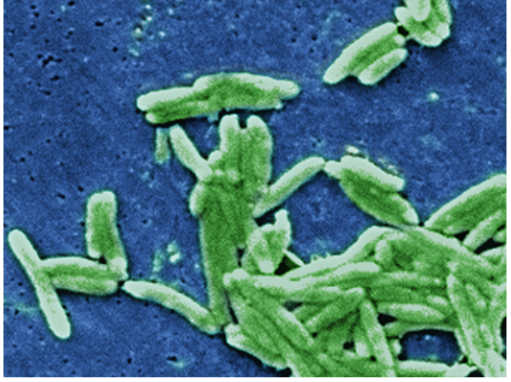


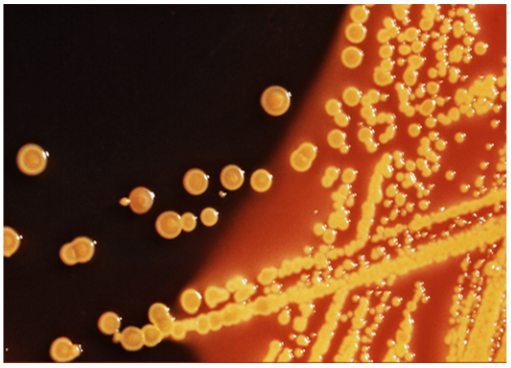
NARMS

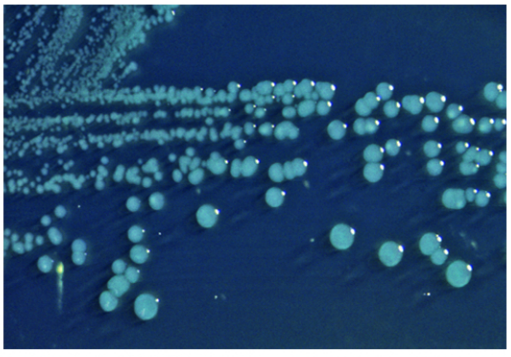
National Antimicrobial Resistance Monitoring System: Enteric Bacteria

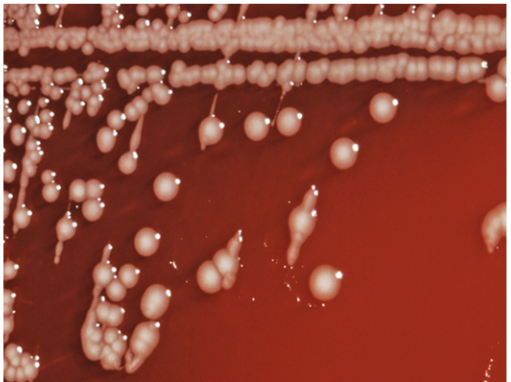
NARMS

2007

Human Isolates Final Report







DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

CDC
Centers for Disease Control and Prevention

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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, trimethoprim-sulfamethoxazole and nalidixic acid
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 2007

Data Presentation and Analysis

In this report, major findings in 2007 are provided in the "Summary of NARMS 2007 Surveillance Data." Tables presenting results for multiple years include the current year of reporting and previous 9 years. This report includes data for 1998 through 2007.

Categories for *Salmonella*

In previous reports, *Salmonella* isolates were categorized into non-Typhi *Salmonella* and *Salmonella* Typhi. In this report, the terms non-typhoidal and typhoidal *Salmonella* are used for reporting purposes. Results for non-typhoidal *Salmonella* are presented in Section 1 (Results). Typhoidal *Salmonella* serotypes, which cause enteric fever, include *Salmonella* Typhi, *Salmonella* Paratyphi A, *Salmonella* Paratyphi B, and *Salmonella* Paratyphi C. Results for typhoidal *Salmonella* are presented in Section 2 (Results).

Multidrug Resistance

In previous reports, a multidrug resistance pattern, MDR-AmpC, was defined as resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur, and decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL). In this report, a new designation more descriptive of the resistance associated with this phenotype is used. The new designation, ACSSuTAuCf, is defined as resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur.

In this report, we are quantifying resistance to antimicrobial categories using classes defined by the Clinical and Laboratory Standards Institute (CLSI). Cephems include ceftriaxone, ceftiofur (third-generation cephalosporins) and cefoxitin (cephamycin). Folate pathway inhibitors include sulfisoxazole, sulfamethoxazole (sulfonamides), and trimethoprim-sulfamethoxazole. In previous reports, we quantified resistance by categories that included CLSI classes and subclasses.

Trends in Antimicrobial Resistance: NARMS Data

In previous reports, a summary of trend analysis of the proportion of specific resistance phenotypes among non-Typhi *Salmonella, Salmonella* Typhi and *Campylobacter* was included. In this report, NARMS data are displayed graphically in the "Summary of NARMS 2007 Surveillance Data" section. The figures display resistance from 1996-2007 for non-typhoidal *Salmonella*, 1999-2007 for *Salmonella* ser. Typhi, and 1999-2007 for *Campylobacter*.

Introduction

The National Antimicrobial Resistance Monitoring System (NARMS) for Enteric Bacteria is a collaboration among the Centers for Disease Control and Prevention (CDC), Food and Drug Administration (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 Center for Veterinary Medicine (http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/default.htm), and resistance in enteric pathogens isolated from animals, conducted by the USDA Agricultural Research Services (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-Typhi *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-Typhi *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 2007 for non-typhoidal *Salmonella*, typhoidal *Salmonella, Shigella*, *Campylobacter* and *E. coli* O157 isolates. Data for earlier years are presented in tables 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 World Health Organization's categorization of antimicrobials of critical importance to human medicine (Table I).

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

WHO Categorization of Antimicrobial Agents

In 2005, the World Health Organization (WHO) convened a panel of experts to develop a list of essential antimicrobial agents according to their importance to human medicine. 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 I: 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 2007 Surveillance Data

Population

In 2007, all 50 states participated in NARMS, representing the entire population of approximately 302 million persons (Table II). Surveillance was conducted in all states for *Escherichia coli* O157, non-typhoidal *Salmonella,* typhoidal *Salmonella,* and *Shigella*. For *Campylobacter*, surveillance was conducted in 10 states that comprise the Foodborne Diseases Active Surveillance Network (FoodNet), representing approximately 46 million persons (15.0% of the U.S. population).

Clinically Important Antimicrobial Resistance Patterns

In the United States, fluoroquinolones 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.Fluoroquinolones are also used to treat *Campylobacter* infections.

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 decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL). A substantial proportion of isolates tested by NARMS in 2007 demonstrated resistance to these clinically important antimicrobial agents, as follows:

- 26.0% (286/1100) of *Campylobacter* isolates were resistant to ciprofloxacin, including
    - 28.6% (30/105) of *Campylobacter coli* isolates
    - 25.8% (256/992) of *Campylobacter jejuni* isolates
- 2.2% (48/2144) of non-typhoidal *Salmonella* isolates were resistant to nalidixic acid, including
    - 5.7% (22/385) of *Salmonella* ser*.* Enteritidis isolates
    - Enteritidis was the most common serotype among nalidixic acid–resistant non-typhoidal *Salmonella* isolates: 45.8% (22/48) of nalidixic acid–resistant isolates were serotype Enteritidis.
- 3.3% (70/2144) of non-typhoidal *Salmonella* isolates were resistant to ceftiofur, including
    - 7.7% (17/220) of S*almonella* ser. Newport isolates
    - Typhimurium was the most common serotype among ceftiofur–resistant non-typhoidal *Salmonella* isolates: 35.7% (25/70) of ceftiofur–resistant isolates were serotype Typhimurium.
- 62.3% (248/398) of *Salmonella* ser. Typhi isolates were resistant to nalidixic acid.
- 1.9% (9/482)) of *Shigella* isolates were resistant to nalidixic acid and a single (1/61) *S. flexneri* isolate was resistant to ciprofloxacin.
- 2.1% (4/190) of *E. coli* O157 isolates were resistant to nalidixic acid and a single (1/190) isolate was resistant to ciprofloxacin.
- No ceftiofur or ceftriaxone resistant *Shigella* or *E. coli* O157 isolates were observed in 2007.

Multidrug Resistance

Multidrug resistance is described in NARMS by the number of antimicrobial classes and also by specific coresistant phenotypes. CLSI classes of antimicrobial agents are used in this report (Table III, Table IV). For non-typhoidal *Salmonella*, a common multidrug-resistant phenotype in 2007 includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide (sulfamethoxazole/sulfisoxazole), and tetracycline (ACSSuT). The ACSSuT phenotype includes resistance to five antimicrobial classes. Another common phenotype includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur (ACSSuTAuCf).The ACSSuTAuCf phenotype includes resistance to 7 antimicrobial classes.

- 18.9% (406/2144) of non-typhoidal *Salmonella* isolates were resistant to one or more CLSI classes, and 11.1% (239/2144) were resistant to three or more CLSI classes.
    - 34.2% (138/403) of *Salmonella* ser. Typhimurium isolates were resistant to three or more classes.
    - 10.5% (23/220) of *Salmonella* ser. Newport isolates were resistant to three or more classes.
    - 1.0% (4/385) of *Salmonella* ser. Enteritidis isolates were resistant to three or more classes.
    - Of 239 non-typhoidal *Salmonella* resistant to three or more classes, most were *Salmonella* ser. Typhimurium (57.7%).

- 6.3% (136/2144) of non-typhoidal *Salmonella* isolates had the ACSSuT resistance pattern, including
    - 22.6% (91/403) of *Salmonella* ser. Typhimurium isolates, and
    - 8.2% (18/220) of *Salmonella* ser. Newport isolates.
- 2.1% (46/2144) of non- typhoidal *Salmonella* isolates had the ACSSuTAuCf resistance pattern, including
    - 7.7% (17/220) of *Salmonella* ser. Newport isolates, and
    - 3.5% (14/403) of *Salmonella* ser. Typhimurium isolates.
- 33.2% (160/482) of *Shigella* isolates were resistant to three or more classes.
- 2.1% (4/190) of *E. coli* O157 isolates were resistant to three or more classes.

Trends in Antimicrobial Resistance: NARMS Data

The following figures display resistance from 1996-2007 for non-typhoidal *Salmonella*, 1999-2007 for *Salmonella* ser. Typhi and 1997-2007 for *Campylobacter*.

Figure 1.01: Proportion of non-typhoidal *Salmonella* isolates resistant to nalidixic acid, by year, 1996-2007.

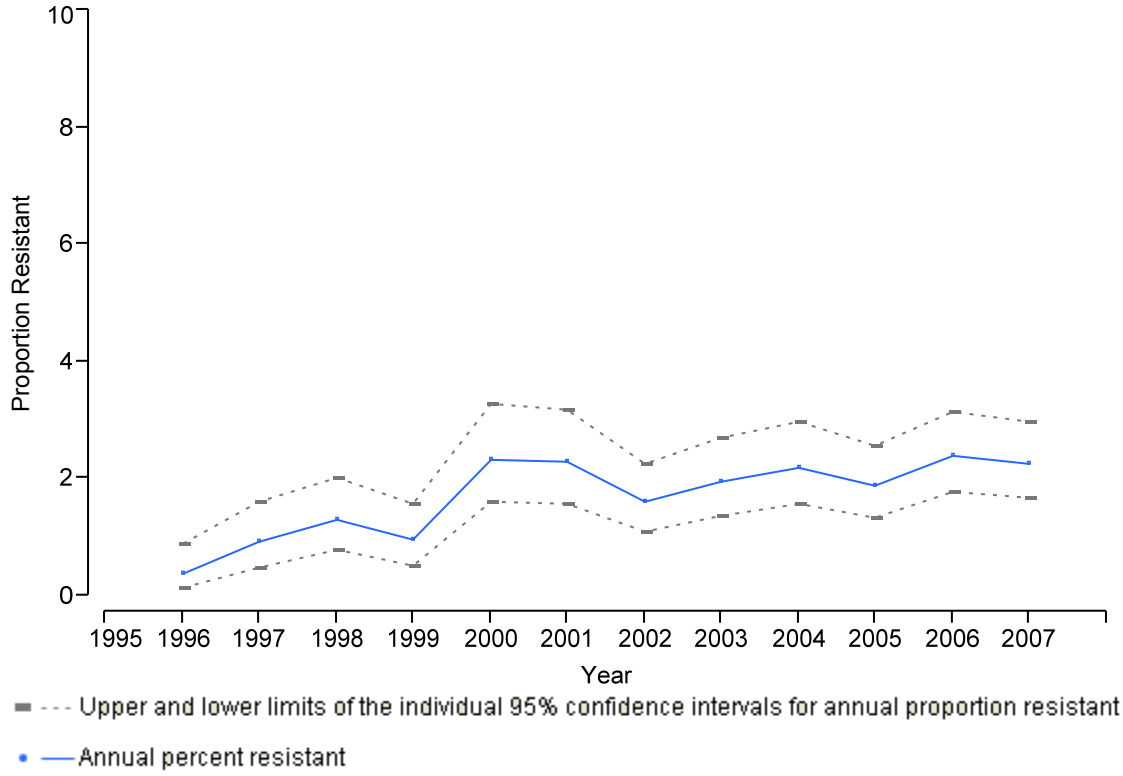


Figure 1.02: Proportion of non-typhoidal *Salmonella* isolates resistant to ceftiofur, by year, 1996-2007.

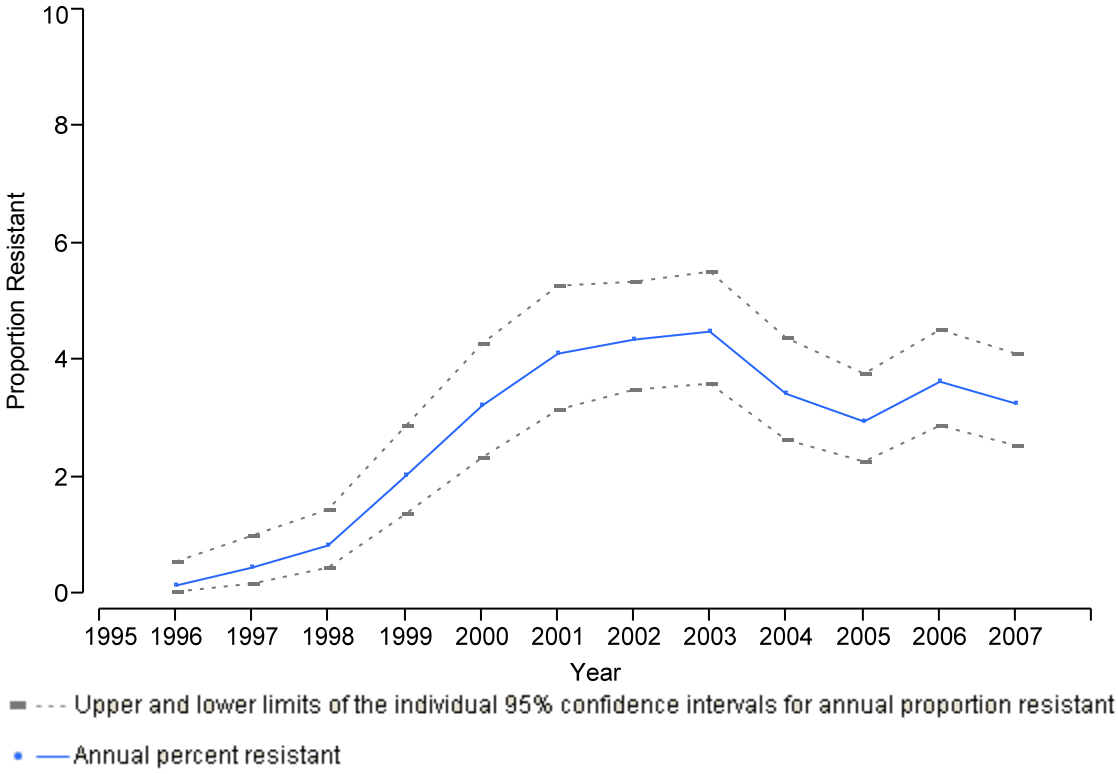


Figure 1.03: Proportion of *Salmonella* ser. Enteritidis isolates resistant to nalidixic acid, by year, 1996-2007.

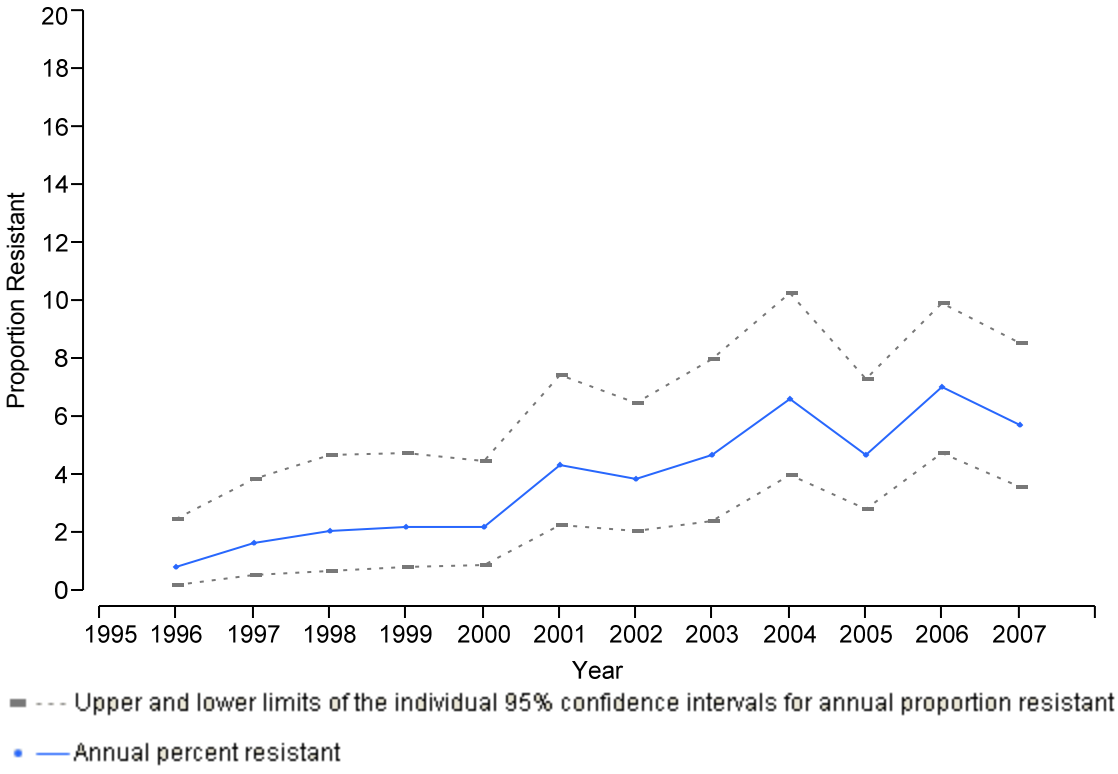


Figure 1.04: Proportion of *Salmonella* ser. Typhimurium isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline (ACSSuT), by year, 1996-2007.

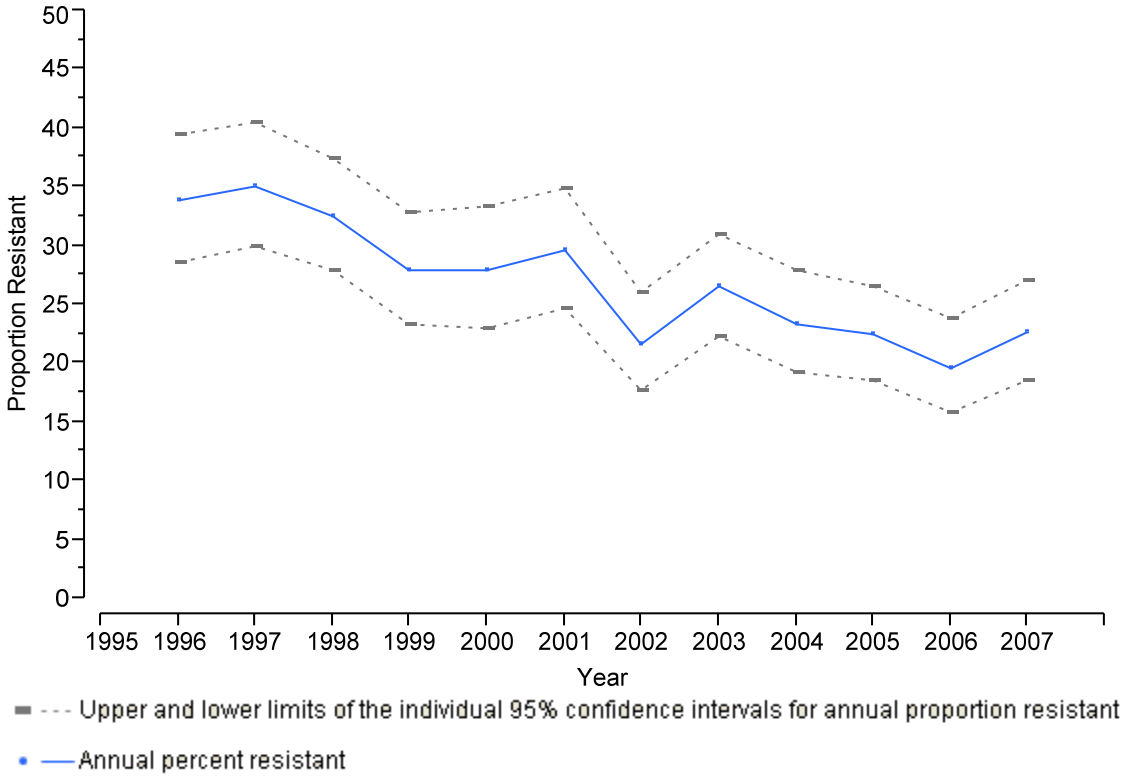


Figure 1.05: Proportion of *Salmonella* ser. Newport isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur (ACSSuTAuCf), by year, 1996-2007.

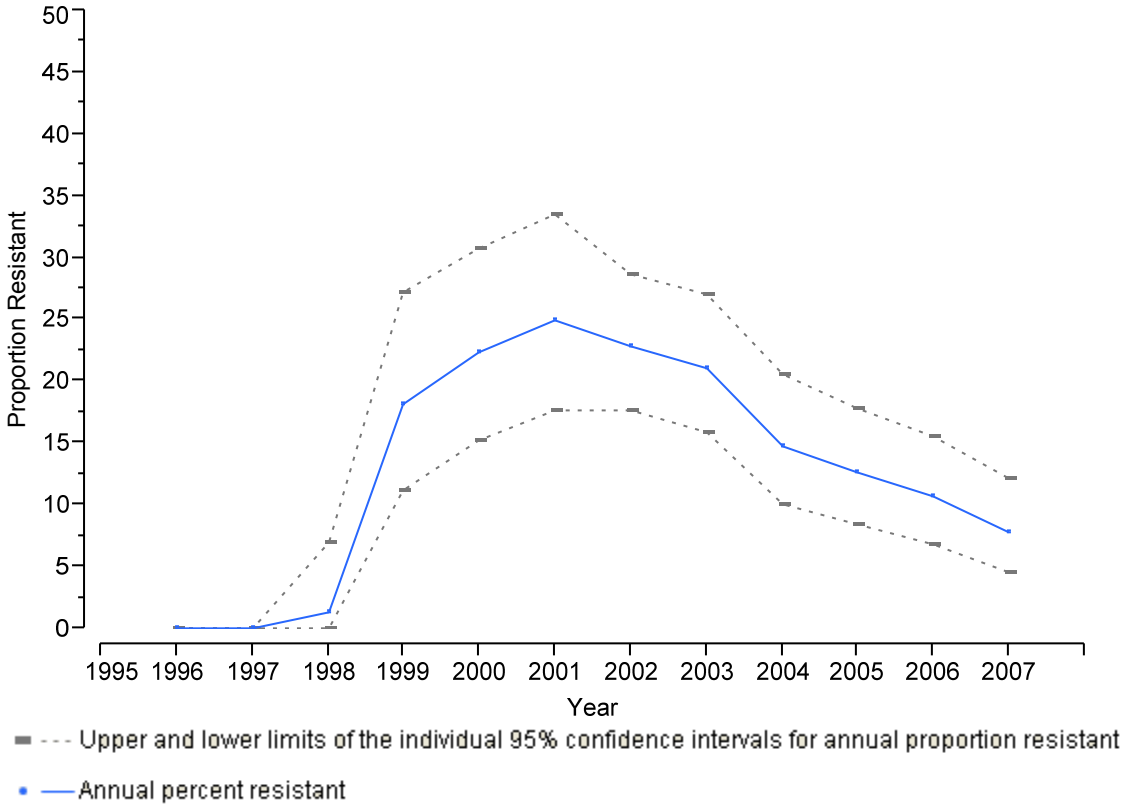


Figure 1.06: Proportion of non-typhoidal *Salmonella* isolates resistant to 1 or more antimicrobial classes, by year, 1996-2007.

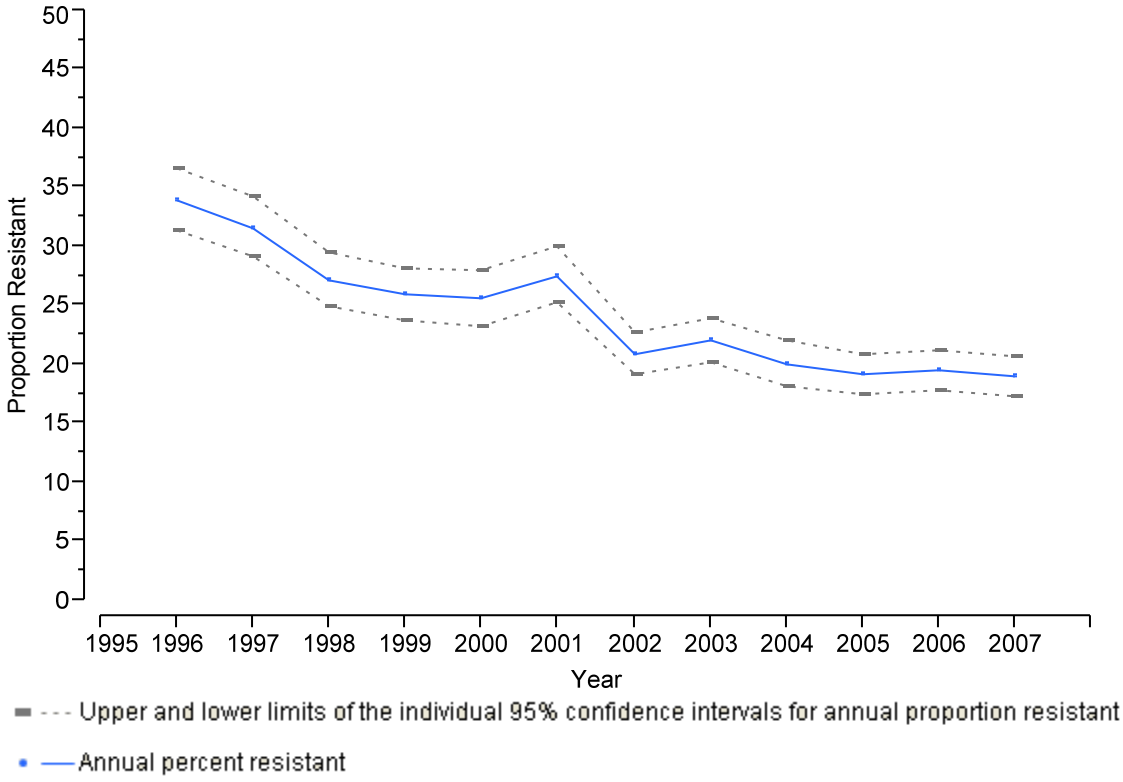


Figure 1.07: Proportion of non-typhoidal *Salmonella* isolates resistant to 3 or more antimicrobial classes, by year, 1996-2007.

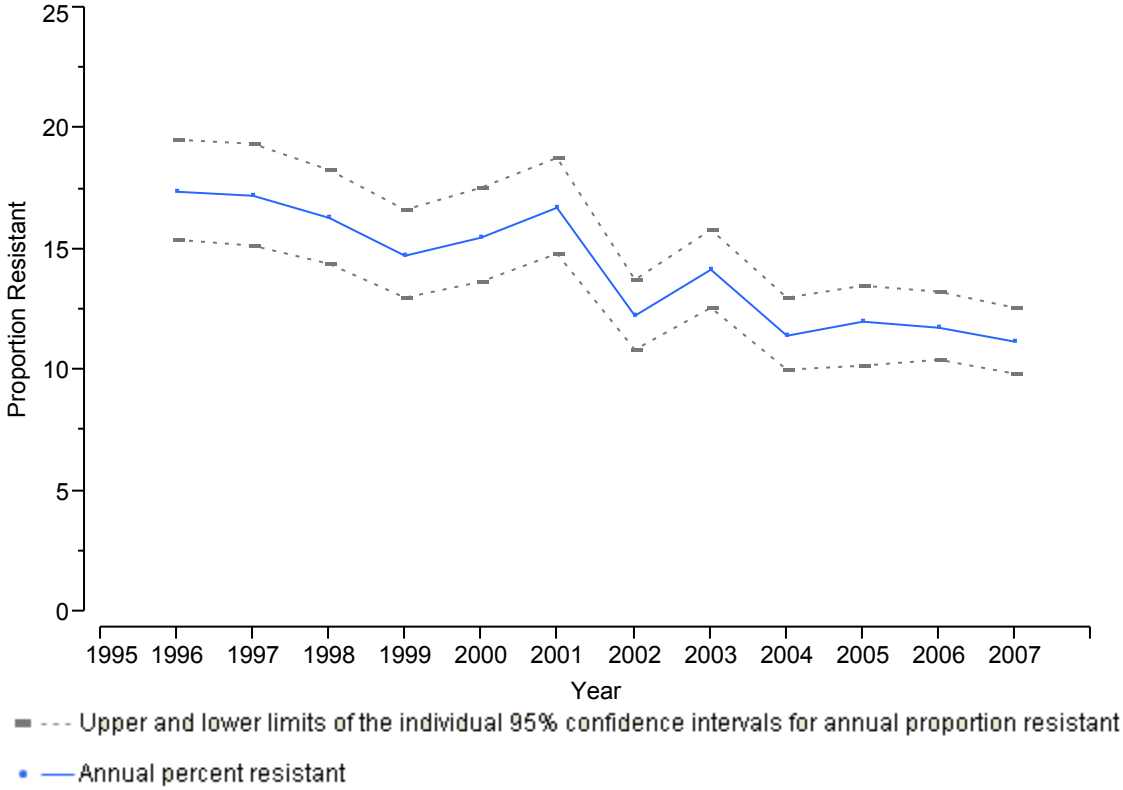


Figure 1.08: Proportion of *Salmonella* ser. Typhi isolates resistant to nalidixic acid, by year, 1999-2007.

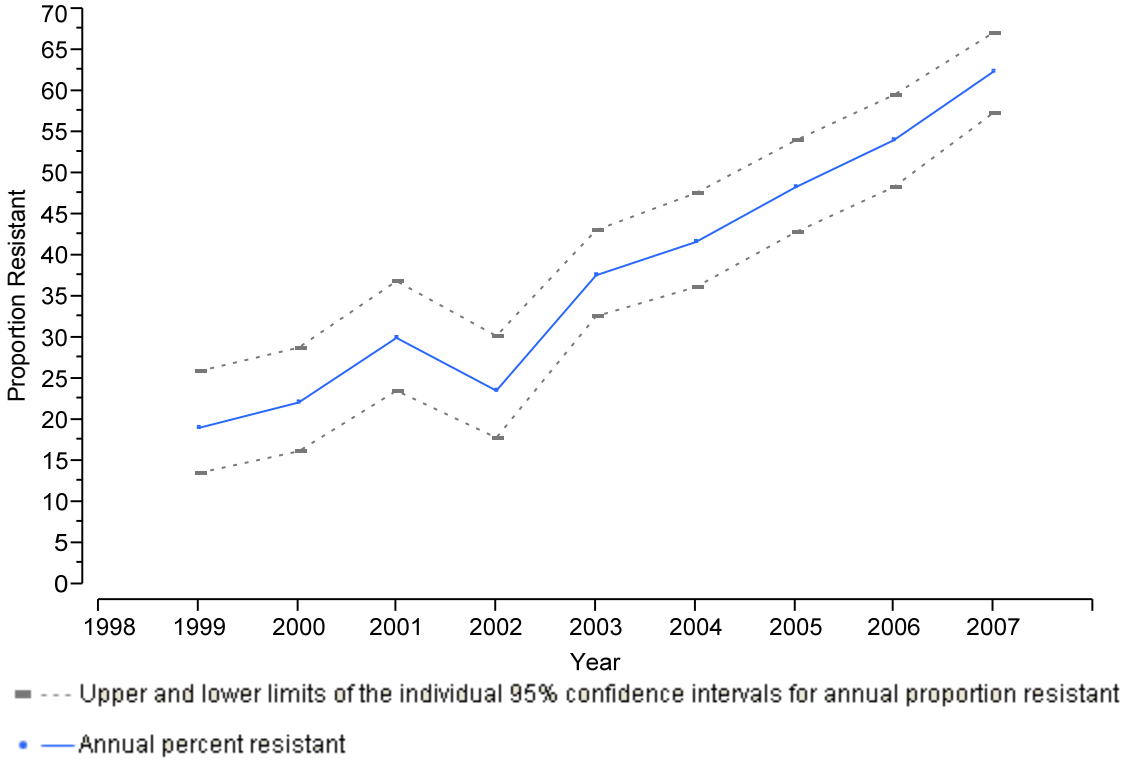


Figure 1.09: Proportion of *Campylobacter* isolates resistant to ciprofloxacin, by year, 1997-2007.

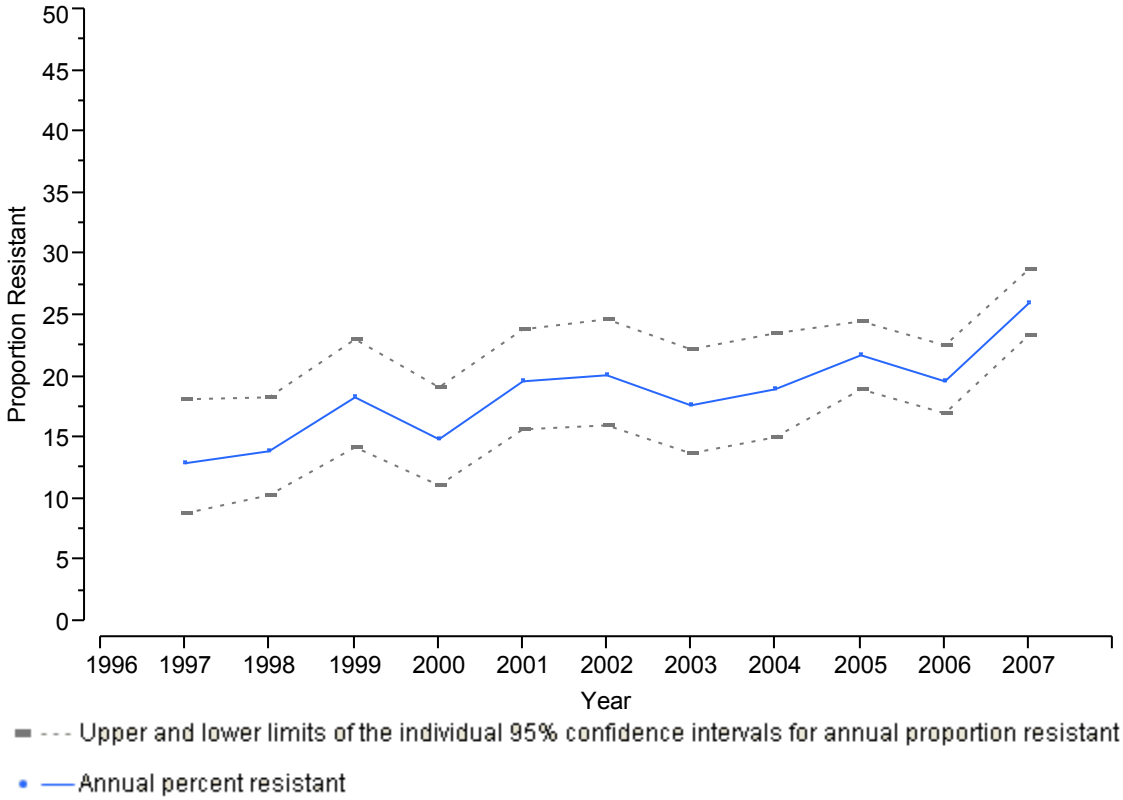


Table II: Population size and number of isolates received and tested, NARMS, 2007

State/Site	Population Size*	Non-typhoidal *Salmonella*		Typhoidal† *Salmonella*		*Shigella*		*E. coli* O157		*Campylobacter* ‡	
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Alabama	4,627,851	60	(2.8%)	1	(0.2%)	39	(8.1%)	4	(2.1%)		
Alaska	683,478	5	(0.2%)	1	(0.2%)	1	(0.2%)	2	(1.1%)		
Arizona	6,338,755	64	(3.0%)	7	(1.7%)	23	(4.8%)	3	(1.6%)		
Arkansas	2,834,797	34	(1.6%)	0	(0.0%)	4	(0.8%)	1	(0.5%)		
California§	26,674,661	206	(9.6%)	57	(13.7%)	2	(0.4%)	12	(6.3%)	59	(5.4%)
Colorado	4,861,515	31	(1.4%)	7	(1.7%)	7	(1.5%)	5	(2.6%)	57	(5.2%)
Connecticut	3,502,309	26	(1.2%)	10	(2.4%)	3	(0.6%)	3	(1.6%)	98	(8.9%)
Delaware	864,764	8	(0.4%)	2	(0.5%)	0	(0.0%)	0	(0.0%)		
District of Columbia	588,292	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Florida	18,251,243	34	(1.6%)	11	(2.7%)	0	(0.0%)	0	(0.0%)		
Georgia	9,544,750	118	(5.5%)	18	(4.3%)	59	(12.2%)	37	(19.5%)	313	(28.5%)
Hawaii	1,283,388	25	(1.2%)	4	(1.0%)	1	(0.2%)	1	(0.5%)		
Houston, Texas¶	4,858,315	40	(1.9%)	6	(1.4%)	22	(4.6%)	2	(1.1%)		
Idaho	1,499,402	10	(0.5%)	1	(0.2%)	0	(0.0%)	4	(2.1%)		
Illinois	12,852,548	101	(4.7%)	16	(3.9%)	38	(7.9%)	6	(3.2%)		
Indiana	6,345,289	39	(1.8%)	2	(0.5%)	3	(0.6%)	4	(2.1%)		
Iowa	2,988,046	23	(1.1%)	1	(0.2%)	5	(1.0%)	2	(1.1%)		
Kansas	2,775,997	18	(0.8%)	0	(0.0%)	2	(0.4%)	2	(1.1%)		
Kentucky	4,241,474	34	(1.6%)	0	(0.0%)	22	(4.6%)	6	(3.2%)		
Los Angeles**	9,878,554	55	(2.6%)	19	(4.6%)	5	(1.0%)	0	(0.0%)		
Louisiana	4,293,204	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Maine	1,317,207	7	(0.3%)	0	(0.0%)	1	(0.2%)	1	(0.5%)		
Maryland	5,618,344	60	(2.8%)	12	(2.9%)	5	(1.0%)	0	(0.0%)	75	(6.8%)
Massachusetts	6,449,755	56	(2.6%)	16	(3.9%)	7	(1.5%)	4	(2.1%)		
Michigan	10,071,822	42	(2.0%)	6	(1.4%)	3	(0.6%)	3	(1.6%)		
Minnesota	5,197,621	35	(1.6%)	8	(1.9%)	11	(2.3%)	8	(4.2%)	154	(14.0%)
Mississippi	2,918,785	40	(1.9%)	0	(0.0%)	41	(8.5%)	2	(1.1%)		
Missouri	5,878,415	29	(1.4%)	1	(0.2%)	15	(3.1%)	4	(2.1%)		
Montana	957,861	8	(0.4%)	0	(0.0%)	1	(0.2%)	1	(0.5%)		
Nebraska	1,774,571	9	(0.4%)	1	(0.2%)	6	(1.2%)	4	(2.1%)		
Nevada	2,565,382	15	(0.7%)	0	(0.0%)	2	(0.4%)	1	(0.5%)		
New Hampshire	1,315,828	11	(0.5%)	4	(1.0%)	0	(0.0%)	1	(0.5%)		
New Jersey	8,685,920	57	(2.7%)	32	(7.7%)	11	(2.3%)	10	(5.3%)		
New Mexico	1,969,915	28	(1.3%)	0	(0.0%)	7	(1.5%)	4	(2.1%)	56	(5.1%)
New York††	11,023,202	69	(3.2%)	20	(4.8%)	5	(1.0%)	8	(4.2%)	130	(11.8%)
New York City‡‡	8,274,527	77	(3.6%)	64	(15.4%)	6	(1.2%)	5	(2.6%)		
North Carolina	9,061,032	87	(4.1%)	11	(2.7%)	3	(0.6%)	3	(1.6%)		
North Dakota	639,715	4	(0.2%)	0	(0.0%)	1	(0.2%)	1	(0.5%)		
Ohio	11,466,917	69	(3.2%)	13	(3.1%)	20	(4.1%)	3	(1.6%)		
Oklahoma	3,617,316	36	(1.7%)	3	(0.7%)	7	(1.5%)	2	(1.1%)		
Oregon	3,747,455	18	(0.8%)	4	(1.0%)	4	(0.8%)	5	(2.6%)	109	(9.9%)
Pennsylvania	12,432,792	94	(4.4%)	9	(2.2%)	7	(1.5%)	3	(1.6%)		
Rhode Island	1,057,832	7	(0.3%)	2	(0.5%)	2	(0.4%)	0	(0.0%)		
South Carolina	4,407,709	53	(2.5%)	1	(0.2%)	7	(1.5%)	0	(0.0%)		
South Dakota	796,214	9	(0.4%)	0	(0.0%)	4	(0.8%)	2	(1.1%)		
Tennessee	6,156,719	81	(3.8%)	1	(0.2%)	19	(3.9%)	3	(1.6%)	49	(4.5%)
Texas§§	19,046,065	59	(2.8%)	13	(3.1%)	10	(2.1%)	2	(1.1%)		
Utah	2,645,330	12	(0.6%)	3	(0.7%)	1	(0.2%)	3	(1.6%)		
Vermont	621,254	4	(0.2%)	0	(0.0%)	0	(0.0%)	1	(0.5%)		
Virginia	7,712,091	71	(3.3%)	25	(6.0%)	9	(1.9%)	4	(2.1%)		
Washington	6,468,424	6	(0.3%)	0	(0.0%)	1	(0.2%)	0	(0.0%)		
West Virginia	1,812,035	1	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Wisconsin	5,601,640	51	(2.4%)	3	(0.7%)	26	(5.4%)	6	(3.2%)		
Wyoming	522,830	8	(0.4%)	0	(0.0%)	4	(0.8%)	2	(1.1%)		
Total	**301,621,157**	**2144**	**(100.0%)**	**415**	**(100.0%)**	**482**	**(100.0%)**	**190**	**(100.0%)**	**1100**	**(100.0%)**

* US Census Bureau, 2007

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

‡ *Campylobacter* isolates are submitted only from FoodNet sites representing a total population 45,954,593. 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 2007, NARMS conducted nationwide surveillance among approximately 302 million persons (2007 U.S. Census Bureau estimates). Public health laboratories systematically selected every 20th non-Typhi *Salmonella* (i.e., all *Salmonella* serotypes except serotype Typhi), *Shigella*, and *Escherichia coli* O157 isolate as well as every *Salmonella* ser. Typhi isolate received at their laboratories and forwarded these isolates to CDC for antimicrobial susceptibility testing. *Salmonella* Paratyphi A, Paratyphi B, and Paratyphi C were included in the every 20th sampling for non-Typhi *Salmonella.*

The following scheme for *Campylobacter* isolate submission has been used since 2005: Public health laboratories of the 10 state health departments that participated in CDC's Foodborne Diseases Active Surveillance Network (FoodNet) forwarded a representative sample of *Campylobacter* isolates to CDC for susceptibility testing. The FoodNet sites, representing approximately 45 million persons (2006 U.S. Census Bureau estimates), included California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee. Depending on burden of *Campylobacter* in each FoodNet site, one of three 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 IV). 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).

Table III: Antimicrobial agents used for susceptibility testing for *Salmonella*, *Shigella*, and *Escherichia coli* O157 isolates, NARMS, 2007

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	≤8	16–32	≥64
	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.
† 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 2007 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 2007 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 2007, *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 2007, 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 V). 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 IV: Antimicrobial agents used for susceptibility testing of *Campylobacter* isolates, NARMS, 1997–2007

CLSI class	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	Breakpoints		
			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* 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 III). 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 2007 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 2007, represented by ciprofloxacin, chloramphenicol/florfenicol, clindamycin, erythromycin, nalidixic acid, and tetracycline.

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 1.01). 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 1.02).

Figure 2.01: How to read a squashtogram

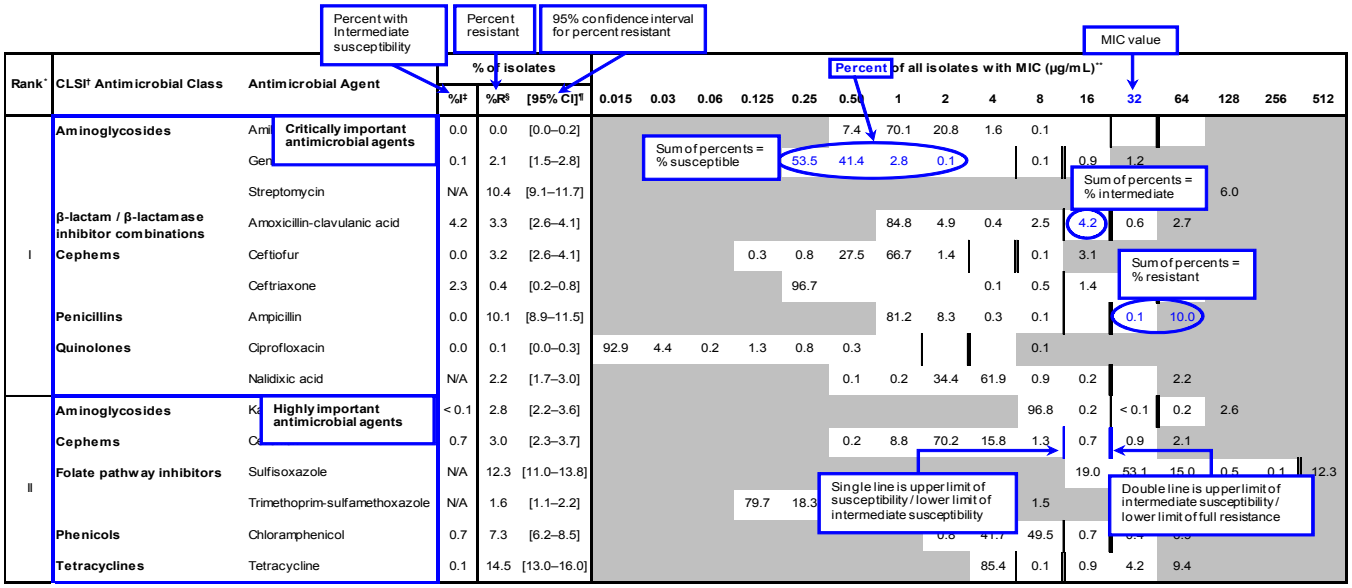


Figure 2.02: Proportional chart, a categorical graph of a squashtogram

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]						7.4	70.1	20.8	1.6	0.1						
		Gentamicin	0.1	2.1	[1.5–2.8]					53.5	41.4	2.8	0.1		0.1	0.9	1.2				
		Streptomycin	N/A	10.4	[9.1–11.7]												89.6	4.4	6.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.2	3.3	[2.6–4.1]							84.8	4.9	0.4	2.3	4.2	0.6	2.7			
	Cephems	Ceftiofur	0.0	3.2	[2.6–4.1]				0.3	0.8	27.5	66.7	1.4		0.1	3.1					
		Ceftriaxone	2.3	0.4	[0.2–0.8]					96.7				0.1	0.5	1.4	0.9	0.3	0.1		
	Penicillins	Ampicillin	0.0	10.1	[8.9–11.5]							81.2	8.3	0.3	0.1		0.1	10.0			
	Quinolones	Ciprofloxacin	0.0	0.1	[0.0–0.3]	92.9	4.4	0.2	1.3	0.8	0.3				0.1						
		Nalidixic acid	N/A	2.2	[1.7–3.0]						0.1	0.2	34.4	61.9	0.9	0.2		2.2			
II	Aminoglycosides	Kanamycin	< 0.1	2.8	[2.2–3.6]										96.8	0.2	< 0.1	0.2	2.6		
	Cephems	Cefoxitin	0.7	3.0	[2.3–3.7]						0.2	0.8	70.2	15.8	1.3	0.7	0.9	2.1			
	Folate pathway inhibitors	Sulfisoxazole	N/A	12.3	[11.0–13.8]											19.0	53.1	15.0	0.5	0.1	12.3
		Trimethoprim-sulfamethoxazole	N/A	1.6	[1.1–2.2]				79.7	18.3	0.2	0.2		0.1	1.5						
	Phenicols	Chloramphenicol	0.7	7.3	[6.2–8.5]								0.8	41.7	49.5	0.7	0.4	6.9			
	Tetracyclines	Tetracycline	0.1	14.5	[13.0–16.0]									85.4	0.1	0.9	4.2	9.4			

* 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

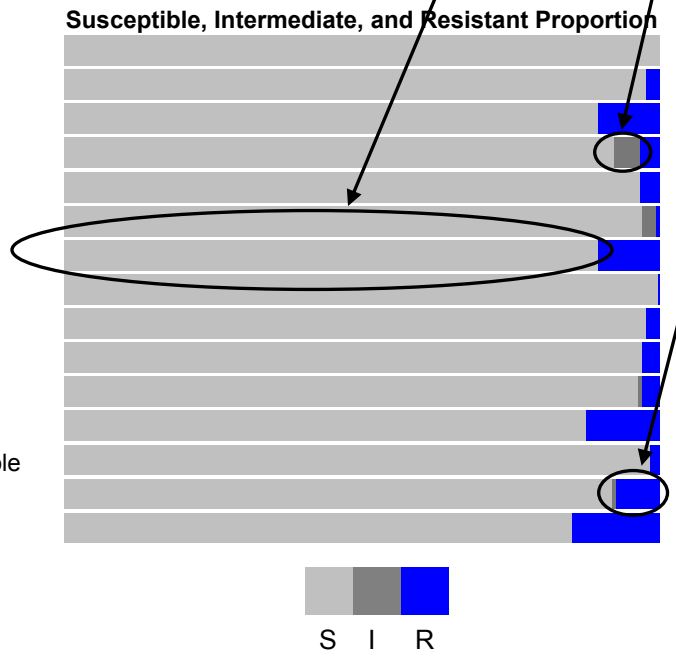
† CLSI: Clinical and Laboratory Standards Institute

‡ 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 percentages 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 1.01: Minimum inhibitory concentrations (MICs) and resistance of non-typhoidal *Salmonella* isolates to antimicrobial agents, 2007 (N=2,144)

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]						7.4	70.1	20.8	1.6	0.1						
		Gentamicin	0.1	2.1	[1.5–2.8]					53.5	41.4	2.8	0.1		0.1	0.9	1.2				
		Streptomycin	N/A	10.4	[9.1–11.7]												89.6	4.4	6.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.2	3.3	[2.6–4.1]							84.8	4.9	0.4	2.5	4.2	0.6	2.7			
	Cephems	Ceftiofur	0.0	3.2	[2.6–4.1]				0.3	0.8	27.5	66.7	1.4		0.1	3.1					
		Ceftriaxone	2.3	0.4	[0.2–0.8]					96.7				0.1	0.5	1.4	0.9	0.3	0.1		
	Penicillins	Ampicillin	0.0	10.1	[8.9–11.5]							81.2	8.3	0.3	0.1		0.1	10.0			
	Quinolones	Ciprofloxacin	0.0	0.1	[0.0–0.3]	92.9	4.4	0.2	1.3	0.8	0.3				0.1						
		Nalidixic acid	N/A	2.2	[1.7–3.0]						0.1	0.2	34.4	61.9	0.9	0.2		2.2			
II	Aminoglycosides	Kanamycin	< 0.1	2.8	[2.2–3.6]										96.8	0.2	< 0.1	0.2	2.6		
	Cephems	Cefoxitin	0.7	3.0	[2.3–3.7]						0.2	8.8	70.2	15.8	1.3	0.7	0.9	2.1			
	Folate pathway inhibitors	Sulfisoxazole	N/A	12.3	[11.0–13.8]											19.0	53.1	15.0	0.5	0.1	12.3
		Trimethoprim-sulfamethoxazole	N/A	1.6	[1.1–2.2]				79.7	18.3	0.2	0.2		0.1	1.5						
	Phenicols	Chloramphenicol	0.7	7.3	[6.2–8.5]								0.8	41.7	49.5	0.7	0.4	6.9			
	Tetracyclines	Tetracycline	0.1	14.5	[13.0–16.0]									85.4	0.1	0.9	4.2	9.4			

* 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
‡ 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 2.03: Antimicrobial resistance pattern for non-typhoidal *Salmonella*, 2007

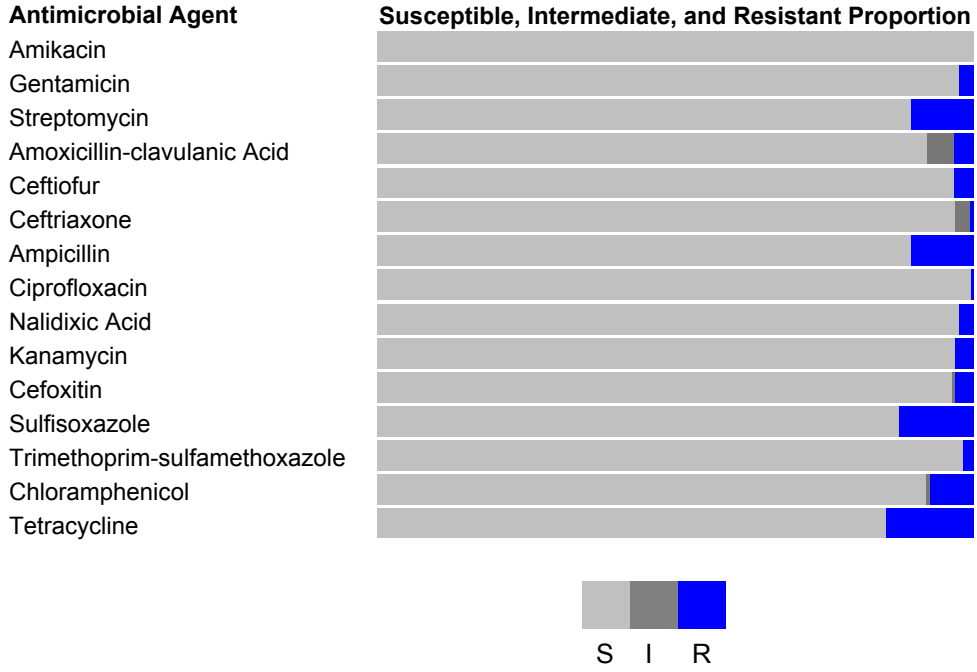


Table 1.02: Percentage and number of non-typhoidal *Salmonella* isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			1455	1493	1372	1410	1998	1855	1782	2034	2173	2144
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	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
		Gentamicin (MIC ≥ 16)	2.8% 41	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
		Streptomycin (MIC ≥ 64)	18.7% 272	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.7% 25	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
	Cephems	Ceftiofur (MIC ≥ 8)	0.8% 12	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
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.3% 5	0.0% 0	0.0% 0	0.2% 4	0.4% 8	0.6% 10	0.1% 3	0.2% 4	0.4% 9
	Penicillins	Ampicillin (MIC ≥ 32)	16.6% 241	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
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.1% 1	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
		Nalidixic acid (MIC ≥ 32)	1.3% 19	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
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	5.7% 83	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	2.3% 33	3.5% 53	4.0% 55	4.0% 57	5.1% 101	5.3% 99	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	19.5% 283	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.3% 34	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	10.0% 145	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	20.3% 295	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

* 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 1.03: Resistance patterns of non-typhoidal *Salmonella* isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	1455	1493	1372	1410	1998	1855	1782	2034	2173	2144
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	72.9% 1060	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
Resistance ≥ 1 CLSI class*	27.1% 395	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
Resistance ≥ 2 CLSI classes*	22.5% 327	20.2% 302	20.0% 275	22.1% 311	15.8% 315	17.5% 325	15.0% 267	14.8% 302	14.6% 318	14.2% 305
Resistance ≥ 3 CLSI classes*	16.3% 237	14.7% 220	15.5% 213	16.7% 236	12.3% 245	14.2% 263	11.4% 204	12.0% 244	11.8% 256	11.1% 239
Resistance ≥ 4 CLSI classes*	12.8% 186	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
Resistance ≥ 5 CLSI classes*	9.8% 142	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
At least ACSSuT†	8.9% 130	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
At least ACT/S‡	0.9% 13	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
At least ACSSuTAuCf§	0.3% 5	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
At least ceftiofur and nalidixic acid resistant	0.0% 0	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

* 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 1.04: Twenty most common non-typhoidal *Salmonella* serotypes in NARMS and the Public Health Laboratory Information System (PHLIS), 2007

NARMS		Isolates	
Rank	Serotype	n	(%)
1	Typhimurium	403	(18.8%)
2	Enteritidis	385	(18.0%)
3	Newport	220	(10.3%)
4	Heidelberg	98	(4.6%)
5	I 4,[5],12:i:-	73	(3.4%)
6	Javiana	65	(3.0%)
7	Muenchen	64	(3.0%)
8	Montevideo	51	(2.4%)
9	Tennessee	38	(1.8%)
10	Mississippi	37	(1.7%)
11	Oranienburg	37	(1.7%)
12	Braenderup	36	(1.7%)
13	Agona	32	(1.5%)
14	Saintpaul	32	(1.5%)
15	Infantis	26	(1.2%)
16	Paratyphi B var. L(+) tartrate+	25	(1.2%)
17	Mbandaka	24	(1.1%)
18	Poona	22	(1.0%)
19	Stanley	20	(0.9%)
20	Schwarzengrund	19	(0.9%)
	Subtotal	**1707**	**(79.6%)**
	All other serotypes	383	(17.9%)
	Unknown serotype	13	(0.6%)
	Partially serotyped	24	(1.1%)
	Rough/Nonmotile isolates	17	(0.8%)
	Subtotal	**437**	**(20.4%)**
	Grand Total	**2144**	**(100.0%)**

PHLIS		Isolates	
Rank	Serotype	n	(%)
1	Typhimurium	5459	(15.6%)
2	Enteritidis	5333	(15.3%)
3	Newport	3119	(8.9%)
4	Heidelberg	1384	(4.0%)
5	Javiana	1118	(3.2%)
6	I 4,[5],12:i:-	1004	(2.9%)
7	Muenchen	871	(2.5%)
8	Montevideo	843	(2.4%)
9	Tennessee	625	(1.8%)
10	Oranienburg	588	(1.7%)
11	Braenderup	493	(1.4%)
12	Infantis	469	(1.3%)
13	Saintpaul	435	(1.2%)
14	Agona	433	(1.2%)
15	Mississippi	430	(1.2%)
16	Thompson	364	(1.0%)
17	Paratyphi B var. L(+) tartrate+	322	(0.9%)
18	Schwarzengrund	277	(0.9%)
19	Hadar	248	(0.8%)
20	Bareilly	227	(0.7%)
	Subtotal	**24042**	**(68.9%)**
	All other serotypes	5298	(15.2%)
	Unknown serotype	4246	(12.2%)
	Partially serotyped	1230	(3.5%)
	Rough/Nonmotile isolates	84	(0.2%)
	Subtotal	**10858**	**(31.1%)**
	Grand Total	**34900**	**(100.0%)**

A. *Salmonella* ser. Enteritidis

Table 1.05: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Enteritidis isolates to antimicrobial agents, 2007 (N=385)

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	[0.0–1.0]						20.3	70.6	8.1	1.0							
		Gentamicin	0.0	0.0	[0.0–1.0]					78.4	20.3	1.0	0.3								
		Streptomycin	N/A	0.6	[0.1–1.9]												99.5	0.3	0.3		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	0.5	[0.1–1.9]							89.4	8.6	0.3	1.3			0.5			
	Cephems	Ceftiofur	0.0	0.3	[0.0–1.4]				0.3	0.3	8.6	88.8	1.8			0.3					
		Ceftriaxone	0.3	0.0	[0.0–1.0]					99.7						0.3					
	Penicillins	Ampicillin	0.0	2.1	[0.9–4.1]							76.6	20.8	0.3	0.3			2.1			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.0]	80.8	13.2		4.4	1.6											
		Nalidixic acid	N/A	5.7	[3.6–8.5]							0.3	15.6	77.1	1.0	0.3		5.7			
II	**Aminoglycosides**	Kanamycin	0.0	0.5	[0.1–1.9]										99.5				0.5		
	Cephems	Cefoxitin	0.3	0.3	[0.0–1.4]						0.3	7.5	85.7	4.4	1.6	0.3		0.3			
	Folate pathway inhibitors	Sulfisoxazole	N/A	1.6	[0.6–3.4]											17.9	64.4	15.3	0.8		1.6
		Trimethoprim-sulfamethoxazole	N/A	1.0	[0.3–2.6]				83.9	14.0	0.5	0.5			1.0						
	Phenicols	Chloramphenicol	0.8	0.6	[0.1–1.9]								1.0	51.2	46.5	0.8	0.3	0.3			
	Tetracyclines	Tetracycline	0.3	3.9	[2.2–6.3]									95.8	0.3		0.3	3.6			

* 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 2.04: Antimicrobial resistance pattern for *Salmonella* ser. Enteritidis, 2007

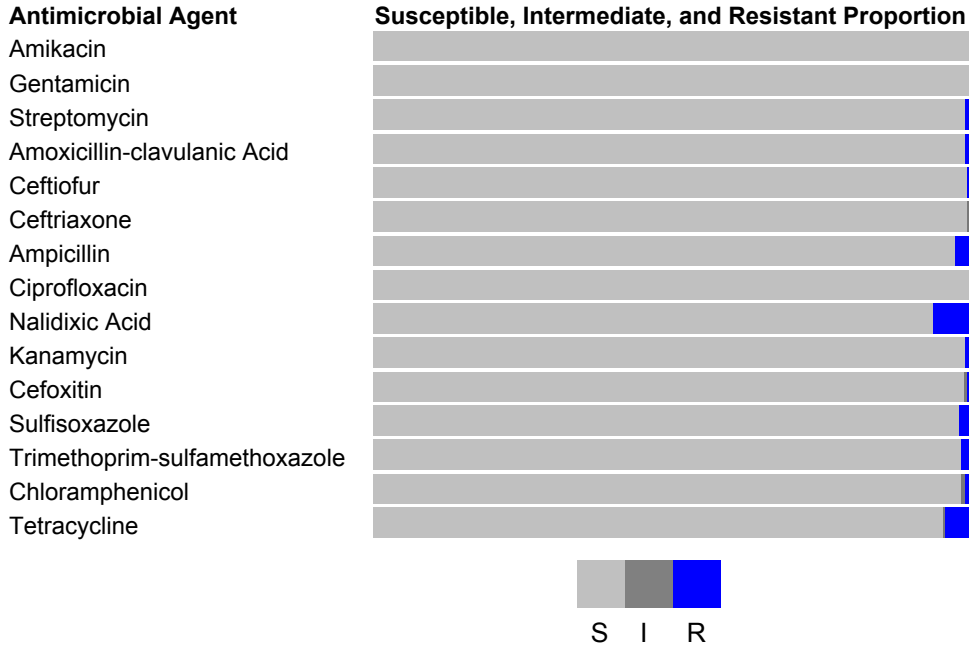


Table 1.06: Percentage and number of *Salmonella* ser. Enteritidis isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			244	269	319	277	337	257	271	384	413	385
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	0.0% 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
		Streptomycin (MIC ≥ 64)	1.6% 4	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	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
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	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
		Ceftriaxone (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
	Penicillins	Ampicillin (MIC ≥ 32)	6.1% 15	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
	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)	2.0% 5	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
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.4% 1	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	0.0% 0	1.9% 5	0.9% 3	1.1% 3	0.6% 2	1.2% 3	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	2.0% 5	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.8% 2	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	6.6% 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

* 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 1.07: Resistance patterns of *Salmonella* ser. Enteritidis isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	244	269	319	277	337	257	271	384	413	385
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	87.7%	83.6%	89.0%	86.6%	87.5%	91.8%	87.1%	91.4%	88.6%	90.4%
	214	225	284	240	295	236	236	351	366	348
Resistance ≥ 1 CLSI class*	12.3%	16.4%	11.0%	13.4%	12.5%	8.2%	12.9%	8.6%	11.4%	9.6%
	30	44	35	37	42	21	35	33	47	37
Resistance ≥ 2 CLSI classes*	6.1%	8.6%	1.9%	4.7%	3.9%	2.3%	3.0%	3.6%	2.9%	3.4%
	15	23	6	13	13	6	8	14	12	13
Resistance ≥ 3 CLSI classes*	0.4%	1.1%	0.3%	2.9%	2.1%	0.4%	1.1%	1.6%	1.7%	1.0%
	1	3	1	8	7	1	3	6	7	4
Resistance ≥ 4 CLSI classes*	0.0%	0.4%	0.0%	1.1%	0.6%	0.4%	0.7%	1.0%	0.7%	0.3%
	0	1	0	3	2	1	2	4	3	1
Resistance ≥ 5 CLSI classes*	0.0%	0.4%	0.0%	0.4%	0.0%	0.4%	0.7%	0.5%	0.2%	0.3%
	0	1	0	1	0	1	2	2	1	1
At least ACSSuT†	0.0%	0.4%	0.0%	0.0%	0.0%	0.4%	0.4%	0.5%	0.0%	0.3%
	0	1	0	0	0	1	1	2	0	1
At least ACT/S‡	0.0%	0.4%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	0	1	0	0	0	1	0	0	0	0
At least ACSSuTAuCf§	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%
	0	1	0	0	0	0	0	1	0	1
At least ceftiofur and nalidixic acid resistant	0.0%	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	1	0	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

B. *Salmonella* ser. Typhimurium

Table 1.08: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhimurium isolates to antimicrobial agents, 2007 (N=403)

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]						2.7	71.0	24.6	1.5	0.2						
		Gentamicin	0.2	2.5	[1.2–4.5]					40.9	53.3	3.0			0.2	1.0	1.5				
		Streptomycin	N/A	32.3	[27.7–37.1]												67.7	17.4	14.9		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	20.1	6.4	[4.3–9.3]							63.3	5.2	0.2	4.7	20.1	0.7	5.7			
	Cephems	Ceftiofur	0.0	6.2	[4.1–9.0]				0.5	0.2	18.1	74.2	0.7		0.2	6.0					
		Ceftriaxone	3.7	0.7	[0.2–2.2]					93.8					1.7	2.7	1.0	0.5	0.2		
	Penicillins	Ampicillin	0.0	31.5	[27.0–36.3]							58.8	9.7					31.5			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.9]	96.5	1.5		0.5	0.5	1.0										
		Nalidixic acid	N/A	1.5	[0.5–3.2]								38.0	59.3	0.7	0.5		1.5			
II	Aminoglycosides	Kanamycin	0.2	5.7	[3.7–8.4]										93.3	0.7	0.2	0.2	5.5		
	Cephems	Cefoxitin	0.7	5.4	[3.5–8.1]							6.0	74.2	12.2	1.5	0.7	1.7	3.7			
	Folate pathway inhibitors	Sulfisoxazole	N/A	37.2	[32.5–42.1]											13.2	46.7	3.0			37.2
		Trimethoprim-sulfamethoxazole	N/A	2.2	[1.0–4.2]				66.0	31.0	0.7				2.2						
	Phenicols	Chloramphenicol	0.2	25.3	[21.1–29.9]								0.2	35.2	39.0	0.2	0.5	24.8			
	Tetracyclines	Tetracycline	0.0	36.7	[32.0–41.6]									63.3		4.2	15.1	17.4			

* 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
‡ 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 2.05: Antimicrobial resistance pattern for *Salmonella* ser. Typhimurium, 2007

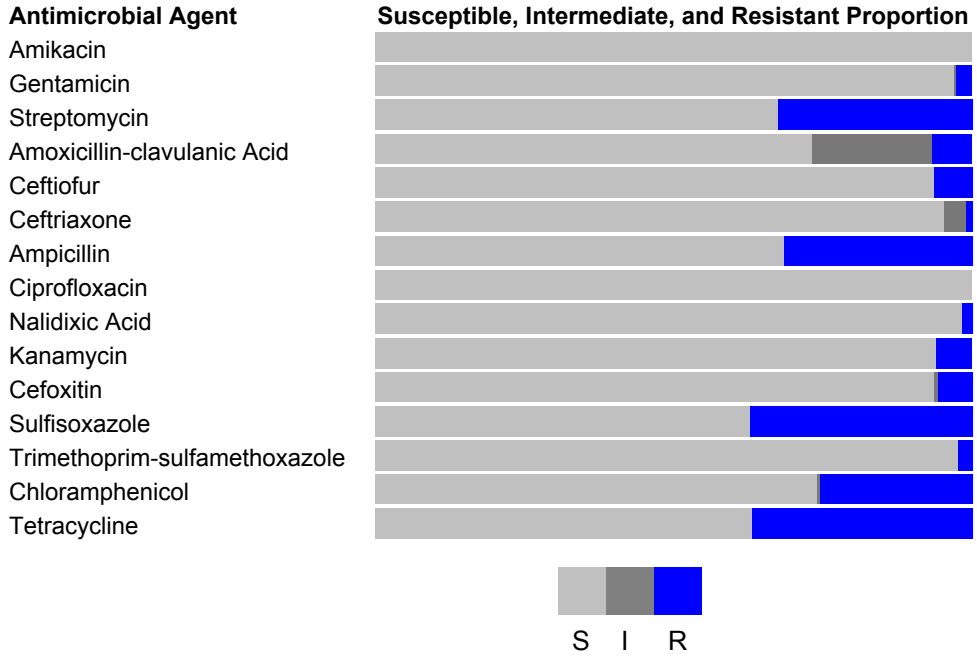


Table 1.09: Percentage and number of *Salmonella* ser. Typhimurium isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			381	363	304	325	394	408	382	438	409	403
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)	3.7% 14	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
		Streptomycin (MIC ≥ 64)	47.8% 182	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	4.5% 17	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
	Cephems	Ceftiofur (MIC ≥ 8)	1.8% 7	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
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.2% 1	0.8% 3	0.0% 0	0.2% 1	0.7% 3
	Penicillins	Ampicillin (MIC ≥ 32)	45.7% 174	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
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.0% 0
		Nalidixic acid (MIC ≥ 32)	0.5% 2	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
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	15.7% 60	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	3.9% 15	4.4% 16	4.3% 13	3.1% 10	5.6% 22	6.1% 25	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	50.1% 191	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	4.5% 17	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	34.1% 130	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	46.5% 177	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

* 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 1.10: Resistance patterns of *Salmonella* ser. Typhimurium isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	381	363	304	325	394	408	382	438	409	403
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	46.5%	50.4%	49.3%	49.2%	59.9%	54.7%	60.7%	65.1%	62.6%	57.6%
	177	183	150	160	236	223	232	285	256	232
Resistance ≥ 1 CLSI class*	53.5%	49.6%	50.7%	50.8%	40.1%	45.3%	39.3%	34.9%	37.4%	42.4%
	204	180	154	165	158	185	150	153	153	171
Resistance ≥ 2 CLSI classes*	51.2%	46.0%	46.4%	47.4%	36.3%	41.4%	36.9%	33.3%	34.0%	39.2%
	195	167	141	154	143	169	141	146	139	158
Resistance ≥ 3 CLSI classes*	46.7%	43.0%	43.4%	41.5%	32.5%	37.3%	31.4%	30.1%	30.3%	34.2%
	178	156	132	135	128	152	120	132	124	138
Resistance ≥ 4 CLSI classes*	43.3%	38.6%	39.8%	37.8%	28.4%	32.4%	27.5%	27.4%	26.9%	29.8%
	165	140	121	123	112	132	105	120	110	120
Resistance ≥ 5 CLSI classes*	34.1%	28.1%	29.6%	29.5%	23.1%	27.7%	24.1%	22.8%	20.8%	24.8%
	130	102	90	96	91	113	92	100	85	100
At least ACSSuT†	32.5%	27.8%	28.0%	29.5%	21.6%	26.5%	23.3%	22.4%	19.6%	22.6%
	124	101	85	96	85	108	89	98	80	91
At least ACT/S‡	2.6%	2.2%	1.6%	0.9%	2.0%	3.2%	1.6%	2.1%	0.7%	1.7%
	10	8	5	3	8	13	6	9	3	7
At least ACSSuTAuCf§	1.0%	0.6%	2.0%	1.2%	1.8%	2.2%	2.6%	1.8%	2.9%	3.5%
	4	2	6	4	7	9	10	8	12	14
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.3%	0.3%	0.5%	0.0%	0.0%	0.0%	0.0%	0.2%
	0	0	1	1	2	0	0	0	0	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

C. *Salmonella* ser. Newport

Table 1.11: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Newport isolates to antimicrobial agents, 2007 (N=220)

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	[0.0–1.7]						3.2	78.6	17.3	0.9							
		Gentamicin	0.0	1.0	[0.1–3.2]					49.5	46.8	2.7				0.5	0.5				
		Streptomycin	N/A	10.0	[6.4–14.7]												90.0	0.5	9.5		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	7.8	[4.6–12.1]							86.4	3.6		2.3		2.3	5.5			
	Cephems	Ceftiofur	0.0	7.7	[4.6–12.1]				0.5	0.5	32.3	59.1				7.7					
		Ceftriaxone	6.4	0.9	[0.1–3.2]					92.3					0.5	3.2	3.2	0.9			
	Penicillins	Ampicillin	0.0	9.5	[6.0–14.2]							86.8	2.7	0.5	0.5			9.5			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.7]	98.6	1.4														
		Nalidixic acid	N/A	0.0	[0.0–1.7]						0.9		33.6	65.5							
II	Aminoglycosides	Kanamycin	0.0	0.9	[0.1–3.2]										99.1				0.9		
	Cephems	Cefoxitin	0.0	7.8	[4.6–12.1]							9.1	77.3	4.1	1.8		2.3	5.5			
	Folate pathway inhibitors	Sulfisoxazole	N/A	10.0	[6.4–14.7]											3.6	58.6	27.3		0.5	10.0
		Trimethoprim-sulfamethoxazole	N/A	1.9	[0.5–4.6]				78.6	19.5				0.5	1.4						
	Phenicols	Chloramphenicol	0.0	9.1	[5.6–13.7]								1.4	65.9	23.6		0.5	8.6			
	Tetracyclines	Tetracycline	0.0	9.6	[6.0–14.2]									90.5			1.4	8.2			

* 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 2.06: Antimicrobial resistance pattern for *Salmonella* ser. Newport, 2007

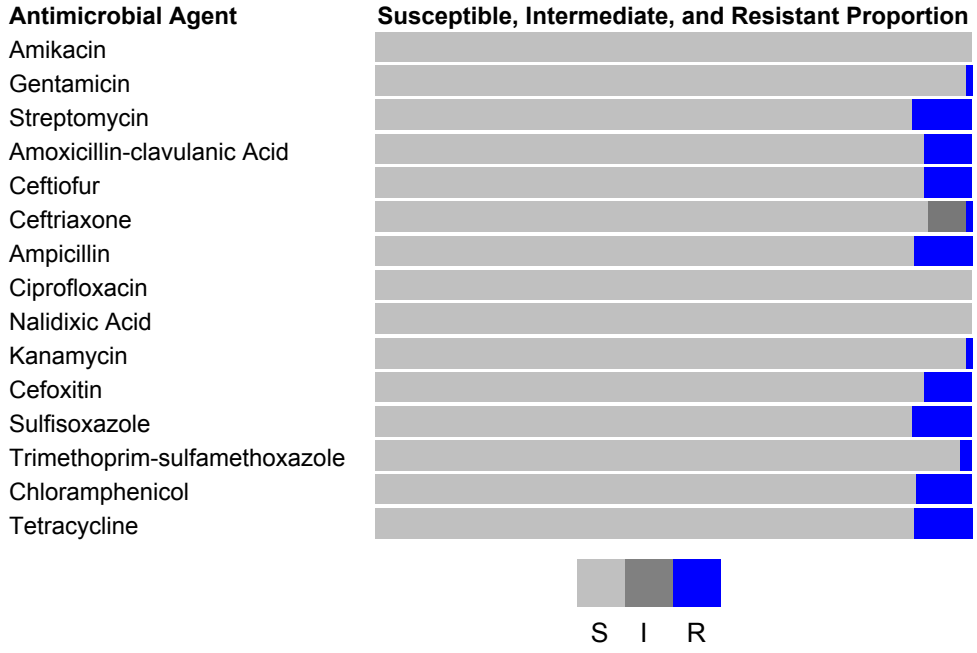


Table 1.12: Percentage and number of *Salmonella* ser. Newport isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			77	99	121	124	241	223	191	207	217	220
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	2.5% 3	3.2% 4	3.3% 8	3.1% 7	0.5% 1	1.0% 2	0.9% 2	0.9% 2
		Streptomycin (MIC ≥ 64)	2.6% 2	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	2.6% 2	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
	Cephems	Ceftiofur (MIC ≥ 8)	1.3% 1	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
		Ceftriaxone (MIC ≥ 64)	0.0% 0	3.0% 3	0.0% 0	0.0% 0	0.8% 2	1.8% 4	2.6% 5	1.4% 3	0.5% 1	0.9% 2
	Penicillins	Ampicillin (MIC ≥ 32)	2.6% 2	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
	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	0.8% 1	0.0% 0	0.8% 2	0.4% 1	0.5% 1	0.0% 0	0.5% 1	0.0% 0
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	1.3% 1	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	2.6% 2	18.2% 18	22.3% 27	26.6% 33	22.8% 55	22.4% 50	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	3.9% 3	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	1.3% 1	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	2.6% 2	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	2.6% 2	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

* 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 1.13: Resistance patterns of *Salmonella* ser. Newport isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	77	99	121	124	241	223	191	207	217	220
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	94.8%	75.8%	75.2%	65.3%	72.2%	73.5%	82.2%	84.1%	82.9%	89.5%
	73	75	91	81	174	164	157	174	180	197
Resistance ≥ 1 CLSI class*	5.2%	24.2%	24.8%	34.7%	27.8%	26.5%	17.8%	15.9%	17.1%	10.5%
	4	24	30	43	67	59	34	33	37	23
Resistance ≥ 2 CLSI classes*	2.6%	18.2%	23.1%	32.3%	25.3%	25.1%	17.3%	15.0%	16.1%	10.5%
	2	18	28	40	61	56	33	31	35	23
Resistance ≥ 3 CLSI classes*	2.6%	18.2%	23.1%	31.5%	25.3%	23.3%	16.2%	14.5%	15.2%	10.5%
	2	18	28	39	61	52	31	30	33	23
Resistance ≥ 4 CLSI classes*	2.6%	18.2%	23.1%	31.5%	25.3%	22.9%	15.7%	14.0%	13.4%	9.1%
	2	18	28	39	61	51	30	29	29	20
Resistance ≥ 5 CLSI classes*	2.6%	18.2%	23.1%	26.6%	23.7%	22.4%	14.7%	12.6%	12.9%	8.2%
	2	18	28	33	57	50	28	26	28	18
At least ACSSuT†	1.3%	18.2%	23.1%	25.8%	23.7%	22.0%	14.7%	12.6%	12.0%	8.2%
	1	18	28	32	57	49	28	26	26	18
At least ACT/S‡	1.3%	2.0%	4.1%	0.8%	3.7%	0.9%	1.0%	1.9%	2.3%	0.5%
	1	2	5	1	9	2	2	4	5	1
At least ACSSuTAuCf§	1.3%	18.2%	22.3%	25.0%	22.8%	21.1%	14.7%	12.6%	10.6%	7.7%
	1	18	27	31	55	47	28	26	23	17
At least ceftiofur and nalidixic acid resistant	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.5%	0.0%	0.0%	0.0%
	0	0	0	0	1	0	1	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 1.14: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. I 4,[5],12:i:- isolates to antimicrobial agents, 2007 (N=73)

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	[0.0–4.9]						2.7	68.5	28.8								
		Gentamicin	0.0	1.4	[0.0–7.4]					38.4	57.5	2.7				1.4					
		Streptomycin	N/A	8.2	[3.1–17.0]												91.8	5.5	2.7		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.4	1.4	[0.0–7.4]							94.5			2.7	1.4		1.4			
	Cephems	Ceftiofur	0.0	2.7	[0.3–9.5]						32.9	63.0	1.4			2.7					
		Ceftriaxone	0.0	1.4	[0.0–7.4]					97.3					1.4				1.4		
	Penicillins	Ampicillin	0.0	5.5	[1.5–13.4]							87.7	5.5	1.4				5.5			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–4.9]	94.5	4.1			1.4											
		Nalidixic acid	N/A	1.4	[0.0–7.4]								61.6	37.0				1.4			
II	Aminoglycosides	Kanamycin	0.0	1.4	[0.0–7.4]										98.6				1.4		
	Cephems	Cefoxitin	0.0	1.4	[0.0–7.4]							12.3	79.5	5.5	1.4		1.4				
	Folate pathway inhibitors	Sulfisoxazole	N/A	4.1	[0.9–11.5]											15.1	74.0	6.8			4.1
		Trimethoprim-sulfamethoxazole	N/A	1.4	[0.0–7.4]				91.8	6.8					1.4						
	Phenicols	Chloramphenicol	0.0	1.4	[0.0–7.4]									65.8	32.9			1.4			
	Tetracyclines	Tetracycline	0.0	9.6	[3.9–18.8]									90.4		1.4	1.4	6.8			

* 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 2.07: Antimicrobial resistance pattern for *Salmonella* ser. I 4,[5],12:i:-, 2007

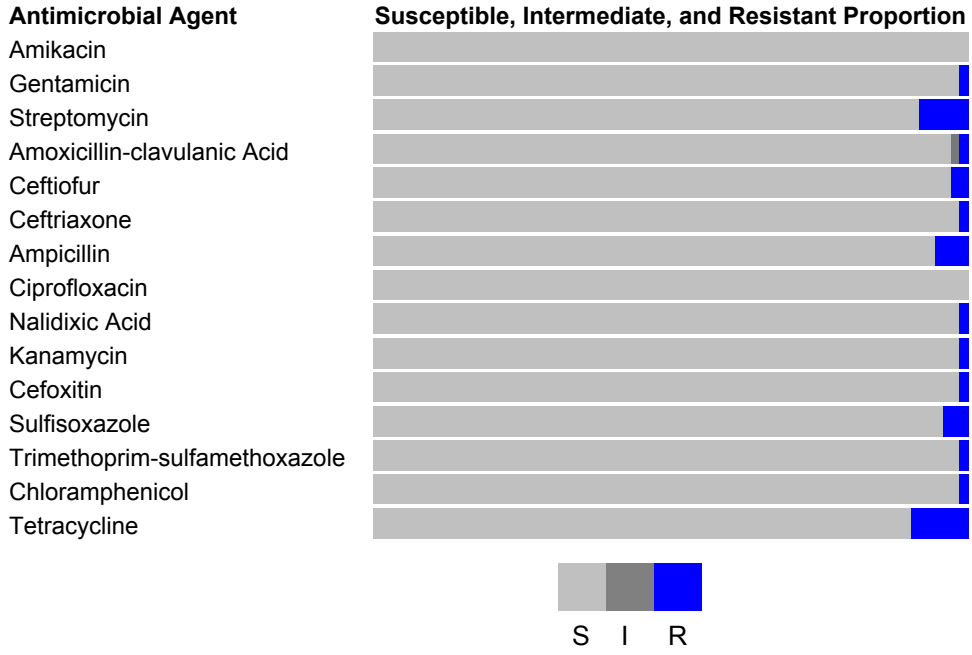


Table 1.15: Percentage and number of *Salmonella* ser. I 4,[5],12:i:- isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			0	8	13	14	35	37	36	33	105	73
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
		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
		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
	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
	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
		Ceftriaxone (MIC ≥ 64)		0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.8% 1	0.0% 0	0.0% 0	1.4% 1
	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
	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
		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
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
	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
		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
	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
		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
	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
	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

* 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 1.16: Resistance patterns of *Salmonella* ser. I 4,[5],12:i:- isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	0	8	13	14	35	37	36	33	105	73
		%	%	%	%	%	%	%	%	%
		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%
		7	12	11	32	29	29	29	90	60
Resistance ≥ 1 CLSI class*		12.5%	7.7%	21.4%	8.6%	21.6%	19.4%	12.1%	14.3%	17.8%
		1	1	3	3	8	7	4	15	13
Resistance ≥ 2 CLSI classes*		0.0%	7.7%	14.3%	8.6%	10.8%	13.9%	3.0%	11.4%	6.8%
		0	1	2	3	4	5	1	12	5
Resistance ≥ 3 CLSI classes*		0.0%	7.7%	7.1%	5.7%	5.4%	8.3%	3.0%	9.5%	5.5%
		0	1	1	2	2	3	1	10	4
Resistance ≥ 4 CLSI classes*		0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	3.8%	2.7%
		0	0	1	1	0	1	0	4	2
Resistance ≥ 5 CLSI classes*		0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	2.9%	1.4%
		0	0	1	1	0	1	0	3	1
At least ACSSuT†		0.0%	0.0%	7.1%	2.9%	0.0%	2.8%	0.0%	1.9%	1.4%
		0	0	1	1	0	1	0	2	1
At least ACT/S‡		0.0%	0.0%	7.1%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%
		0	0	1	1	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
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

* 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 1.17: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Heidelberg isolates to antimicrobial agents, 2007 (N=98)

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	[0.0–3.7]						9.2	69.4	20.4	1.0							
		Gentamicin	2.0	16.3	[9.6–25.2]					55.1	24.5	2.0			2.0	9.2	7.1				
		Streptomycin	N/A	12.2	[6.5–20.4]												87.8	6.1	6.1		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	3.1	7.1	[2.9–14.2]							79.6	2.0		8.2	3.1	2.0	5.1			
	Cephems	Ceftiofur	0.0	7.1	[2.9–14.2]						42.9	49.0	1.0			7.1					
		Ceftriaxone	5.1	0.0	[0.0–3.7]					92.9					2.0	5.1					
	Penicillins	Ampicillin	0.0	18.4	[11.3–27.5]							79.6	2.0					18.4			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–3.7]	96.9	3.1														
		Nalidixic acid	N/A	0.0	[0.0–3.7]								13.3	86.7							
II	Aminoglycosides	Kanamycin	1.0	11.3	[5.7–19.2]										87.8		1.0	3.1	8.2		
	Cephems	Cefoxitin	0.0	7.1	[2.9–14.2]							25.5	64.3	3.1			5.1	2.0			
	Folate pathway inhibitors	Sulfisoxazole	N/A	18.4	[11.3–27.5]											44.9	29.6	6.1	1.0		18.4
		Trimethoprim-sulfamethoxazole	N/A	0.0	[0.0–3.7]				84.7	15.3											
	Phenicols	Chloramphenicol	1.0	3.1	[0.6–8.7]									26.5	69.4	1.0		3.1			
	Tetracyclines	Tetracycline	0.0	22.5	[14.6–32.0]									77.6			4.1	18.4			

* 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
‡ 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 2.08: Antimicrobial resistance pattern for *Salmonella* ser. Heidelberg, 2007

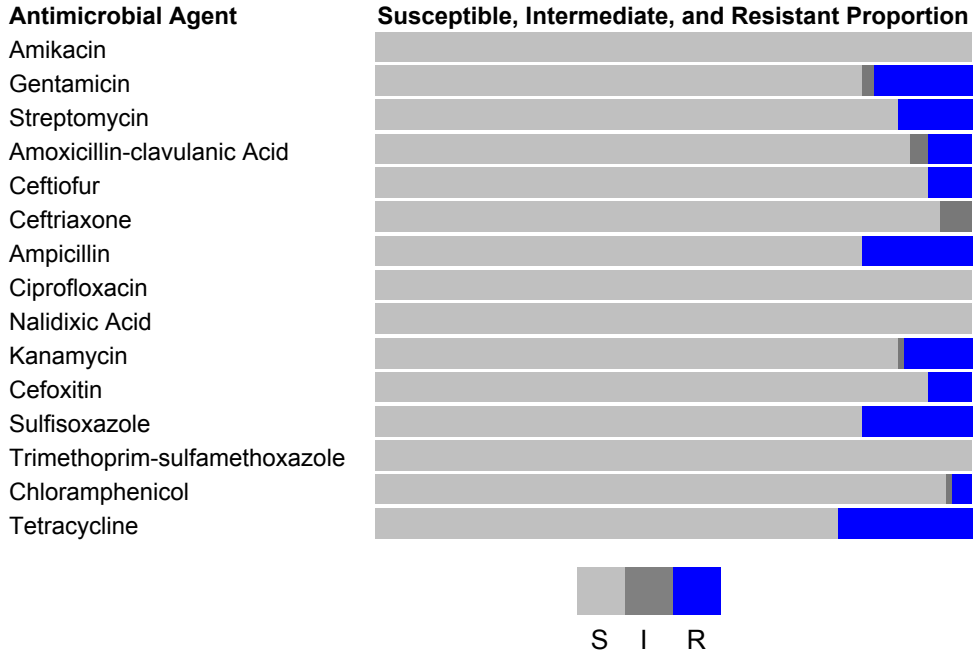


Table 1.18: Percentage and number of *Salmonella* ser. Heidelberg isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			101	88	79	102	105	96	93	125	102	98
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)	16.8% 17	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
		Streptomycin (MIC ≥ 64)	30.7% 31	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.0% 1	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
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	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
		Ceftriaxone (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
	Penicillins	Ampicillin (MIC ≥ 32)	16.8% 17	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
	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)	1.0% 1	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
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	12.9% 13	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	5.9% 6	3.4% 3	5.1% 4	3.9% 4	10.5% 11	7.3% 7	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	21.8% 22	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.0% 2	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.0% 1	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	19.8% 20	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

* 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 1.19: Resistance patterns of *Salmonella* ser. Heidelberg isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	101	88	79	102	105	96	93	125	102	98
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	56.4%	68.2%	63.3%	64.7%	67.6%	68.8%	55.9%	62.4%	67.6%	58.2%
	57	60	50	66	71	66	52	78	69	57
Resistance ≥ 1 CLSI class*	43.6%	31.8%	36.7%	35.3%	32.4%	31.3%	44.1%	37.6%	32.4%	41.8%
	44	28	29	36	34	30	41	47	33	41
Resistance ≥ 2 CLSI classes*	33.7%	26.1%	26.6%	28.4%	25.7%	17.7%	23.7%	24.8%	23.5%	28.6%
	34	23	21	29	27	17	22	31	24	28
Resistance ≥ 3 CLSI classes*	13.9%	10.2%	7.6%	7.8%	12.4%	10.4%	14.0%	15.2%	12.7%	17.3%
	14	9	6	8	13	10	13	19	13	17
Resistance ≥ 4 CLSI classes*	3.0%	3.4%	3.8%	2.0%	1.9%	0.0%	4.3%	4.8%	2.0%	5.1%
	3	3	3	2	2	0	4	6	2	5
Resistance ≥ 5 CLSI classes*	0.0%	0.0%	2.5%	1.0%	1.9%	0.0%	3.2%	1.6%	2.0%	4.1%
	0	0	2	1	2	0	3	2	2	4
At least ACSSuT†	0.0%	0.0%	1.3%	1.0%	1.0%	0.0%	1.1%	0.0%	0.0%	3.1%
	0	0	1	1	1	0	1	0	0	3
At least ACT/S‡	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	0	0	1	0	0	0	0	0
At least ACSSuTAuCf§	0.0%	0.0%	1.3%	1.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0	0	1	1	1	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 1.20: Number and percentage of ACSSuT-, ACSSuTAuCf, Nalidixic Acid-, and Ceftiofur-resistant isolates among the 20 most common non-typhoidal *Salmonella* serotypes isolated in NARMS, 2007

			ACSSuT*		ACSSuTAuCf		Nalidixic Acid		Ceftiofur	
Rank	Serotype	N	n	(%)	n	(%)	n	(%)	n	(%)
1	Typhimurium	403	**91**	**(66.9%)**	**14**	**(30.4%)**	**6**	**(12.5%)**	**25**	**(35.7%)**
2	Enteritidis	385	**1**	**(0.7%)**	**1**	**(2.2%)**	**22**	**(45.8%)**	**1**	**(1.4%)**
3	Newport	220	**18**	**(13.2%)**	**17**	**(37.0%)**	0	(0.0%)	**17**	**(24.3%)**
4	Heidelberg	98	**3**	**(2.2%)**	0	(0.0%)	0	(0.0%)	**7**	**(10.0%)**
5	I 4,[5],12:i:-	73	**1**	**(0.7%)**	0	(0.0%)	**1**	**(2.1%)**	**2**	**(2.9%)**
6	Javiana	65	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
7	Muenchen	64	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
8	Montevideo	51	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
9	Tennessee	38	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
10	Mississippi	37	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
11	Oranienburg	37	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
12	Braenderup	36	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
13	Agona	32	**7**	**(5.1%)**	**7**	**(15.2%)**	**1**	**(2.1%)**	**8**	**(11.4%)**
14	Saintpaul	32	0	(0.0%)	0	(0.0%)	0	(0.0%)	**1**	**(1.4%)**
15	Infantis	26	0	(0.0%)	0	(0.0%)	0	(0.0%)	**1**	**(1.4%)**
16	Paratyphi B var. L(+) tartrate+	25	**2**	**(1.5%)**	0	(0.0%)	0	(0.0%)	0	(0.0%)
17	Mbandaka	24	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
18	Poona	22	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
19	Stanley	20	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
20	Schwarzengrund	19	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	Subtotal	**1707**	**123**	**(90.4%)**	**39**	**(84.8%)**	**30**	**(62.5%)**	**62**	**(88.6%)**
	All Other Serotypes	383	10	(7.4%)	5	(10.9%)	17	(35.4%)	6	(8.6%)
	Unknown serotype	13	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	Partially serotyped	24	3	(2.2%)	2	(4.3%)	0	(0.0%)	2	(2.9%)
	Rough/Nonmotile isolates	17	0	(0.0%)	0	(0.0%)	1	(2.1%)	0	(0.0%)
	Total	**2144**	**136**	**(100.0%)**	**46**	**(100.0%)**	**48**	**(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 2.01: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhi isolates to antimicrobial agents, 2007 (N=398)

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]						29.9	65.6	4.3	0.3							
		Gentamicin	0.0	0.0	[0.0–0.9]					95.0	5.0										
		Streptomycin	N/A	15.6	[12.2–19.5]												84.4	0.3	15.3		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.5	0.3	[0.0–1.4]							82.2	0.8	3.5	12.8	0.5	0.3				
	Cephems	Ceftiofur	0.0	0.0	[0.0–0.9]				1.0	5.5	85.2	8.3									
		Ceftriaxone	0.0	0.0	[0.0–0.9]					99.7	0.3										
	Penicillins	Ampicillin	0.0	17.1	[13.5–21.2]							82.7	0.3					17.1			
	Quinolones	Ciprofloxacin	0.8	1.0	[0.3–2.6]	35.2	0.8	1.0	14.3	41.2	5.5	0.3	0.8		1.0						
		Nalidixic acid	N/A	62.3	[57.3–67.1]						0.3	4.5	29.1	2.5	0.5	0.8	1.5	60.8			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0–0.9]										100.0						
	Cephems	Cefoxitin	0.8	0.5	[0.1–1.8]						4.0	34.4	9.0	44.5	6.8	0.8		0.5			
	Folate pathway inhibitors	Sulfisoxazole	N/A	17.6	[14.0–21.7]											61.6	17.8	2.5	0.3	0.3	17.6
		Trimethoprim-sulfamethoxazole	N/A	16.3	[12.8–20.3]				80.4	3.3					16.3						
	Phenicols	Chloramphenicol	0.5	15.8	[12.4–19.8]								7.0	71.4	5.3	0.5		15.8			
	Tetracyclines	Tetracycline	0.0	6.3	[4.1–9.1]									93.7				6.3			

* 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 3.01: Antimicrobial resistance pattern for *Salmonella* ser. Typhi, 2007

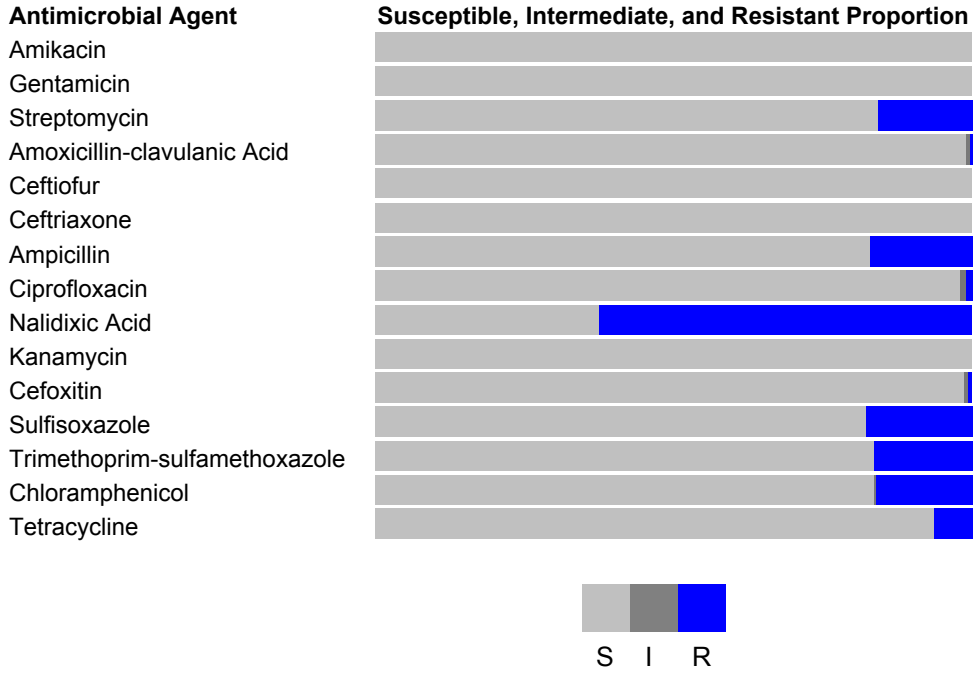


Table 2.02: Percentage and number of *Salmonella* ser. Typhi isolates resistant to antimicrobial agents, 1999–2007

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			167	177	197	195	334	304	318	322	398
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
		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
		Streptomycin (MIC ≥ 64)	13.8% 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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.3% 1
	Cephems	Ceftiofur (MIC ≥ 8)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.6% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Ceftriaxone (MIC ≥ 64)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	13.2% 22	9.0% 16	20.3% 40	5.6% 11	16.2% 54	11.8% 36	13.2% 42	20.8% 67	17.1% 68
	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
		Nalidixic acid (MIC ≥ 32)	19.2% 32	22.0% 39	29.9% 59	23.6% 46	37.7% 126	41.8% 127	48.4% 154	53.7% 173	62.3% 248
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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.6% 1	0.5% 1	0.0% 0	0.9% 3	0.0% 0	0.0% 0	0.3% 1	0.5% 2
		Cephalothin (MIC ≥ 32)	2.4% 4	1.1% 2	0.5% 1	1.5% 3	0.6% 2	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	16.8% 28	11.3% 20	20.8% 41	6.2% 12	17.1% 57	11.8% 36	14.2% 45	20.8% 67	17.6% 70
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	13.2% 22	9.0% 16	20.8% 41	6.7% 13	16.8% 56	13.2% 40	14.5% 46	20.8% 67	16.3% 65
	Phenicols	Chloramphenicol (MIC ≥ 32)	12.6% 21	10.7% 19	20.8% 41	6.2% 12	16.5% 55	13.2% 40	13.2% 42	19.6% 63	15.8% 63
	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

* 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 2.03: Resistance patterns of *Salmonella* ser. Typhi isolates, 1999–2007

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	167	177	197	195	334	304	318	324	398
	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	71.3% 119	72.3% 128	58.9% 116	74.4% 145	56.3% 188	56.6% 172	48.1% 153	40.4% 131	35.4% 141
Resistance ≥ 1 CLSI class*	28.7% 48	27.7% 49	41.1% 81	25.6% 50	43.7% 146	43.4% 132	51.9% 165	59.6% 193	64.6% 257
Resistance ≥ 2 CLSI classes*	15.0% 25	10.7% 19	22.8% 45	7.2% 14	18.0% 60	13.2% 40	14.5% 46	21.6% 70	18.1% 72
Resistance ≥ 3 CLSI classes*	13.2% 22	9.6% 17	21.8% 43	6.7% 13	17.1% 57	12.8% 39	13.8% 44	20.7% 67	17.6% 70
Resistance ≥ 4 CLSI classes*	13.2% 22	9.0% 16	21.3% 42	6.2% 12	16.5% 55	12.5% 38	12.9% 41	19.1% 62	17.1% 68
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
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
At least ACT/S‡	12.6% 21	9.0% 16	17.8% 35	5.6% 11	15.6% 52	11.8% 36	12.9% 41	18.5% 60	15.3% 61
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
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

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

Species	2007 N	(%)
Paratyphi A	16	(94.1%)
Paratyphi B	1	(5.9%)
Paratyphi C	0	(0.0%)
Total	**17**	**(100%)**

Table 2.05: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates to antimicrobial agents, 2007 (N=17)

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	[0.0–19.5]						94.1	5.9									
		Gentamicin	0.0	0.0	[0.0–19.5]					88.2	11.8										
		Streptomycin	N/A	0.0	[0.0–19.5]												100.0				
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	0.0	[0.0–19.5]							41.2	58.8								
	Cephems	Ceftiofur	0.0	0.0	[0.0–19.5]					5.9		94.1									
		Ceftriaxone	0.0	0.0	[0.0–19.5]					100.0											
	Penicillins	Ampicillin	0.0	0.0	[0.0–19.5]								100.0								
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–19.5]	5.9			5.9		88.2										
		Nalidixic acid	N/A	94.1	[71.3–99.9]									5.9			5.9	88.2			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0–19.5]										100.0						
	Cephems	Cefoxitin	0.0	0.0	[0.0–19.5]									82.4	17.6						
	Folate pathway inhibitors	Sulfisoxazole	N/A	0.0	[0.0–19.5]											41.2	47.1	11.8			
		Trimethoprim-sulfamethoxazole	N/A	0.0	[0.0–19.5]				70.6	29.4											
	Phenicols	Chloramphenicol	23.5	0.0	[0.0–19.5]										76.5	23.5					
	Tetracyclines	Tetracycline	0.0	0.0	[0.0–19.5]									100.0							

* 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 3.02: Antimicrobial resistance pattern for *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C, 2007

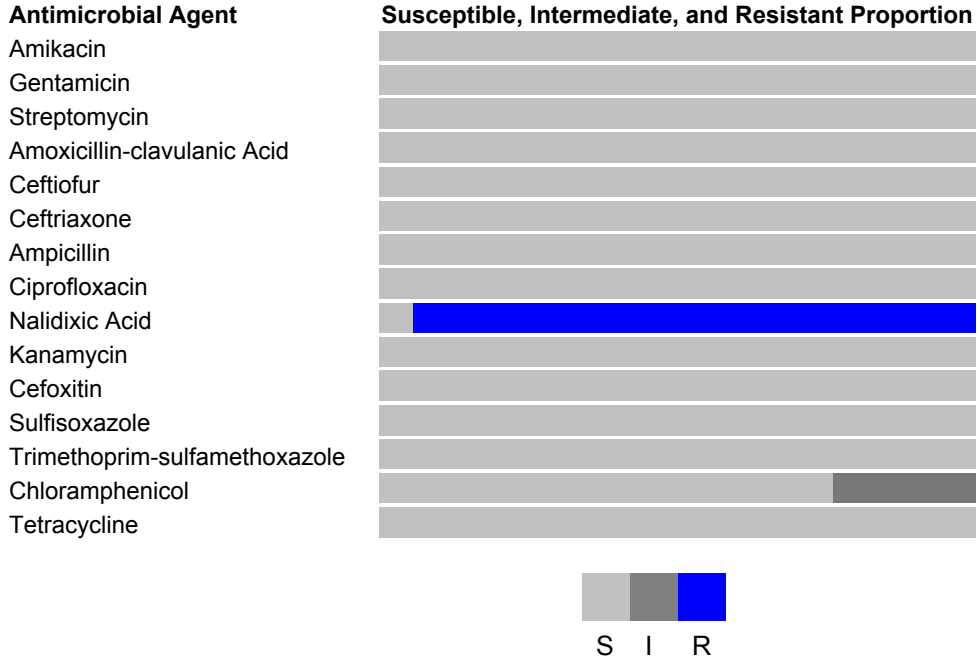


Table 2.06: Percentage and number of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			5	2	5	9	10	8	11	18	16	17
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	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
	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	0.0% 0
	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	0.0% 0
		Ceftriaxone (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
	Penicillins	Ampicillin (MIC ≥ 32)	0.0% 0	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
	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)	20.0% 1	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
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	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
		Cephalothin (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
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	0.0% 0	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.0% 0	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	0.0% 0	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

* 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 2.07: Resistance patterns of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	5	2	5	9	10	8	11	18	16	17
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	80.0% 4	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
Resistance ≥ 1 CLSI class*	20.0% 1	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
Resistance ≥ 2 CLSI classes*	0.0% 0	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
Resistance ≥ 3 CLSI classes*	0.0% 0	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
Resistance ≥ 4 CLSI classes*	0.0% 0	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
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	0.0% 0
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	0.0% 0
At least ACT/S‡	0.0% 0	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
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	0.0% 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

3. *Shigella*

Table 3.01: Frequency of *Shigella* species isolated in NARMS, 2007

Species	2007	
	n	(%)
Shigella sonnei	416	(86.3%)
Shigella flexneri	61	(12.7%)
Shigella boydii	4	(0.8%)
Other	1	(0.2%)
Total	**482**	**(100.0%)**

Table 3.02: Minimum inhibitory concentrations (MICs) and resistance of *Shigella* isolates to antimicrobial agents, 2007 (N=482)

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	[0.0–0.8]						1.7	3.1	38.6	52.5	4.1						
		Gentamicin	0.0	0.8	[0.2–2.1]					4.4	20.7	67.0	7.1			0.2	0.6				
		Streptomycin	N/A	73.0	[68.8–76.9]												27.0	44.6	28.4		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	38.2	0.4	[0.1–1.5]							3.9	3.7	27.4	26.3	38.2	0.4				
	Cephems	Ceftiofur	0.0	0.0	[0.0–0.8]				5.2	79.9	12.2	2.7									
		Ceftriaxone	0.0	0.0	[0.0–0.8]					99.4	0.4	0.2									
	Penicillins	Ampicillin	1.0	63.5	[59.0–67.8]							6.8	23.4	4.6	0.6	1.0	0.4	63.1			
	Quinolones	Ciprofloxacin	0.0	0.2	[0.0–1.2]	97.3	0.2	0.2	1.2	0.6	0.2			0.2							
		Nalidixic acid	N/A	1.8	[0.9–3.5]						2.5	70.3	22.4	2.3	0.4	0.2	0.6	1.2			
II	**Aminoglycosides**	Kanamycin	0.0	0.2	[0.0–1.2]										99.4	0.4		0.2			
	Cephems	Cefoxitin	0.2	0.0	[0.0–0.8]						0.2	4.8	74.7	19.5	0.6	0.2					
	Folate pathway inhibitors	Sulfisoxazole	N/A	25.7	[21.9–29.9]											68.5	4.6	0.8	0.4		25.7
		Trimethoprim-sulfamethoxazole	N/A	34.7	[30.4–39.1]				15.8	8.9	12.9	20.5	7.3	4.6	30.1						
	Phenicols	Chloramphenicol	0.4	8.3	[6.0–11.1]								12.2	70.3	8.7	0.4	0.6	7.7			
	Tetracyclines	Tetracycline	0.2	25.4	[21.7–29.7]									74.3	0.2	0.6	6.8	18.0			

* 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 4.01: Antimicrobial resistance pattern for *Shigella*, 2007

