available (Table 53). The 95% CIs for the percentage of resistant isolates calculated using the Clopper-Pearson exact method, are included in the MIC distribution tables. Similarly, multiclass resistance by CLSI antimicrobial class was defined as resistance to two or more classes.

RESULTS

In 2008, CDC received 58 isolates; of these, 57 (98.3%) were viable *E. coli* isolates. MIC was determined for *E. coli* isolates for 15 antimicrobial agents (Table 54). Of the 57 *E. coli* isolates, 26.3% were resistant to ampicillin, 14.0% to sulfonamides, 14.0% to tetracycline, and 12.3% to nalidixic acid (Table 55).

Multidrug-Resistant *E. coli*

Multidrug resistance is described in NARMS by the number of antimicrobial classes and also by specific coresistant phenotypes. Antimicrobial classes of agents defined by CLSI are used in this report.

- 12.3% (7/57) of *E. coli* isolates were resistant to three or more classes of antimicrobial agents (Table 56).
- 7.0% (4/57) of *E. coli* isolates were resistant to five or more classes of antimicrobial agents (Table 56).

Clinically Important Resistance

Antimicrobial agents commonly used to treat serious *E. coli* infections in humans include third-generation cephalosporins and fluoroquinolones.

- 1.8% (1/57) of *E. coli* isolates were resistant to ceftriaxone (Table 55).
- 10.5% (6/57) of *E. coli* isolates were resistant to ciprofloxacin (Table 55).

REFERENCES

1. Levy SB, Fitzgerald GB, Macone AB. Changes in intestinal flora of farm personnel after introduction of a tetracycline-supplemented feed on a farm. The New England Journal of Medicine 1976;295:583–8.
2. Schaberg DR, Culver DH, Gaynes RP. Major trends in the microbial etiology of nosocomial infection. The American Journal of Medicine 1991;91(Suppl 3B):3B-72S–5S.
3. Van den Bogaard AE, Stobberingh EE. Epidemiology of resistance to antibiotics: links between animals and humans. International Journal of Antimicrobial Agents 2000;14:327–35.
4. Corpet DE. Antibiotic resistance from food. The New England Journal of Medicine 1988;318:1206–7.
5. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; Eighteenth Informational Supplement. CLSI Document M100-S19. CLSI, Wayne, Pennsylvania, 2010.

Table 53. Antimicrobial agents used for susceptibility testing of *Escherichia coli*, 2008

CLSI class	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	MIC Interpretive Standard (µg/mL)		
			Susceptible	Intermediate	Resistant
Aminoglycosides	Amikacin	0.5 – 64	≤16	32	≥64
	Gentamicin	0.25 – 16	≤4	8	≥16
	Kanamycin	8 – 64	≤16	32	≥64
	Streptomycin	32 – 64	≤32		≥64
β –lactam / β-lactamase inhibitor combinations	Amoxicillin–Clavulanic acid	1/0.5 – 32/16	≤8/4	16/8	≥32/16
Cephems	Cefoxitin	0.5 – 32	≤8	16	≥32
	Ceftiofur	0.12– 8	≤2	4	≥8
	Ceftriaxone	0.25 – 64	≤1	2	≥4
Folate pathway inhibitors	Sulfisoxazole	16 – 256	≤256		≥512
	Trimethoprim–Sulfamethoxazole	0.12/2.38 – 4/76	≤2/38		≥4/76
Penicillins	Ampicillin	1 – 32	≤8	16	≥32
Phenicols	Chloramphenicol	2 – 32	≤8	16	≥32
Quinolones	Ciprofloxacin	0.015 – 4	≤1	2	≥4
	Nalidixic acid	0.5 – 32	≤16		≥32
Tetracyclines	Tetracycline	4 – 32	≤4	8	≥16

* The resistance breakpoint for amikacin, according to Clinical and Laboratory Standards Institute (CLSI) guidelines, is 64µg/mL. For isolates that grew in all amikacin dilutions on the Sensititre panel (minimum inhibitory concentration [MIC] >4 µg/mL), E-Test (AB BIODISK, Solna, Sweden) was performed in order to determine amikacin MIC. The amikacin E-Test strip range of dilutions is 0.016-256 µg/mL.