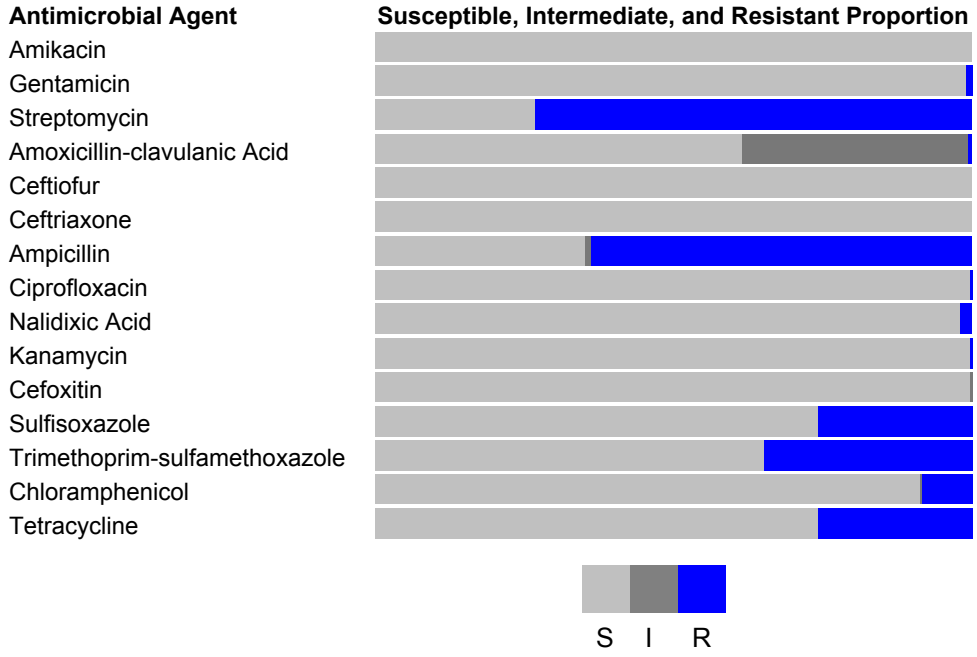


Table 3.03: Percentage and number of *Shigella* isolates resistant to antimicrobial agents, 1999–2007

Year / Total Isolates			1999 375	2000 450	2001 344	2002 620	2003 495	2004 316	2005 396	2006 402	2007 482
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
		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
		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
	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
	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
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.0% 0	0.0% 0
	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
	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
		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
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
	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
		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
	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
		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
	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
	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

* 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 3.04: Resistance patterns of *Shigella* isolates, 1999–2007

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

Table 3.05: Minimum inhibitory concentrations (MICs) and resistance of *Shigella sonnei* isolates to antimicrobial agents, 2007 (N=416)

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]						1.2	3.1	42.1	50.5	3.1						
		Gentamicin	0.0	0.9	[0.3–2.4]					3.4	21.4	67.3	7.0			0.2	0.7				
		Streptomycin	N/A	76.4	[72.1–80.4]												23.6	50.0	26.4		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	36.3	0.5	[0.1–1.7]							3.4	1.4	29.6	28.8	36.3	0.5				
	Cephems	Ceftiofur	0.0	0.0	[0.0–0.9]					2.9	82.2	12.7	2.2								
		Ceftriaxone	0.0	0.0	[0.0–0.9]						99.3	0.5	0.2								
	Penicillins	Ampicillin	1.2	63.7	[58.9–68.3]							4.1	25.2	5.3	0.5	1.2	0.5	63.2			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.9]	98.1		0.2	1.2	0.5											
		Nalidixic acid	N/A	1.5	[0.5–3.1]						2.6	73.3	20.0	2.4	0.2		0.5	1.0			
II	Aminoglycosides	Kanamycin	0.0	0.2	[0.0–1.3]										99.3	0.5		0.2			
	Cephems	Cefoxitin	0.2	0.0	[0.0–0.9]						0.2	5.5	81.0	12.7	0.2	0.2					
	Folate pathway inhibitors	Sulfisoxazole	N/A	20.0	[16.2–24.1]											74.0	4.6	1.0	0.5		20.0
		Trimethoprim-sulfamethoxazole	N/A	32.2	[27.7–36.9]				13.9	7.5	14.2	23.8	8.4	5.3	26.9						
	Phenicols	Chloramphenicol	0.5	1.2	[0.4–2.8]								9.1	79.6	9.6	0.5		1.2			
	Tetracyclines	Tetracycline	0.2	16.1	[12.7–20.0]									83.7	0.2	0.7	7.5	7.9			

* 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
† 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 4.02: Antimicrobial resistance pattern for *Shigella sonnei*, 2007

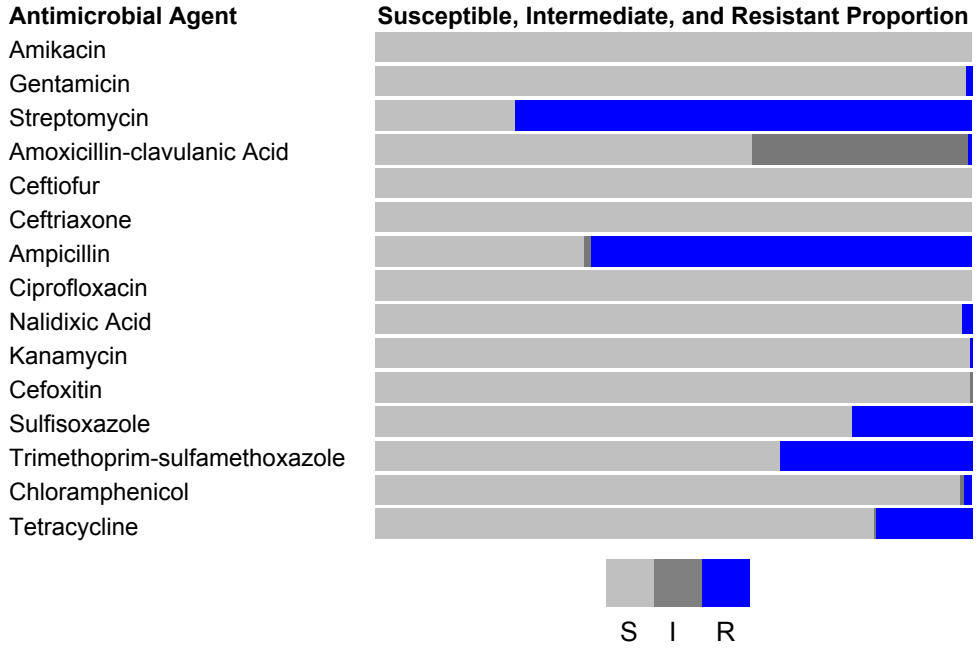


Table 3.06: Percentage and number of *Shigella sonnei* isolates resistant to antimicrobial agents, 1999–2007

Year			1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			275	366	239	536	434	241	340	321	416
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
		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
		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
	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
	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
		Ceftriaxone (MIC ≥ 64)	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
	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
	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
		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
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
	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
		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
	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
		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
	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
	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

* 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 3.07: Resistance patterns of *Shigella sonnei* isolates, 1999–2007

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

Table 3:08: Minimum inhibitory concentrations and resistance of *Shigella flexneri* isolates to antimicrobial agents, 2007 (N=61)

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	[0.0–5.9]						4.9	3.3	16.4	63.9	11.5						
		Gentamicin	0.0	0.0	[0.0–5.9]					11.5	16.4	63.9	8.2								
		Streptomycin	N/A	52.5	[39.3–65.4]												47.5	11.5	41.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	52.5	0.0	[0.0–5.9]							8.2	19.7	9.8	9.8	52.5					
	Cephems	Ceftiofur	0.0	0.0	[0.0–5.9]				19.7	65.6	8.2	6.6									
		Ceftriaxone	0.0	0.0	[0.0–5.9]					100.0											
	Penicillins	Ampicillin	0.0	63.9	[50.6–75.8]							26.2	8.2		1.6			63.9			
	Quinolones	Ciprofloxacin	0.0	1.6	[0.0–8.8]	93.4			1.6	1.6	1.6			1.6							
		Nalidixic acid	N/A	4.9	[1.0–13.7]							55.7	36.1	1.6	1.6		1.6	3.3			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0–5.9]										100.0						
	Cephems	Cefoxitin	0.0	0.0	[0.0–5.9]								32.8	63.9	3.3						
	Folate pathway inhibitors	Sulfisoxazole	N/A	62.3	[49.0–74.4]											32.8	4.9				62.3
		Trimethoprim-sulfamethoxazole	N/A	49.2	[36.1–62.3]				27.9	18.0	4.9				49.2						
	Phenicols	Chloramphenicol	0.0	55.7	[42.4–68.5]								31.1	9.8	3.3		4.9	50.8			
	Tetracyclines	Tetracycline	0.0	83.6	[71.9–91.8]									16.4			3.3	80.3			

* 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 4.03: Antimicrobial resistance pattern for *Shigella flexneri*, 2007

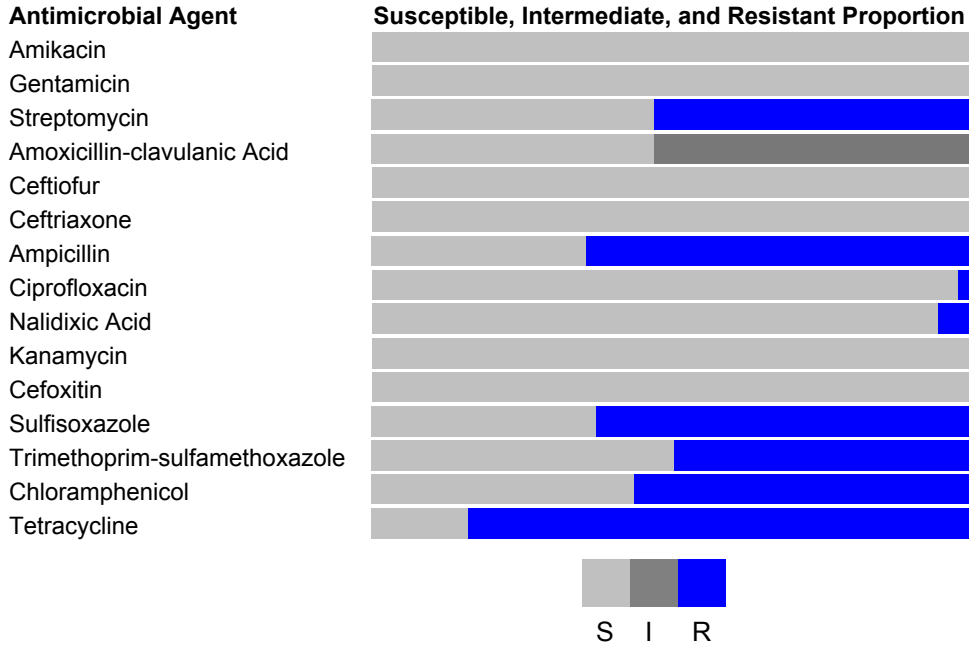


Table 3.09: Percentage and number of *Shigella flexneri* isolates resistant to antimicrobial agents, 1999–2007

Year Total Isolates			1999 87	2000 75	2001 91	2002 73	2003 51	2004 62	2005 52	2006 74	2007 61
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
		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
		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
	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
	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
		Ceftriaxone (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
	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
	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
		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
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
	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
		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
	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
		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
	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
	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

* 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 3.10: Resistance patterns of *Shigella flexneri* isolates, 1999–2007

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	87	75	91	73	51	62	52	74	61
	%	%	%	%	%	%	%	%	%
	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	3	11	4	0	3	4	6
Resistance ≥ 1 CLSI class*	95.4%	96.0%	96.7%	84.9%	92.2%	100.0%	94.2%	94.6%	90.2%
	83	72	88	62	47	62	49	70	55
Resistance ≥ 2 CLSI classes*	83.9%	82.7%	89.0%	76.7%	86.3%	93.5%	80.8%	85.1%	80.3%
	73	62	81	56	44	58	42	63	49
Resistance ≥ 3 CLSI classes*	79.3%	81.3%	79.1%	75.3%	80.4%	90.3%	78.8%	75.7%	68.9%
	69	61	72	55	41	56	41	56	42
Resistance ≥ 4 CLSI classes*	63.2%	64.0%	62.6%	57.5%	62.7%	64.5%	65.4%	47.3%	55.7%
	55	48	57	42	32	40	34	35	34
Resistance ≥ 5 CLSI classes*	37.9%	32.0%	25.3%	19.2%	31.4%	29.0%	30.8%	28.4%	27.9%
	33	24	23	14	16	18	16	21	17
At least ACSSuT†	33.3%	29.3%	22.0%	15.1%	29.4%	27.4%	28.8%	27.0%	26.2%
	29	22	20	11	15	17	15	20	16
At least ACT/S‡	34.5%	32.0%	23.1%	21.9%	27.5%	24.2%	32.7%	28.4%	26.2%
	30	24	21	16	14	15	17	21	16
At least AT/S§	44.8%	38.7%	25.3%	27.4%	37.3%	35.5%	38.5%	43.2%	36.1%
	39	29	23	20	19	22	20	32	22
At least ANT/S¶	1.1%	0.0%	1.1%	1.4%	5.9%	0.0%	1.9%	2.7%	1.6%
	1	0	1	1	3	0	1	2	1
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
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	1	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
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCf: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftiofur

4. *Escherichia coli* O157

Table 4.01: Minimum inhibitory concentrations (MICs) and resistance of *Escherichia coli* O157 isolates to antimicrobial agents, 2007 (N=190)

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	[0.0–1.9]						2.6	65.3	30.0	1.6	0.5						
		Gentamicin	0.0	0.0	[0.0–1.9]					34.2	61.1	4.7									
		Streptomycin	N/A	2.1	[0.6–5.3]												97.9	1.6	0.5		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.1	0.5	[0.0–2.9]							1.6	7.4	87.4	2.1	1.1		0.5			
	Cephems	Ceftiofur	0.0	0.0	[0.0–1.9]				1.6	6.8	88.4	3.2									
		Ceftriaxone	0.0	0.0	[0.0–1.9]					100.0											
	Penicillins	Ampicillin	0.0	2.1	[0.6–5.3]							5.3	70.5	22.1				2.1			
	Quinolones	Ciprofloxacin	0.0	0.5	[0.0–2.9]	96.3	1.6			1.1		0.5			0.5						
		Nalidixic acid	N/A	2.1	[0.6–5.3]							2.1	75.3	20.5				2.1			
II	**Aminoglycosides**	Kanamycin	0.0	0.0	[0.0–1.9]										100.0						
	Cephems	Cefoxitin	3.2	0.0	[0.0–1.9]							2.1	3.2	67.4	24.2	3.2					
	Folate pathway inhibitors	Sulfisoxazole	N/A	2.6	[0.9–6.0]											88.4	7.9	0.5	0.5		2.6
		Trimethoprim-sulfamethoxazole	N/A	1.1	[0.1–3.8]				85.3	13.7					1.1						
	Phenicols	Chloramphenicol	2.1	0.5	[0.0–2.9]								0.5	17.9	78.9	2.1		0.5			
	Tetracyclines	Tetracycline	1.1	4.7	[2.2–8.8]									94.2	1.1	0.5	0.5	3.7			

* 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 5.01: Antimicrobial resistance pattern for *Escherichia coli* O157, 2007

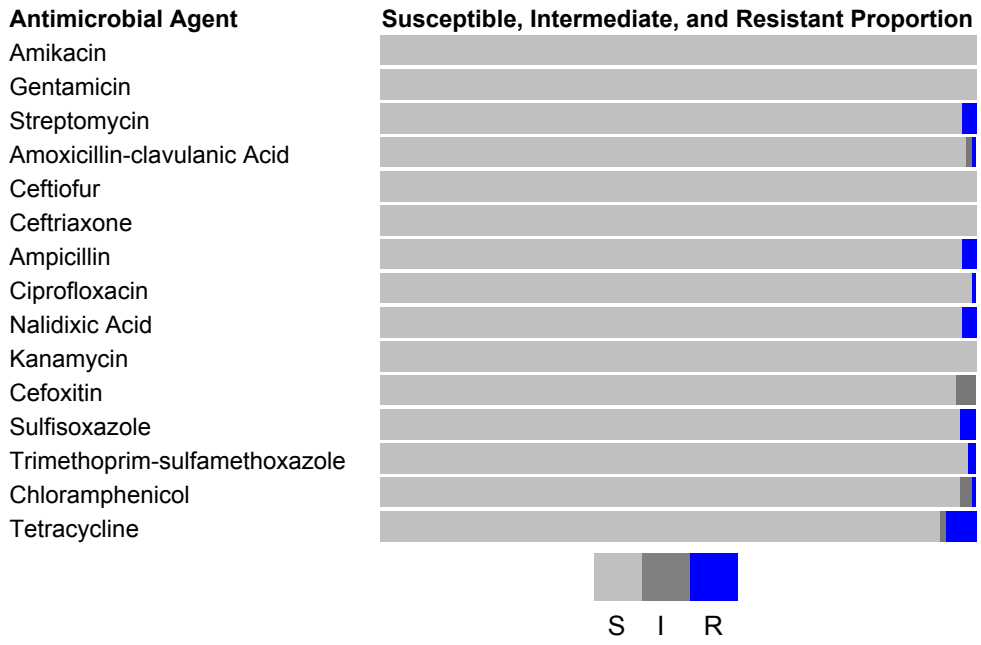


Table 4.02: Percentage and number of *Escherichia coli* O157 isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			318	292	407	277	399	158	169	194	233	190
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	0.5% 2	0.4% 1	0.0% 0	0.0% 0	0.6% 1	0.5% 1	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	1.9% 6	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
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	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
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	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
		Ceftriaxone (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	0.9% 2	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	2.5% 8	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
	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	0.4% 1	0.5% 1
		Nalidixic acid (MIC ≥ 32)	0.0% 0	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
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.3% 1	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
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	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
		Cephalothin (MIC ≥ 32)	0.0% 0	0.7% 2	1.2% 5	1.4% 4	1.5% 6	3.2% 5	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	5.7% 18	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
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.6% 2	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
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.3% 1	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
	Tetracyclines	Tetracycline (MIC ≥ 16)	4.4% 14	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

* 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 4.03: Resistance patterns of *Escherichia coli* O157 isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	318	292	407	277	399	158	169	194	233	190
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	92.8% 295	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
Resistance ≥ 1 CLSI subclass*	7.2% 23	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
Resistance ≥ 2 CLSI subclasses*	5.0% 16	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
Resistance ≥ 3 CLSI subclasses*	1.9% 6	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
Resistance ≥ 4 CLSI subclasses*	0.6% 2	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
Resistance ≥ 5 CLSI subclasses*	0.0% 0	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
At least ACSSuT†	0.0% 0	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
At least ACT/S‡	0.0% 0	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
At least ACSSuTAuCf§	0.0% 0	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
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	0.4% 1	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 5.01: Frequency of *Campylobacter* species isolated in NARMS, 2007

Species	2007	
	N	(%)
Campylobacter jejuni	992	(90.2%)
Campylobacter coli	105	(9.5%)
Other	3	(0.3%)
Total	**1100**	**(100.0%)**

Table 5.02: Minimum inhibition concentrations (MICs) and resistance of *Campylobacter* isolates to antimicrobial agents, 2007 (N=1100)

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	< 0.1	0.6	[0.3–1.3]				2.5	33.7	55.5	7.2	0.4	< 0.1				0.6			
	Ketolide	Telithromycin	0.6	1.5	[0.8–2.4]				0.7	14.1	35.4	31.5	13.0	3.2	0.6	1.5					
	Macrolides	Azithromycin	0.0	2.0	[1.3–3.0]	1.3	24.0	45.4	21.5	5.5	0.3	0.1							2.0		
		Erythromycin	0.0	2.0	[1.3–3.0]			0.3	6.1	38.8	30.7	15.8	5.4	0.9				0.1	1.9		
	Quinolones	Ciprofloxacin	0.2	26.0	[23.4–28.7]		2.3	42.5	22.1	5.5	1.5		0.2	1.5	10.3	8.5	4.2	1.2	0.3		
		Nalidixic acid	0.4	26.5	[23.9–29.2]									56.0	14.9	2.3	0.4	2.4	24.1		
II	**Phenicols**	Florfenicol††	N/A	0.0	[0.0–0.3]					0.3	22.5	61.1	13.5	2.7							
	Tetracyclines	Tetracycline	< 0.1	44.3	[41.4–47.4]			3.5	24.5	17.0	6.1	3.4	0.7	0.4	< 0.1	0.8	2.9	12.0	28.6		
III	**Lincosamides**	Clindamycin	0.3	1.7	[1.0–2.7]		1.3	25.8	41.2	19.5	7.2	2.5	0.6	0.3	0.3	0.9	0.5				

* 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 6.01: Antimicrobial resistance pattern for *Campylobacter*, 2007

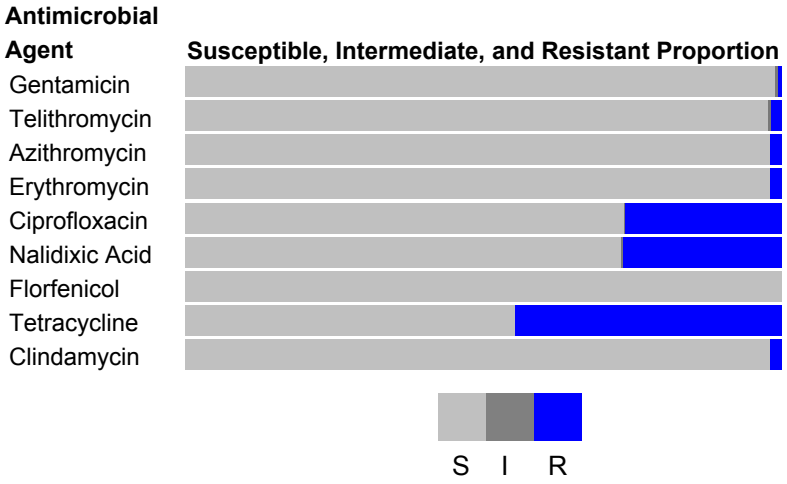


Table 5.03: Percentage and number of *Campylobacter* isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			310	317	324	384	354	328	347	890	816	1100
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.3% 1	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
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 9	1.6% 13	1.5% 16
	Macrolides	Azithromycin (MIC ≥ 8)	0.6% 2	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
		Erythromycin (MIC ≥ 32)	1.0% 3	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
	Quinolones	Ciprofloxacin (MIC ≥ 4)	13.9% 43	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
		Nalidixic acid (MIC ≥ 64)	16.8% 52	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
II	Phenicols	Chloramphenicol (MIC ≥ 32)	2.9% 9	0.6% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.4% 5	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5	0.0% 0	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	45.5% 141	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
III	Lincosamides	Clindamycin (MIC ≥ 8)	1.3% 4	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

* 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 5.04: Resistance patterns of *Campylobacter* isolates, 1998–2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates	310	317	324	384	354	328	347	890	816	1100
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	45.2% 140	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
Resistance ≥ 1 CLSI class*	54.8% 170	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
Resistance ≥ 2 CLSI classes*	9.7% 30	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
Resistance ≥ 3 CLSI classes*	2.6% 8	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
Resistance ≥ 4 CLSI classes*	0.3% 1	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
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	0.0% 0

* CLSI: Clinical and Laboratory Standards Institute

Table 5.05: Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter jejuni* isolates to antimicrobial agents, 2007, (N=992)

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	0.1	0.7	[0.3–1.4]				2.7	35.7	55.1	5.4	0.2	0.1				0.7			
	Ketolide	Telithromycin	0.3	1.0	[0.5–1.8]				0.8	14.1	37.1	32.7	12.1	1.9	0.3	1.0					
	Macrolides	Azithromycin	0.0	1.6	[0.9–2.6]	1.4	25.6	47.9	19.4	3.9	0.1	0.1							1.6		
		Erythromycin	0.0	1.6	[0.9–2.6]			0.3	6.7	41.4	31.3	14.7	3.7	0.3				0.1	1.5		
	Quinolones	Ciprofloxacin	0.2	25.8	[23.1–28.6]		2.3	44.3	21.9	4.8	0.7		0.2	1.4	10.5	7.9	4.4	1.3	0.3		
		Nalidixic acid	0.4	26.1	[23.4–29.0]									58.2	13.6	1.7	0.4	1.8	24.3		
II	**Phenicols**	Florfenicol††	N/A	0.0	[0.0–0.4]					0.3	23.3	62.8	10.8	2.8							
	Tetracyclines	Tetracycline	0.1	44.7	[41.6–47.9]			3.7	26.3	16.0	5.5	2.7	0.5	0.3	0.1	0.7	3.1	12.7	28.2		
III	**Lincosamides**	Clindamycin	0.1	1.3	[0.7–2.2]		1.3	27.9	43.2	18.4	5.5	1.6	0.5	0.1	0.3	0.6	0.4				

* 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; 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 6.02: Antimicrobial resistance pattern for *Campylobacter jejuni*, 2007

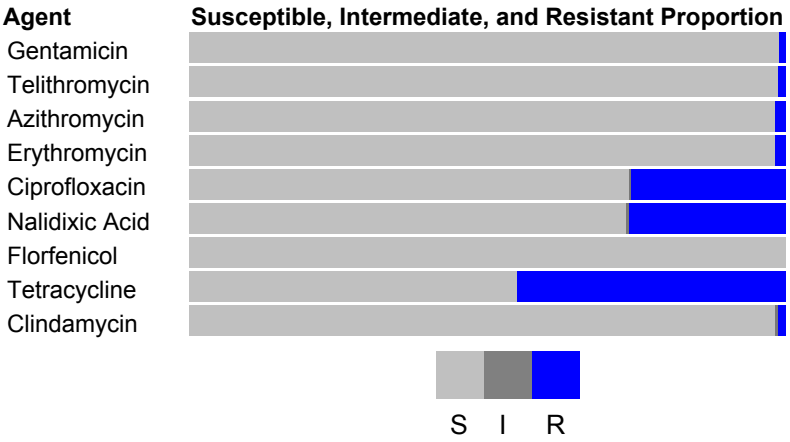


Table 5.06: Percentage and number of *Campylobacter jejuni* isolates resistant to antimicrobial agents, 1998–2007

Year Total Isolates			1998 297	1999 293	2000 306	2001 365	2002 329	2003 303	2004 320	2005 791	2006 709	2007 992
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.3% 1	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
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5	0.8% 6	1.0% 10
	Macrolides	Azithromycin (MIC ≥ 8)	0.3% 1	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
		Erythromycin (MIC ≥ 32)	0.7% 2	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
	Quinolones	Ciprofloxacin (MIC ≥ 4)	13.8% 41	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
		Nalidixic acid (MIC ≥ 64)	15.5% 46	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
II	Phenicols	Chloramphenicol (MIC ≥ 32)	1.0% 3	0.7% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.6% 5	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.5% 4	0.0% 0	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	46.1% 137	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
III	Lincosamides	Clindamycin (MIC ≥ 8)	1.0% 3	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

* 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 5.07: Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter coli* isolates to antimicrobial agents, 2007 (N=105)

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	0.0	[0.0–3.5]					14.3	61.0	23.8	1.0								
	Ketolide	Telithromycin	3.8	5.7	[2.1–12.0]					14.3	18.1	21.9	21.0	15.2	3.8	5.7					
	Macrolides	Azithromycin	0.0	5.7	[2.1–12.0]		8.6	21.9	41.0	21.0	1.9								5.7		
		Erythromycin	0.0	5.7	[2.1–12.0]				1.0	15.2	25.7	24.8	21.0	6.7					5.7		
	Quinolones	Ciprofloxacin	0.0	28.6	[20.2–38.2]		1.9	25.7	23.8	12.4	7.6			2.9	8.6	15.2	1.9				
		Nalidixic acid	0.0	30.5	[21.9–40.2]									35.2	27.6	6.7		7.6	22.9		
II	**Phenicols**	Florfenicol††	N/A	0.0	[0.0–3.5]						15.2	44.8	38.1	1.9							
	Tetracyclines	Tetracycline	0.0	41.9	[32.3–51.9]			1.9	5.7	26.7	10.5	9.5	2.9	1.0		1.9	1.0	5.7	33.3		
III	**Lincosamides**	Clindamycin	1.9	5.7	[2.1–12.0]		1.0	6.7	21.0	28.6	22.9	10.5	1.9	1.9		3.8	1.9				

* 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 6.03: Antimicrobial resistance pattern for *Campylobacter coli*, 2007

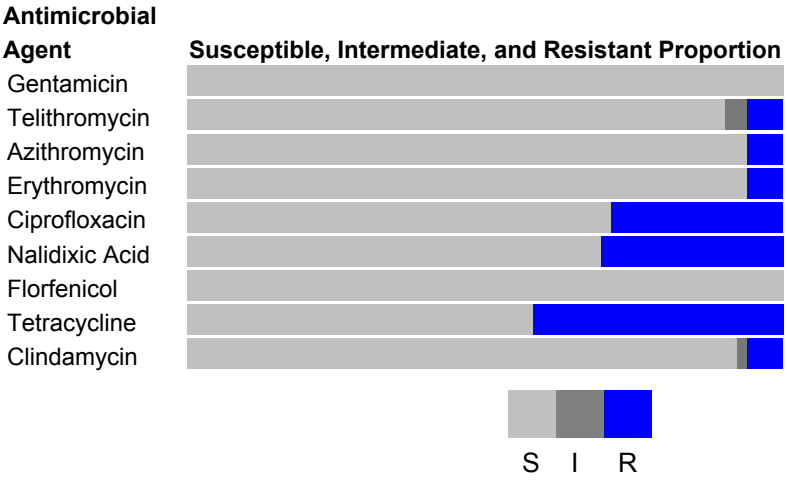


Table 5.08: Percentage and number of *Campylobacter coli* isolates resistant to antimicrobial agents, 1998–2007

Year			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Isolates			8	20	12	17	25	22	26	98	97	105
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.0% 0	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
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	4.1% 4	7.2% 7	5.7% 6
	Macrolides	Azithromycin (MIC ≥ 8)	12.5% 1	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
		Erythromycin (MIC ≥ 32)	12.5% 1	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
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	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
		Nalidixic acid (MIC ≥ 64)	50.0% 4	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
II	Phenicols	Chloramphenicol (MIC ≥ 32)	37.5% 3	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 1	0.0% 0	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	50.0% 4	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
III	Lincosamides	Clindamycin (MIC ≥ 8)	12.5% 1	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

* 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

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Whichard, J.M., Gay, K., White, D.G., Chiller, T.M. Surveillance for antimicrobial resistance among foodborne bacteria: the U.S. approach. p. 79-92 *in* M'ikanatha, N.M., Lynfield, R., Van Beneden, C.A. and de Valk, H. (ed.) *Infectious Disease Surveillance.* Blackwell: Malden, Massachusetts. 2007.

APPENDIX A
Summary of *Escherichia coli* Resistance Surveillance Pilot Study, 2007

***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 2007 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 2007, 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 A.01).

Interpretive criteria from CLSI were used (Table A.01). 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 2007, CDC received 68 stool samples, of these, 66 (97%) were viable *E. coli* isolates (Table A.02). MIC was determined for *E. coli* isolates for 15 antimicrobial agents (Table A.03).

Of the *E. coli* isolates, 24.2% were resistant to sulfonamides; 21.2%, to ampicillin; 21.2% to tetracycline; and 10.6% to nalidixic acid (Table A.04).

In 2007, 24.2% of *E. coli* isolates were resistant to two or more CLSI classes, and 4.5% were resistant to five or more CLSI classes (Table A.05).

Multidrug-Resistant *E. coli*

- 24.2% of 66 *E. coli* isolates tested were resistant to two or more classes of antimicrobial agents.
- 4.5% of 66 *E. coli* isolates tested were resistant to five or more classes of antimicrobial agents.

Clinically Important Resistance

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

- 0.0% of 66 *E. coli* isolates were resistant to ceftiofur (Table A.04).
- 7.6% of 66 *E. coli* isolates were resistant to ciprofloxacin (Table A.04).

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Table A.01: Antimicrobial agents used for susceptibility testing of *Escherichia coli*, 2007

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	≤8	16-32	≥64
Folate pathway inhibitors	Sulfisoxazole	16 – 256	≤256		≥512
	Trimethoprim–Sulfamethoxazole	0.12/2.4 – 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

Table A.02: Minimum inhibition concentrations (MICs) and resistance of *Escherichia coli* isolates to antimicrobial agents, 2007 (N=66)

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	[0.0–5.4]						1.5	36.4	56.1	6.1							
		Gentamicin	0.0	3.0	[0.4–10.5]					13.6	72.7	10.6					3.0				
		Streptomycin	N/A	13.6	[6.4–24.3]												86.4	4.5	9.1		
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	0.0	[0.0–5.4]							3.0	21.2	53.0	22.7						
	Cephems	Ceftiofur	0.0	0.0	[0.0–5.4]					7.6	59.1	30.3	3.0								
		Ceftriaxone	0.0	0.0	[0.0–5.4]						100.0										
	Penicillins	Ampicillin	0.0	21.2	[12.1–33.0]							12.1	47.0	19.7			1.5	19.7			
	Quinolones	Ciprofloxacin	0.0	7.6	[2.5–16.8]	84.8	4.5				3.0				7.6						
		Nalidixic Acid	N/A	10.6	[4.4–20.6]							13.6	63.6	9.1	1.5	1.5		10.6			
II	**Aminoglycosides**	Kanamycin	0.0	1.5	[0.0–8.2]										97.0	1.5			1.5		
	Cephems	Cefoxitin	0.0	0.0	[0.0–5.4]						3.0	1.5	34.8	50.0	10.6						
	Folate pathway inhibitors	Sulfisoxazole	N/A	24.2	[14.5–36.4]											63.6	9.1	3.0			24.2
		Trimethoprim-sulfamethoxazole	N/A	15.2	[7.5–26.1]					66.7	15.2	1.5		1.5	15.2						
	Phenicols	Chloramphenicol	1.5	3.0	[0.4–10.5]									45.5	50.0	1.5	1.5	1.5			
	Tetracyclines	Tetracycline	0.0	21.2	[12.1–33.0]									78.8		1.5	3.0	16.7			

* 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 A.01: Antibiotic resistance pattern for *Escherichia coli*, 2007

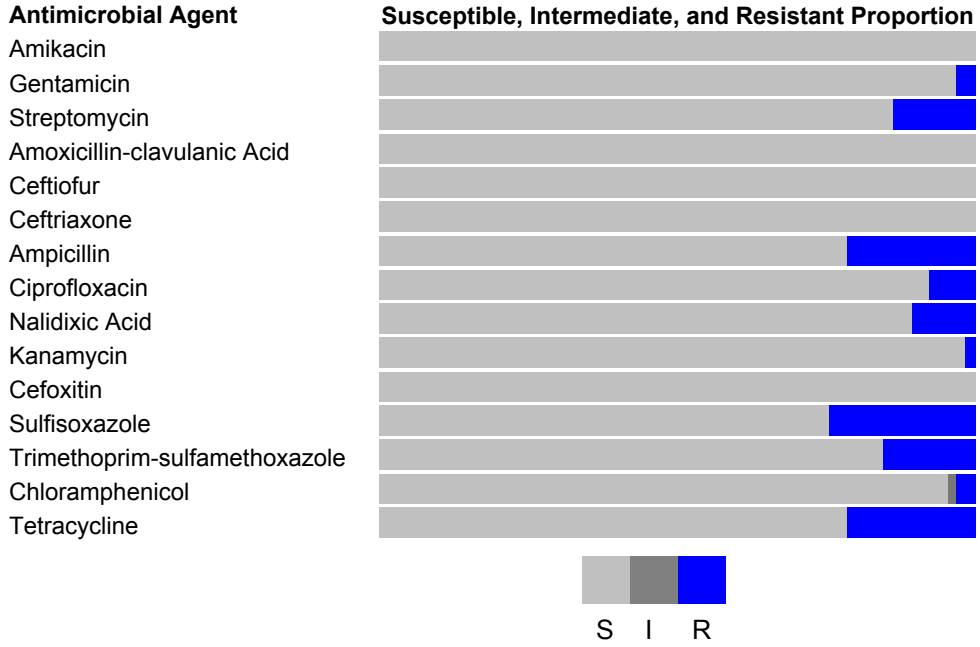

Table A.03: Percentage and number of *Escherichia coli* isolates resistant to antimicrobial agents, 2004–2007

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

‡ Results unavailable for 5 isolates

Table A.04: Resistance patterns of *Escherichia coli* isolates, 2004–2007

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

* CLSI: Clinical and Laboratory Standards Institute

† ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxa

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

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