Table 54. Minimum inhibition concentrations (MICs) and resistance of *Escherichia coli* isolates to antimicrobial agents, 2008 (N=57)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 6.3]							8.8	71.9	19.3							
		Gentamicin	3.5	0.0	[0.0 - 6.3]					3.5	70.2	22.8			3.5						
		Streptomycin	N/A	8.8	[2.9 - 19.3]												91.2		8.8		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.8	3.5	[0.4 - 12.1]								22.8	49.1	22.8	1.8	3.5				
	Cephems	Ceftiofur	0.0	1.8	[0.02 - 9.4]				1.8	57.9	38.6				1.8						
		Ceftriaxone	0.0	1.8	[0.02 - 9.4]					98.2						1.8					
	Penicillins	Ampicillin	1.8	26.3	[15.5 - 39.7]							5.3	52.6	14.0		1.8	1.8	24.6			
	Quinolones	Ciprofloxacin	0.0	10.5	[3.9 - 21.5]	86.0				1.8	1.8			1.8	8.8						
		Nalidixic acid	N/A	12.3	[5.1 - 23.7]							31.6	52.6	1.8		1.8		12.3			
II	Aminoglycosides	Kanamycin	1.8	1.8	[0.02 - 9.4]										96.5		1.8		1.8		
	Cephems	Cefoxitin	3.5	0.0	[0.0 - 6.3]							1.8	38.6	50.9	5.3	3.5					
	Folate pathway inhibitors	Sulfisoxazole	N/A	14.0	[6.2 - 25.8]											78.9	7.0				14.0
		Trimethoprim-sulfamethoxazole	N/A	12.3	[5.1 - 23.7]				77.2	7.0	3.5				12.3						
	Phenicols	Chloramphenicol	1.8	5.3	[1.1 - 14.6]									49.1	43.9	1.8		5.3			
	Tetracyclines	Tetracycline	0.0	14.0	[6.2 - 25.8]									86.0			1.8	12.3			

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important

† CLSI: Clinical and Laboratory Standards Institute

‡ Percent of isolates with intermediate susceptibility, N/A if no MIC range of intermediate susceptibility exists

§ Percent of isolates that were resistant

¶ 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).

** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 27. Antibiotic resistance pattern for *Escherichia coli*, 2008

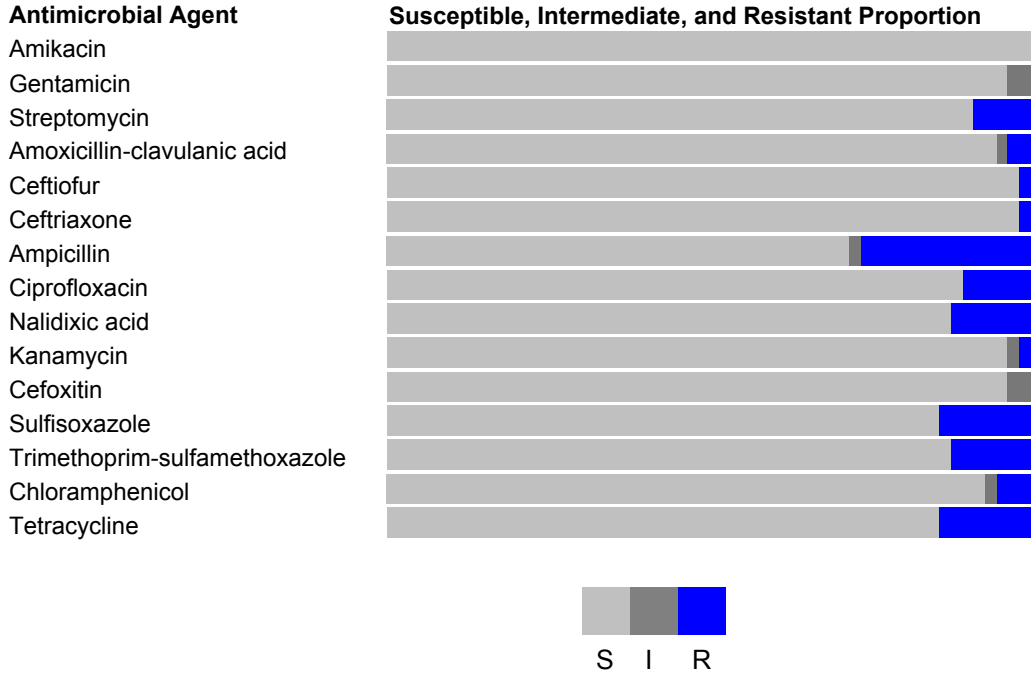

Table 55. Percentage and number of *Escherichia coli* isolates resistant to antimicrobial agents, 2004–2008

Year Total Isolates			2004 151	2005 119	2006 82	2007 66	2008 57
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)					
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.0% 3	3.4% 4	3.7% 3	3.0% 2	0.0% 0
		Streptomycin (MIC ≥ 64)	10.6% 16	14.3% 17	7.3% 6	13.6% 9	8.8% 5
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.6% 4	4.2% 5	3.7% 3	0.0% 0	3.5% 2
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.8% 1	0.0% 0	0.0% 0	1.8% 1
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.8% 1	0.0% 0	0.0% 0	1.8% 1
	Penicillins	Ampicillin (MIC ≥ 32)	24.5% 37	26.1% 31	28.0% 23	21.2% 14	26.3% 15
	Quinolones	Ciprofloxacin (MIC ≥ 4)	3.3% 5	7.6% 9	4.9% 4	7.6% 5	10.5% 6
		Nalidixic Acid (MIC ≥ 32)	9.3% 14	9.2% 11	11.0% 9	10.6% 7	12.3% 7
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	2.0% 3	0.0% 0	0.0% 0	1.5% 1	1.8% 1
	Cephems	Cefoxitin (MIC ≥ 32)	2.6% 4	0.8% 1	1.2% 1	0.0% 0	0.0% 0
	Folate pathway inhibitors	Sulfisoxazole‡ (MIC ≥ 512)	17.9% 27	18.4% 21	17.1% 14	24.2% 16	14.0% 8
		Trimethoprim-sulfamethoxazole‡ (MIC ≥ 4)	11.3% 17	14.9% 17	12.2% 10	15.2% 10	12.3% 7
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.3% 2	2.5% 3	3.7% 3	3.0% 2	5.3% 3
	Tetracyclines	Tetracycline (MIC ≥ 16)	13.2% 20	19.3% 23	14.6% 12	21.2% 14	14.0% 8

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I):

Table 56. Resistance patterns of *Escherichia coli* isolates, 2004–2008

Year	2004	2005	2006	2007	2008
Total Isolates	**151**	**119**	**82**	**66**	**57**
	% n	% n	% n	% n	% n
No resistance detected	62.9% 95	63.0% 75	62.2% 51	63.6% 42	64.9% 37
Resistance ≥1CLSI class*	37.7% 57	37.0% 44	37.8% 31	36.4% 24	35.1% 20
Resistance ≥2 CLSI classes*	21.9% 33	23.5% 28	23.2% 19	24.2% 16	22.8% 13
Resistance ≥3 CLSI classes*	14.6% 22	17.6% 21	18.3% 15	18.2% 12	12.3% 7
Resistance ≥4 CLSI classes*	6.0% 9	9.2% 11	11.0% 9	10.6% 7	8.8% 5
Resistance ≥5 CLSI classes*	3.3% 5	7.6% 9	1.2% 1	4.5% 3	7.0% 4
At least ACSSuT†	1.3% 2	0.8% 1	0.0% 0	0.0% 0	1.8% 1
At least ACT/S‡	1.3% 2	0.8% 1	1.2% 1	1.5% 1	3.5% 2
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftiofur and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.8% 1

* CLSI: Clinical and Laboratory Standards Institute

† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline

‡ ACT/S: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

§ ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur