Table of Contents

Suggested Citation: CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2009. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2010.

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

Disclaimer: Commercial products are mentioned for identification only and do not represent endorsement

List of Tables

List of Figures

List of Boxes

List of Abbreviations and Acronyms

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

NARMS Working Group

Centers for Disease Control and Prevention

Enteric Diseases Epidemiology Branch

Enteric Diseases Laboratory Branch

Division of Foodborne, Waterborne and Environmental Diseases

National Center for Emerging and Zoonotic Infectious Diseases

Olympia Anderson
Frederick Angulo
Ezra Barzilay
Jason Folster
Peter Gerner-Smidt
Audrey Green
Patricia Griffin
Robert Michael Hoekstra
Rebecca Howie
Kevin Joyce
Maria Karlsson
Beth Karp
Amy Krueger
Kathryn Lupoli
Andre McCullough
Felicita Medalla
Gary Pecic
Jared Reynolds
Regan Rickert
Jacinta Smith
Andrew Stuart
Robert Tauxe
Jean Whichard

U.S. Food and Drug Administration
Center for Veterinary Medicine

Heather Green
Claudine Kabera
Patrick McDermott
Emily Tong
Niketta Womack

Participating State and Local Health Departments

Alabama Department of Public Health
LaDonna Cranidiotis
Sherri Davidson
Sharon Massingale
Patricia Morrow
Joanna Roberson

Alaska Department of Health and Social Services
Shellie Smith
Catherine Xavier

Arizona Department of Health Services
Shoana Anderson
Aarikha D'Souza
Daniel Flood
Melissa Hoffman
Ken Komatsu
William Slanta
Victor Waddell

Arkansas Department of Health
Rossina Stefanova

California Department of Health Services
Wendy Cheung
Claudia Crandall
Samar Fontanoz
Paul Kimsey
Will Probert
Sam Shin
Duc Vugia

Colorado Department of Public Health and Environment
Alicia Cronquist
Laura Gillim-Ross
Joyce Knutsen
Hugh Maguire

Connecticut Department of Public Health
Diane Barden
Sharon Hurd
Aristea Kinney
Mona Mandour

Delaware Health and Social Services
Gaile McLaughlin
Bela Patel
Debra Rutledge

Florida Department of Health
Ronald Baker
Maria Calcaterra
Sonia Etheridge
Dian Sharma

Georgia Division of Public Health
Jim Benson
Elizabeth Franko
Tameka Hayes
Mary Hodel
Susan Lance
Bob Manning
Mahin Park
Lynett Poventud
Suzanne Segler
Stepy Thomas
Melissa Tobin-D'Angelo

Hawaii Department of Health
Rebecca Kanenaka
Norman O'Connor

Houston Health and Human Services Department
Raouf Arafat
Adebowale Awosika-Olumo
Gregory Dufour
Vern Juchau
Sudha Pottumarthy
Joan Rogers

Idaho Department of Health and Welfare
Colleen Greenwalt
Vivian Lockary
Raemi Nolevanko

Illinois Department of Public Health
Nancy Barstead
Bob Cox
Mark Dworkin
Juan Garcia
Rebecca Hambelton
Stephen Hendren
Steve Hopkins
Patrick Miller
Mohammad Nasir
Kiran Patel
Tricia Patterson
Guinevere Reserva
Bindu Shah
Andrea Stadsholt

Indiana State Department of Health
Brent Barrett
Amie May
John Radosevic

Iowa Department of Public Health, University Hygienic Laboratory
Mary DeMartino
Randy Groepper

Kansas Department of Health and Environment
Cheryl Banez-Ocfemia
Robert Flahart
Gail Hansen
Carissa Pursell
June Sexton
Kathleen Waters

Kentucky Department of Public Health
Robin Cotton
Karim George
William Grooms
Darrin Sevier
Jack Wiedo

Los Angeles County Department of Health Services
Michael Stephens
Sheena Chu
Sue Sabet
Laurene Mascola
Roshan Reporter
Joan Sturgeon

Louisiana Department of Health and Hospitals
Gary Balsamo
Erin Delaune
Wayne Dupree
Catrin Jones-Nazar
Lori Kravet
Steven Martin
Raoult Ratard
Theresa Sokol
Susanne Straif-Bourgeois

Maine Department of Human Services
Geoff Beckett
Kathleen Gensheimer
Jeff Randolph
Vicki Rea
Lori Webber
Donna Wrigley
Anthony Yartel

Maryland Department of Health and Mental Hygiene
David Blythe
Kirsten Larson
Celere Leonard
Amanda Palmer
Jafar Razeq
Pat Ryan

Massachusetts Department of Public Health
Catherine Brown
Alfred DeMaria
Robert Goldbaum
Emily Harvey
Patricia Kludt
Joseph Peppe
Tracy Stiles

Michigan Department of Community Health
Carrie Anglewicz
Frances Downes
Teri Lee Dyke
James Rudrik
William Schneider
Patricia Somsel

Minnesota Department of Health
John Besser
Billie Juni
Fe Leano
Stephanie Meyer
Kirk Smith
Charlott Taylor
Theresa Weber

Mississippi Department of Health
Jannifer Anderson
Jane Campbell
Gloria Kendrick
Sheryl Hand
Cathie Hoover
Daphne Ware

Missouri Department of Health
David Byrd
Steve Gladbach
Jason Herstein
Harvey Marx
JoAnn Rudroff

Montana Department of Public Health and Human Services
Bonnie Barnard
Anne Weber
Susanne Zanto

Nebraska Health and Human Services and the Nebraska Public Heatlh Laboratory
Amy Armbrust
Jude Dean
Paul Fey
Peter Iwen
Tom Safranek

Nevada Department of Health and Human Services
Vince Abitria
Patricia Armour
Stephanie Ernaga
Jaime Frank
Paul Hug
Bradford Lee
Susanne Quianzon
Lisa Southern
Stephanie Van Hooser

New Hampshire Department of Health and Human Services

Christine Adamski
Christine Bean
Elizabeth Daly
Wendy Lamothe
Nancy Taylor
Daniel Tullo

New Jersey Department of Health
Ruth Besco
Michelle Malavet
Sylvia Matiuck
Paul Seitz

New Mexico Department of Health
Lisa Butler
Cynthia Nicholson
Lisa Onischuk
Erica Pierce
Paul Torres

New York City Department of Health
Sharon Balter
Ludwin Chicaiza
Heather Hanson
Lillian Lee
Jennifer Rakeman
Vasudha Reddy

New York State Department of Health

Leeanna Armstrong
Nellie Dumas
Tammy Quinlan
Dale Morse
Tim Root
Shelley Zansky

North Carolina Department of Health and Human Services

Denise Griffin
Debra Springer

North Dakota Department of Health

Lisa Elijah
Julie Wagendorf
Eric Hieb
Nicole Meier
Tracy Miller
Lisa Well

Ohio Department of Health

Rick Bokanyi
Tammy Bannerman
Jane Carmean
Larry King
Mary Kay Parrish
Susan Luning
Ellen Salehi

Oklahoma State Department of Health

Rebekah Berry
Mike Lytle
Mike McDermot

Oregon Department of Human Service

Debbie Berquist
Cathy Ciaffoni
Paul Cieslak
Dawn Daly
Emilio Debess
Julie Hatch
Beletsachew Shiferaw
Larry Stauffer
Janie Tierheimer
Robert Vega
Veronica Williams

Pennsylvania Department of Human Service

Wayne Chmielecki
Lisa Dettinger
Nkuchia Mikanatha
Stanley Reynolds
Carol Sandt
James Tait

Rhode Island Department of Health

Tara Cooper
Deanna Simmons
Cindy Vanner

South Carolina Department of Health and Environmental Control

Dana Giurgiutiu
Mamie Turner
Jennifer Meredith
Arthur Wozniak

South Dakota Department of Health

Christopher Carlson
Lon Kightlinger
Mike Smith
Yvette Thomas

Tennessee Department of Health

Parvin Arjmandi
Paula Bailey
John Dunn
Samir Hanna
Henrietta Hardin

Texas Department of State Health Services

Tamara Baldwin
Leslie Bullion
Elizabeth Delamater
Linda Gaul
Eldridge Hutcheson
Miriam Johnson
Susan Neill
Pushker Raj
Ana Valle

Utah Department of Health

Dan Andrews
Kim Christensen
Jana Coombs
Cindy Fisher
David Jackson
Barbara Jepson
Susan Mottice

Vermont Department of Health

Erica Berl
Valerie Cook
Eunice H. Froeliger
Christine LaBarre

Virginia Division of Consolidated Laboratory Services and Virginia Department of Health

Ellen Basinger
Sherry Giese
Jody Lowman
Mary Mismas
Denise Toney

Washington Department of Health

Jennifer Breezee
Romesh Gautom
Donna Green
Brian Hiatt
Yolanda Houze
Kathryn MacDonald

West Virginia Department of Health and Human Resources

Danae Bixler
Christi Clark
Maria del Rosario
Loretta Haddy
Andrea Labik
Megan Young

Wisconsin Department of Health and Family Services

John Archer
Susann Ahrabi-Fard
Charles Brokopp
Jeffrey Davis
Rick Heffernan
Rachel Klos
Tim Monson
Dave Warshauer

Wyoming Department of Health
Richard Harris
John Harrison
Clay Van Houten
Tracy Murphy
Jim Walford

What is New in the NARMS Report for 2009

Mutually exclusive criteria heading
In Box 2 (page 47), we describe the 4 most common multidrug-resistant (MDR) patterns among non-typhoidal *Salmonella* isolates based on resistance to 7 of the 15 agents currently tested in NARMS: ampicillin (A), chloramphenicol (C), streptomycin (S), sulfonamide (Su), tetracycline (T), amoxicillin-clavulanic acid (Au), and ceftriaxone (Cx). Resistance to the 7 agents has been used in NARMS to categorize specific MDR patterns. Unlike MDR criteria used for tables in previous reports and other sections of this report, we used mutually exclusive criteria in the new section. Use of mutually exclusive criteria is important in monitoring major and emerging patterns, which may be driven by different resistance mechanisms.

Update of trimethoprim-sulfamethoxazole data for *Shigella*
Automated fluorescence-based methods have been used since 2001 to determine minimum inhibitory concentrations (MIC) for the drugs tested for *Enterobacteriaceae*. These automated fluorescence-based methods are designed to emulate MICs that would be obtained if the results were read visually. Recent laboratory comparison studies showed that the automated fluorescence-based method was not reproducibly emulating visually-determined results for trimethoprim-sulfamethoxazole with *Shigella* species. The test manufacturer has updated the automated fluorescence-based method to improve concordance with visual results, and these updates have been applied retroactively to the affected data in the database. This has resulted in lower MIC results and lower prevalence of trimethoprim-sulfamethoxazole resistance for *Shigella*.

Introduction

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

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

Before NARMS was established, CDC monitored antimicrobial resistance in *Salmonella, Shigella*, and *Campylobacter* through periodic surveys of isolates from a panel of sentinel counties. NARMS at CDC began in 1996 with prospective monitoring of antimicrobial resistance among clinical non-typhoidal *Salmonella* and *Escherichia coli* O157 isolates in 14 sites. In 1997, testing of clinical *Campylobacter* isolates was initiated in the five sites participating in FoodNet. Testing of clinical *Salmonella enterica* serotype Typhi and *Shigella* isolates was added in 1999. Since 2003, all 50 states have been forwarding a representative sample of non-typhoidal *Salmonella, Salmonella* ser. Typhi, *Shigella*, and *E. coli* O157 isolates to NARMS for antimicrobial susceptibility testing, and 10 FoodNet states have been participating in *Campylobacter* surveillance. Since 2008, all 50 states have been forwarding every *Salmonella* Paratyphi A and C to NARMS for antimicrobial susceptibility testing.

This annual report includes CDC's surveillance data for 2009 for non-typhoidal *Salmonella*, typhoidal *Salmonella, Shigella*, *Campylobacter* and *E. coli* O157 isolates. Data for earlier years are presented in tables and graphs when appropriate. Antimicrobial classes defined by Clinical and Laboratory Standards Institute (CLSI) are used in data presentation and analysis. CLSI classes constitute major classifications of antimicrobial agents, e.g., aminoglycosides and cephems.

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

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

WHO Categorization of Antimicrobial Agents

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

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

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

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

*In 2010, WHO recategorized tetracycline from highly important to critically important. The NARMS 2010 annual report will reflect this change.

Summary of NARMS 2009 Surveillance Data

Population

In 2009, all 50 states participated in NARMS, representing the entire U.S. population of approximately 307 million persons (Table 2). Surveillance was conducted in all states for non-typhoidal *Salmonella,* typhoidal *Salmonella, Shigella*, and *Escherichia coli* O157. For *Campylobacter*, surveillance was conducted in 10 states that comprise the Foodborne Diseases Active Surveillance Network (FoodNet), representing approximately 47 million persons (15% of the U.S. population).

Clinically Important Antimicrobial Resistance Patterns

In the United States, fluoroquinolones (e.g., ciprofloxacin) and third-generation cephalosporins (e.g., ceftriaxone) are commonly used to treat severe *Salmonella* infections, including *Salmonella* ser. Typhi, the organism that causes typhoid fever. In *Enterobacteriaceae*, resistance to nalidixic acid, an elementary quinolone, correlates with decreased susceptibility to ciprofloxacin (MIC ≥0.12 µg/mL) and possible fluoroquinolone treatment failure. A substantial proportion of *Enterobacteriaceae* isolates tested in 2009 demonstrated resistance to these clinically important antimicrobial agents.

Among non-typhoidal *Salmonella* isolates:

- 1.8% (39/2192) were resistant to nalidixic acid. The most common serotypes among the nalidixic acid-resistant isolates were Enteritidis (15/39, 38%) and Typhimurium (8/39, 21%)
    - 3.7% (15/410) of *Salmonella* ser. Enteritidis isolates were nalidixic acid resistant
    - 2.2% (8/371) of *Salmonella* ser. Typhimurium isolates were nalidixic acid resistant
- 3.4% (75/2192) were resistant to ceftriaxone. The most common serotypes among the ceftriaxone resistant isolates were Typhimurium (24/75, 32%) and Heidelberg (18/75, 24%)
    - 21% (18/86) of *Salmonella* ser. Heidelberg isolates were ceftriaxone resistant
    - 6.5% (24/371) of *Salmonella* ser. Typhimurium isolates were ceftriaxone resistant

Among *Salmonella* ser. Typhi isolates:

- 60% (217/361) were resistant to nalidixic acid and 3.3% (12/361) to ciprofloxacin

Among *Shigella* isolates:

- 2.1% (10/475) were resistant to nalidixic acid and 0.6% (3/475) to ciprofloxacin

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

- 23% (344/1502) were ciprofloxacin resistant, including
    - 23% (312/1355) of *Campylobacter jejuni* isolates
    - 22% (31/143) of *Campylobacter coli* isolates
- 1.7% (25/1502) were erythromycin resistant, including
    - 1.5% (21/1355) *Campylobacter jejuni* isolates
    - 2.8% (4/143) of *Campylobacter coli* isolates

Multidrug Resistance

Multidrug resistance is described in NARMS as resistance to three or more CLSI antimicrobial classes. Antimicrobial classes of agents defined by the Clinical and Laboratory Standards Institute (CLSI) are used in this report (Table 3, Table 4). For non-typhoidal *Salmonella*, an important multidrug-resistant phenotype includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide (sulfamethoxazole or sulfisoxazole), and tetracycline (ACSSuT). The ACSSuT phenotype includes resistance to at least five CLSI classes. Another important phenotype includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftriaxone (ACSSuTAuCx). The ACSSuTAuCx phenotype includes resistance to at least 7 CLSI classes.

Among non-typhoidal *Salmonella* isolates:

- 13% (284/2192) were resistant to two or more CLSI classes of agents, 9.5% (209/2192) to three or more CLSI classes. Of the 209 isolates resistant to three or more CLSI classes, 50% were ser.Typhimurium. The serotypes with the highest proportion of isolates resistant to three or more CLSI classes were
    - Typhimurium (28%, 104/371), Heidelberg (26%, 22/86), and Newport (7.6%, 18/236)
- 5.1% (112/2192) were at least ACSSuT resistant. The serotypes with the highest proportion of isolates resistant to this phenotype were
    - Typhimurium (19%, 72/371) and Newport (6.4%, 15/236)
- 1.4% (30/2192) were at least ACSSuTAuCx resistant. The serotypes with the highest proportion of isolates resistant to this phenotype were
    - Newport (6.4%, 15/236) and Typhimurium (1.6%, 6/371)

Additional isolates resistant to three or more CLSI classes include

- 13% (46/361) of *Salmonella* ser. Typhi isolates
- 36% (173/475) of *Shigella* isolates
- 5.9% (11/188) of *E. coli* O157 isolates

Box 1. Changes in antimicrobial resistance: 2009 vs. 2003–07

To understand changes in prevalence of antimicrobial resistance over time, we used logistic regression to compare the prevalence of specific antimicrobial resistance patterns among *Salmonella* and *Campylobacter* isolates tested in 2009 with the reference, which was the average prevalence of resistance in 2003–07. Since 2003, all 50 states have participated in *Salmonella* surveillance and all 10 FoodNet sites in *Campylobacter* surveillance. A description of the methods is included in this report (refer to Surveillance and Laboratory Testing Methods).

The differences between the prevalence of resistance in 2009 and the average prevalence of resistance in 2003–07 (Figure 1) were statistically significant for the following:

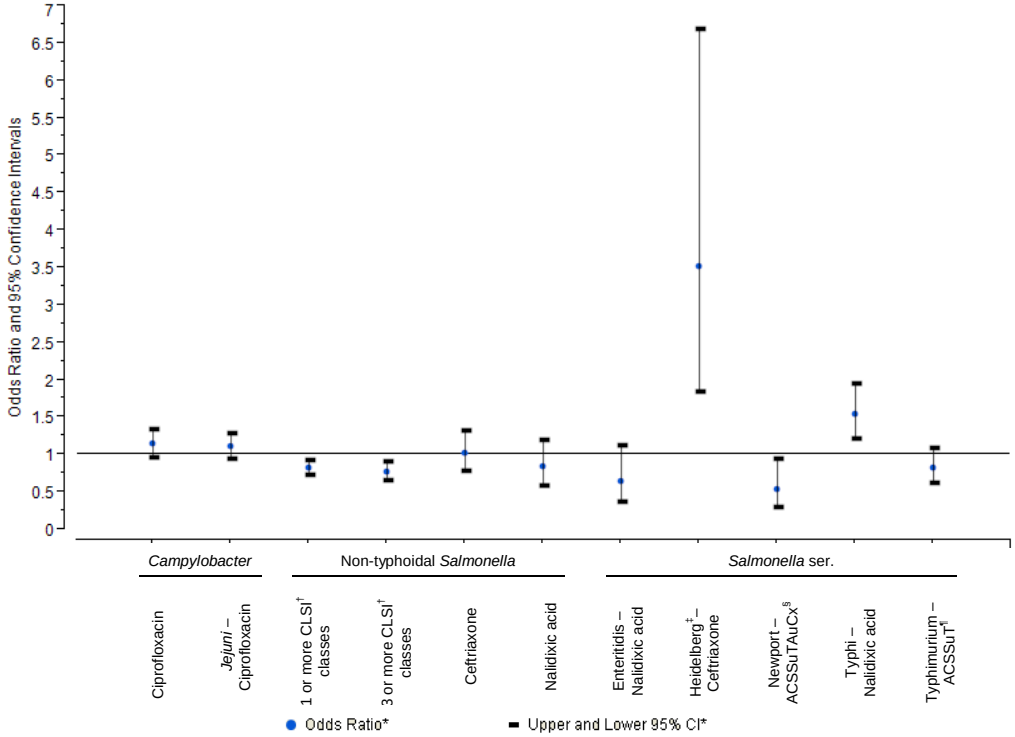
- Resistance to one or more CLSI classes in non-typhoidal *Salmonella* (NTS), lower in 2009 (17%) than in 2003–07 (20%) (OR=0.8, 95% CI [0.7–0.9])
- Resistance to three or more CLSI classes in NTS, lower in 2009 (9.5%) than in 2003–07 (12%) (OR=0.8, 95% CI [0.7–0.9])
- ACSSuTAuCx resistance in *Salmonella enterica* ser. Newport, lower in 2009 (6.4%) than in 2003–07 (13%) (OR=0.5, 95% CI [0.3–1.0])
- Nalidixic acid resistance in *Salmonella enterica* ser. Typhi, higher in 2009 (60%) than in 2003–07 (49%) (OR=1.6, 95% CI [1.2–2.0])

Ceftriaxone resistance in *Salmonella* ser. Heidelberg was higher in 2009 (21%) than the average prevalence of resistance in 2003–07 (7.9%) (OR=3.5, 95% CI [1.8, 6.7]) (Figure 1). The data indicate that increased resistance was mainly driven by California and Washington. Trend analysis excluding California and Washington shows no significant change (OR=1.4, 95% CI [0.6, 3.6]). Thus, the reported OR represents a summary of unequal trends among sites.

The differences between the prevalence of resistance in 2009 and the average prevalence of resistance in 2003–07 (Figure 1) were not statistically significant for the following:

- Nalidixic acid resistance in NTS (OR=0.9, 95% CI [0.6–1.2])
- Ceftriaxone resistance in NTS (OR=1.0, 95% CI [0.8–1.3])
- Nalidixic acid resistance in *Salmonella enterica* ser. Enteritidis (OR=0.7, 95% CI [0.4–1.1])
- ACSSuT resistance in *Salmonella enterica* ser. Typhimurium (OR=0.8, 95% CI [0.6–1.1])
- Ciprofloxacin resistance in *Campylobacter* (OR=1.1, 95% CI [1.0–1.3])
- Ciprofloxacin resistance in *Campylobacter jejuni* (OR=1.1, 95% CI [1.0–1.4])

Figure 1. Summary of trend analysis of the prevalence of specific resistance patterns among *Salmonella* and *Campylobacter* isolates, 2009 compared with 2003–2007*

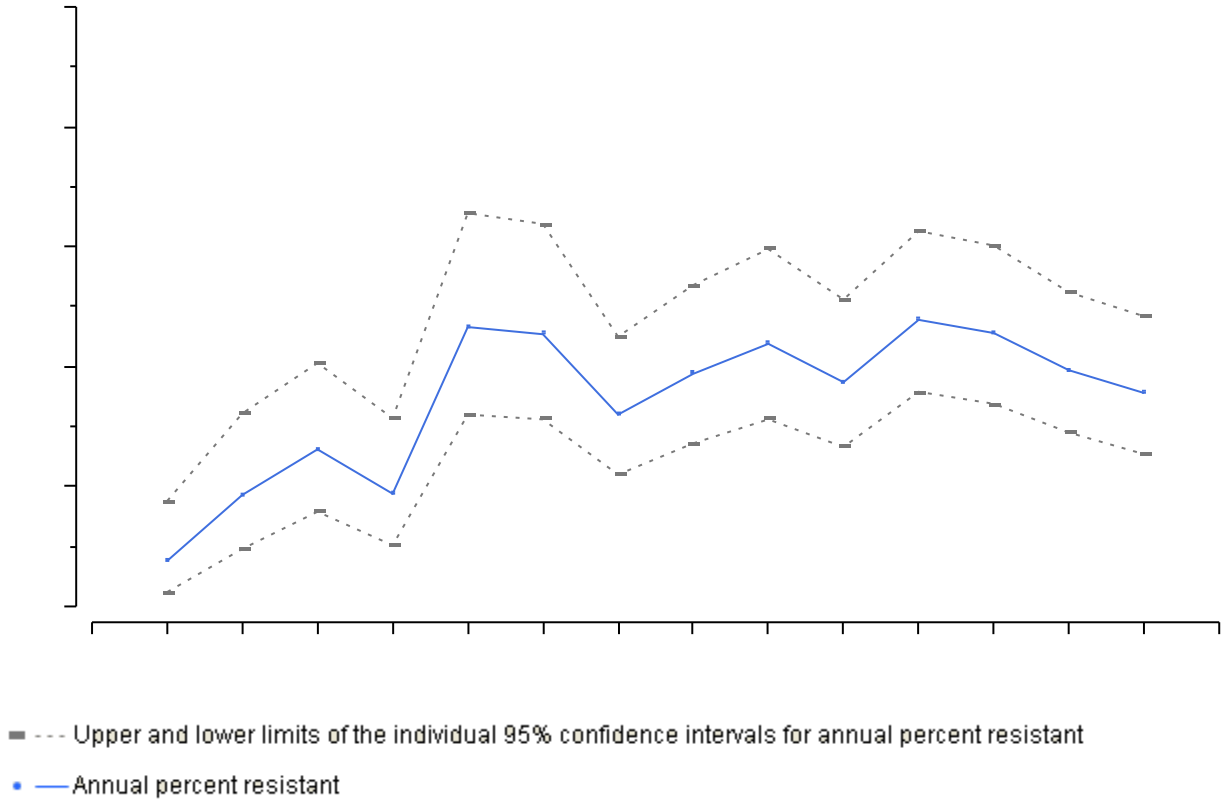


*The reference is the average prevalence of resistance in 2003–07. Logistic regression models adjusted for site. The odds ratios (ORs) and 95% confidence intervals (CIs) for 2009 compared with the reference were calculated using unconditional maximum likelihood estimation. ORs that do not include 1.0 in the 95% CIs are reported as statistically significant.
†Antimicrobial classes of agents defined by the Clinical and Laboratory Standards Institute (CLSI) are used.
‡Descriptive analysis suggests that increased resistance in 2009 was mainly driven by California and Washington. Thus, the reported OR represents a summary of unequal trends across sites.
§ACSSuTAuCx: resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftriaxone.
¶ACSSuT: resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline.

Antimicrobial Resistance: 1996–2009

The following figures display resistance from 1996–2009 for non-typhoidal *Salmonella*, 2000–2009 for *Salmonella* ser. Typhi, and 1997–2009 for *Campylobacter*.

Figure 1. Percentage of non-typhoidal *Salmonella* isolates resistant to nalidixic acid, by year, 1996–2009



Upper and lower limits of the individual 95% confidence intervals for annual percent resistant

Annual percent resistant

Figure 2. Percentage of non-typhoidal *Salmonella* isolates resistant to ceftriaxone, by year, 1996–2009

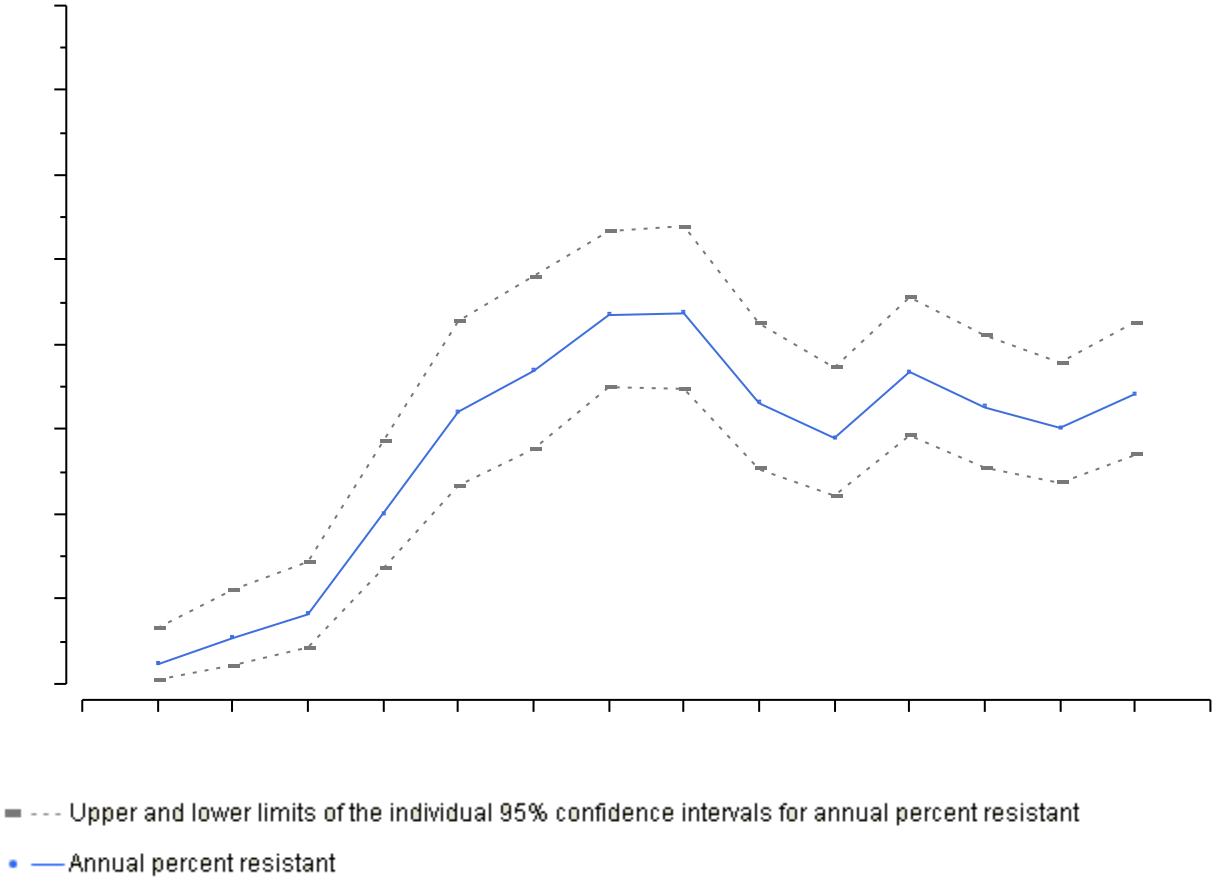


Figure 3. Percentage of *Salmonella* ser. Enteritidis isolates resistant to nalidixic acid, by year, 1996–2009

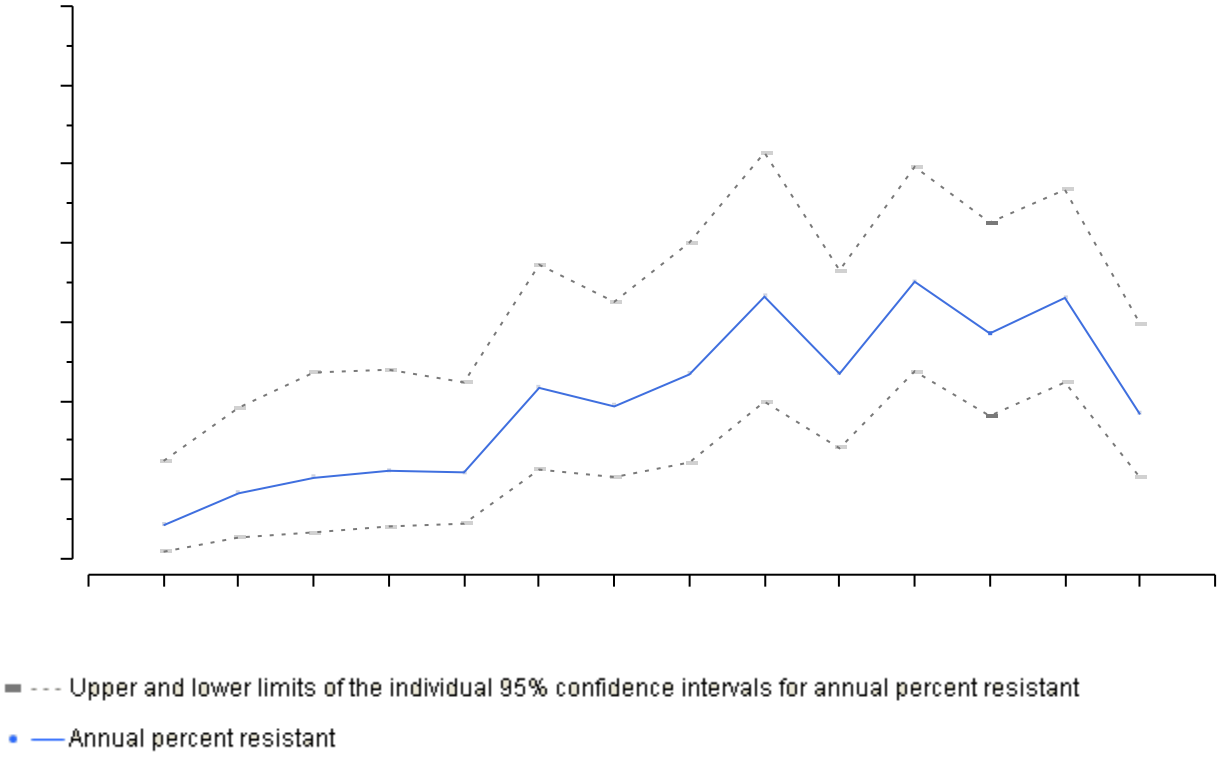


Figure 4. Percentage of *Salmonella* ser. Heidelberg isolates resistant to ceftriaxone, by year, 1996–2009

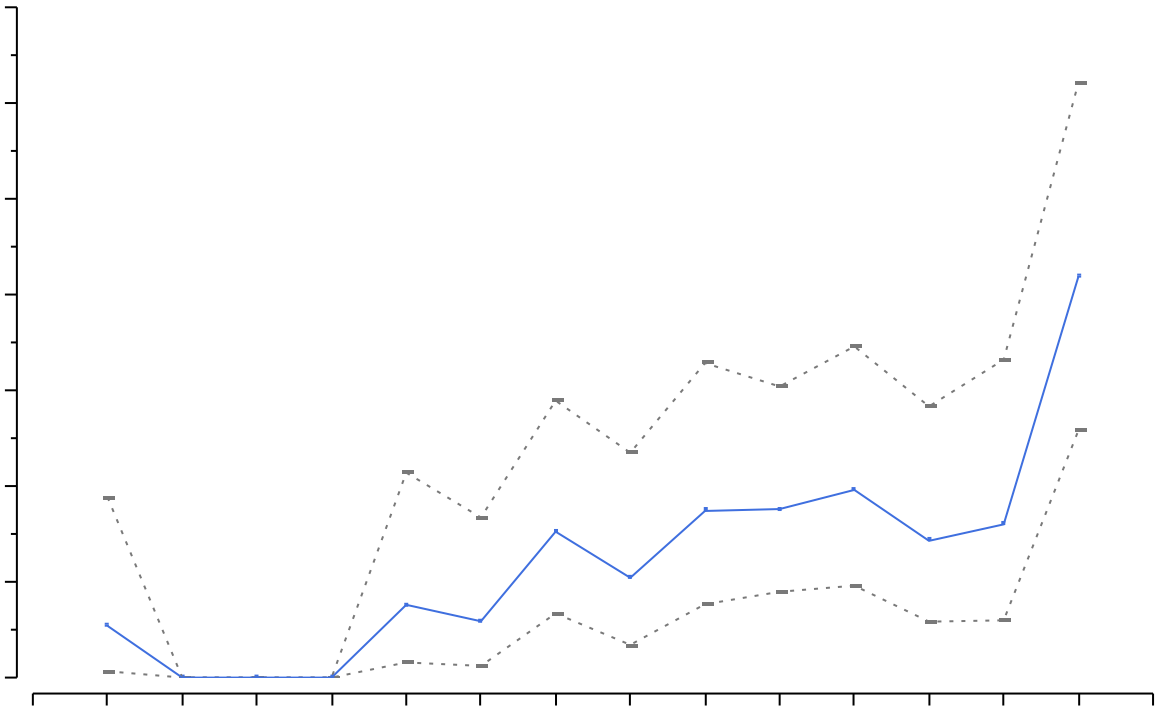


Figure 5. Percentage of *Salmonella* ser. Typhimurium isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, and tetracycline (ACSSuT), by year, 1996–2009

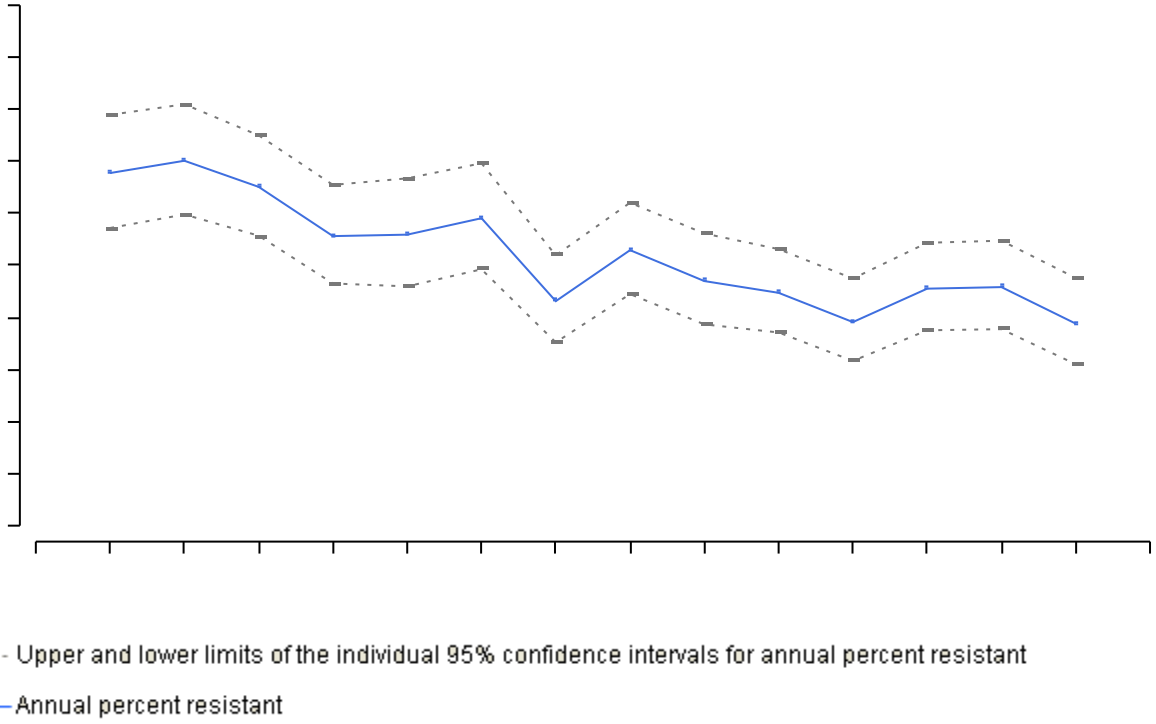


Figure 6. Percentage of *Salmonella* ser. Newport isolates resistant to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftriaxone (ACSSuTAuCx), by year, 1996–2009

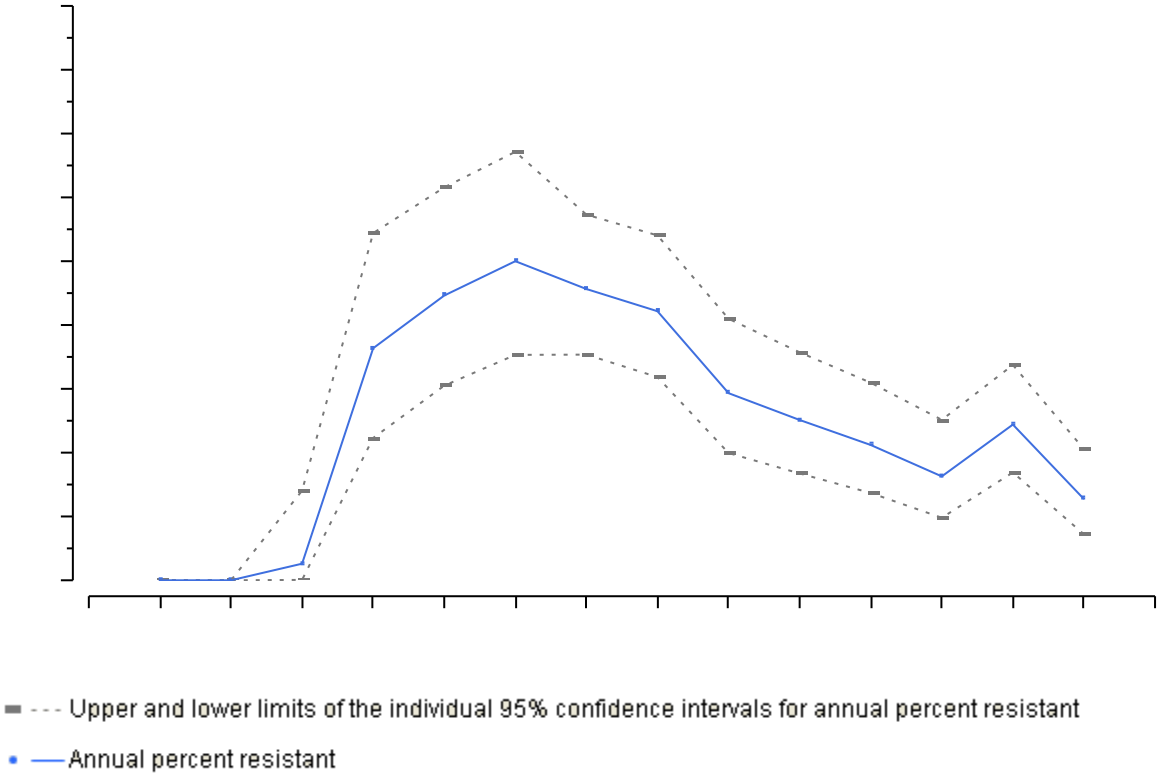


Figure 7. Percentage of non-typhoidal *Salmonella* isolates resistant to 1 or more antimicrobial classes, by year, 1996–2009

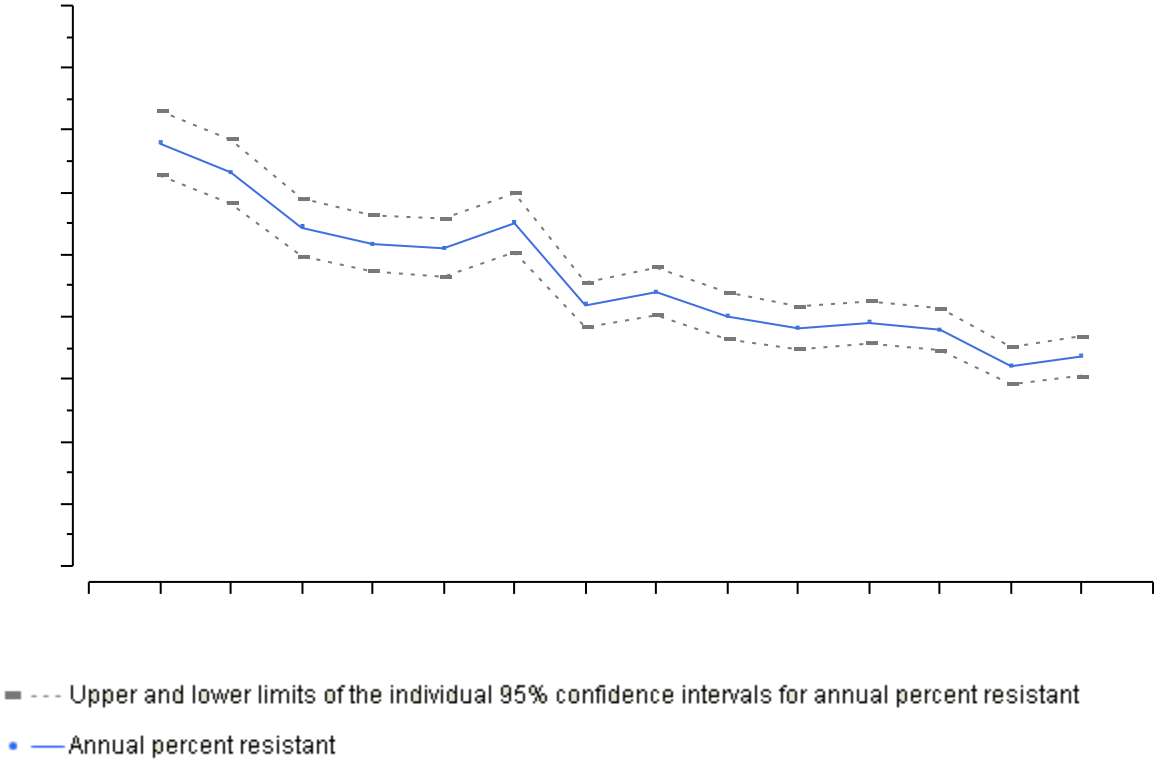
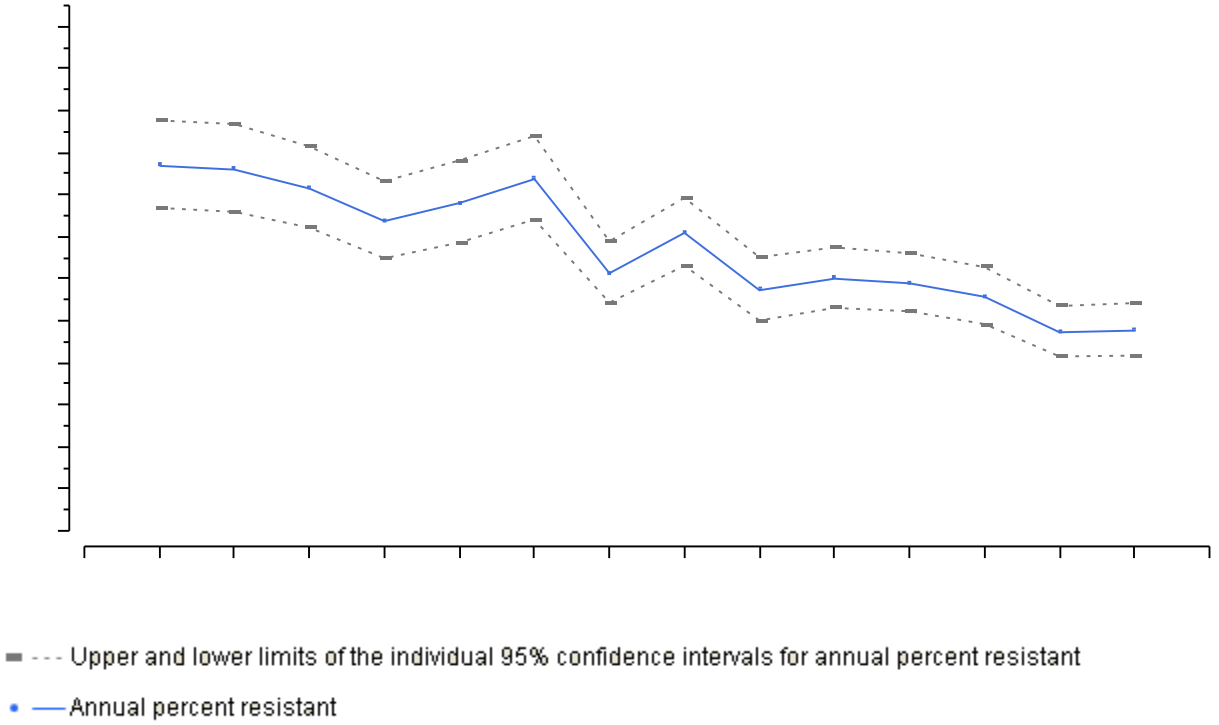


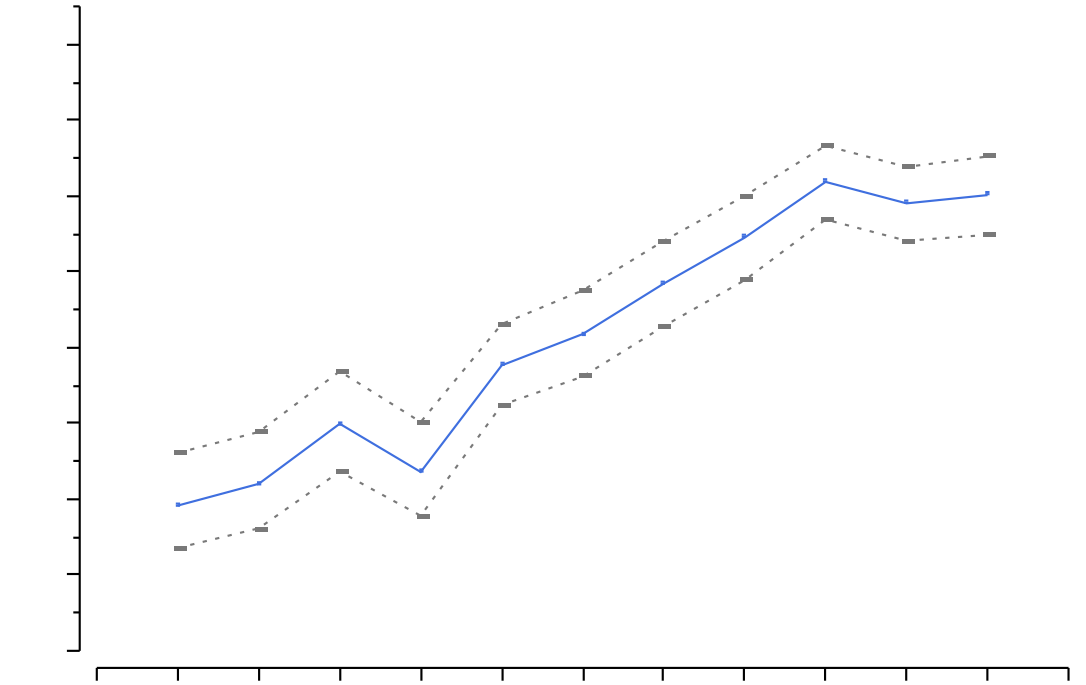
Figure 8. Percentage of non-typhoidal *Salmonella* isolates resistant to 3 or more antimicrobial classes, by year, 1996–2009



Upper and lower limits of the individual 95% confidence intervals for annual percent resistant

Annual percent resistant

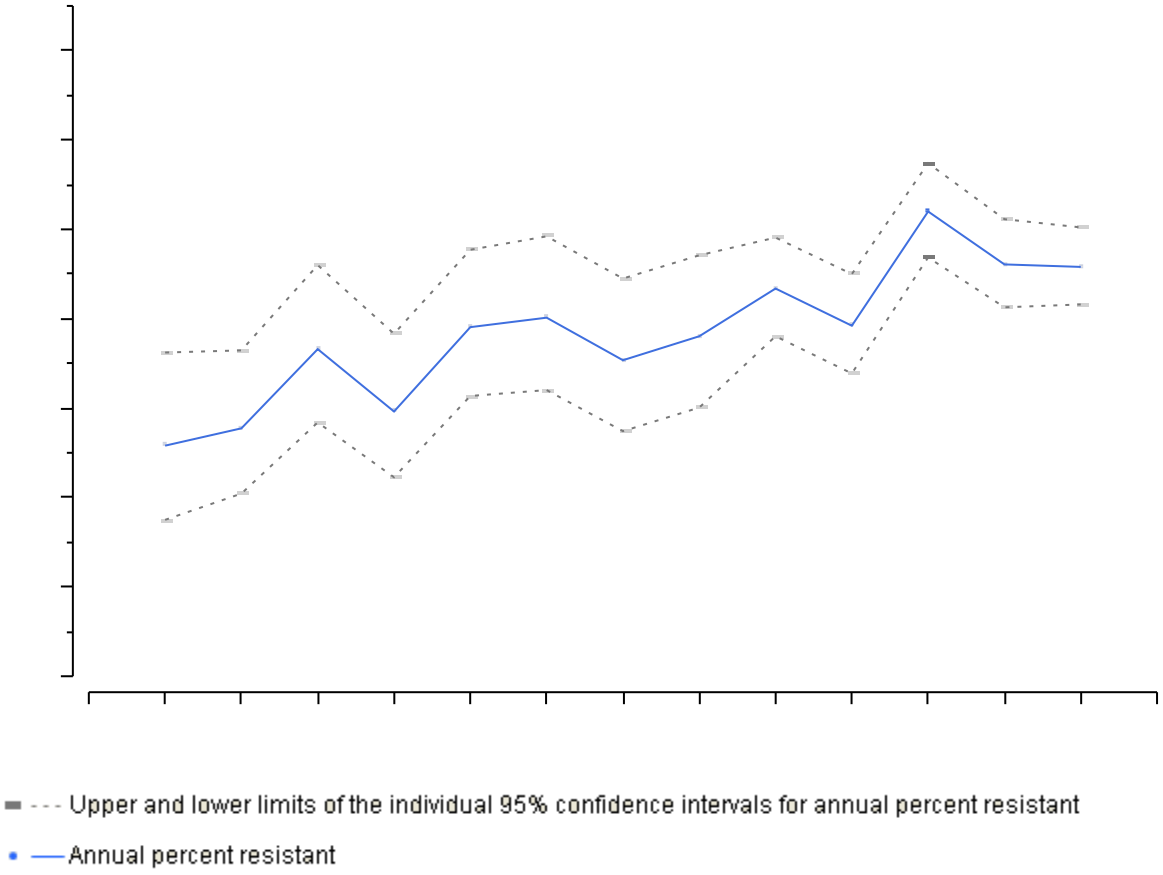
Figure 9. Percentage of *Salmonella* ser. Typhi isolates resistant to nalidixic acid, by year, 2000–2009



Upper and lower limits of the individual 95% confidence intervals for annual percent resistant

Annual percent resistant

Figure 10. Percentage of *Campylobacter* isolates resistant to ciprofloxacin, by year, 1997–2009



Upper and lower limits of the individual 95% confidence intervals for annual percent resistant

Annual percent resistant

Table 2. Population size and number of isolates received and tested, NARMS, 2009

State/Site	Population Size*	Non-typhoidal *Salmonella*		Typhoidal† *Salmonella*		*Shigella*		*E. coli* O157		*Campylobacter* ‡	
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Alabama	4,708,708	65	(3.0%)	2	(0.4%)	9	(1.9%)	2	(1.1%)		
Alaska	698,473	4	(0.2%)	0	(0.0%)	1	(0.2%)	0	(0.0%)		
Arizona	6,595,778	56	(2.6%)	4	(0.9%)	27	(5.7%)	2	(1.1%)		
Arkansas	2,889,450	23	(1.0%)	0	(0.0%)	9	(1.9%)	2	(1.1%)		
California§	27,113,653	184	(8.4%)	57	(12.3%)	2	(0.4%)	5	(2.7%)	76	(5.1%)
Colorado	5,024,748	34	(1.6%)	12	(2.6%)	6	(1.3%)	7	(3.7%)	57	(3.8%)
Connecticut	3,518,288	25	(1.1%)	5	(1.1%)	1	(0.2%)	4	(2.1%)	123	(8.2%)
Delaware	885,122	8	(0.4%)	0	(0.0%)	7	(1.5%)	0	(0.0%)		
District of Columbia	599,657	37	(1.7%)	3	(0.6%)	0	(0.0%)	0	(0.0%)		
Florida	18,537,969	17	(0.8%)	28	(6.0%)	0	(0.0%)	0	(0.0%)		
Georgia	9,829,211	133	(6.1%)	12	(2.6%)	29	(6.1%)	14	(7.4%)	473	(31.5%)
Hawaii	1,295,178	16	(0.7%)	6	(1.3%)	3	(0.6%)	1	(0.5%)		
Houston, Texas¶	2,257,926	34	(1.6%)	8	(1.7%)	8	(1.7%)	0	(0.0%)		
Idaho	1,545,801	8	(0.4%)	2	(0.4%)	1	(0.2%)	2	(1.1%)		
Illinois	12,910,409	78	(3.6%)	15	(3.2%)	30	(6.3%)	17	(9.0%)		
Indiana	6,423,113	31	(1.4%)	4	(0.9%)	1	(0.2%)	2	(1.1%)		
Iowa	3,007,856	17	(0.8%)	0	(0.0%)	4	(0.8%)	4	(2.1%)		
Kansas	2,818,747	14	(0.6%)	0	(0.0%)	9	(1.9%)	1	(0.5%)		
Kentucky	4,314,113	21	(1.0%)	0	(0.0%)	4	(0.8%)	0	(0.0%)		
Los Angeles**	9,848,011	63	(2.9%)	6	(1.3%)	2	(0.4%)	0	(0.0%)		
Louisiana	4,492,076	30	(1.4%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Maine	1,318,301	1	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Maryland	5,699,478	60	(2.7%)	18	(3.9%)	17	(3.6%)	24	(12.8%)	186	(12.4%)
Massachusetts	6,593,587	58	(2.6%)	16	(3.5%)	11	(2.3%)	4	(2.1%)		
Michigan	9,969,727	42	(1.9%)	15	(3.2%)	8	(1.7%)	2	(1.1%)		
Minnesota	5,266,214	28	(1.3%)	5	(1.1%)	4	(0.8%)	8	(4.3%)	166	(11.1%)
Mississippi	2,951,996	37	(1.7%)	1	(0.2%)	4	(0.8%)	0	(0.0%)		
Missouri	5,987,580	38	(1.7%)	1	(0.2%)	35	(7.4%)	6	(3.2%)		
Montana	974,989	7	(0.3%)	1	(0.2%)	1	(0.2%)	2	(1.1%)		
Nebraska	1,796,619	10	(0.5%)	0	(0.0%)	8	(1.7%)	3	(1.6%)		
Nevada	2,643,085	12	(0.5%)	3	(0.6%)	3	(0.6%)	1	(0.5%)		
New Hampshire	1,324,575	10	(0.5%)	0	(0.0%)	2	(0.4%)	2	(1.1%)		
New Jersey	8,707,739	57	(2.6%)	44	(9.5%)	15	(3.2%)	7	(3.7%)		
New Mexico	2,009,671	10	(0.5%)	1	(0.2%)	4	(0.8%)	2	(1.1%)	142	(9.5%)
New York††	11,149,572	76	(3.5%)	19	(4.1%)	7	(1.5%)	6	(3.2%)	125	(8.3%)
New York City‡‡	8,391,881	74	(3.4%)	55	(11.9%)	18	(3.8%)	2	(1.1%)		
North Carolina	9,380,884	85	(3.9%)	11	(2.4%)	5	(1.1%)	2	(1.1%)		
North Dakota	646,844	6	(0.3%)	0	(0.0%)	2	(0.4%)	1	(0.5%)		
Ohio	11,542,645	81	(3.7%)	13	(2.8%)	20	(4.2%)	5	(2.7%)		
Oklahoma	3,687,050	34	(1.6%)	2	(0.4%)	12	(2.5%)	1	(0.5%)		
Oregon	3,825,657	26	(1.2%)	2	(0.4%)	3	(0.6%)	4	(2.1%)	113	(7.5%)
Pennsylvania	12,604,767	82	(3.7%)	22	(4.8%)	59	(12.4%)	1	(0.5%)		
Rhode Island	1,053,209	8	(0.4%)	1	(0.2%)	2	(0.4%)	1	(0.5%)		
South Carolina	4,561,242	58	(2.6%)	1	(0.2%)	4	(0.8%)	1	(0.5%)		
South Dakota	812,383	10	(0.5%)	2	(0.4%)	1	(0.2%)	3	(1.6%)		
Tennessee	6,296,254	41	(1.9%)	4	(0.9%)	16	(3.4%)	7	(3.7%)	41	(2.7%)
Texas§§	22,524,376	137	(6.3%)	16	(3.5%)	12	(2.5%)	2	(1.1%)		
Utah	2,784,572	23	(1.0%)	0	(0.0%)	1	(0.2%)	4	(2.1%)		
Vermont	621,760	1	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)		
Virginia	7,882,590	60	(2.7%)	30	(6.5%)	7	(1.5%)	3	(1.6%)		
Washington	6,664,195	44	(2.0%)	5	(1.1%)	7	(1.5%)	7	(3.7%)		
West Virginia	1,819,777	35	(1.6%)	0	(0.0%)	10	(2.1%)	4	(2.1%)		
Wisconsin	5,654,774	34	(1.6%)	11	(2.4%)	22	(4.6%)	6	(3.2%)		
Wyoming	544,270	9	(0.4%)	0	(0.0%)	2	(0.4%)	4	(2.1%)		
Total	**307,006,550**	**2192**	**(100.0%)**	**463**	**(100.0%)**	**475**	**(100.0%)**	**188**	**(100.0%)**	**1502**	**(100.0%)**

* US Census Bureau, 2009

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

‡ *Campylobacter* isolates are submitted only from FoodNet sites representing a total population 46,859,541. 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 2009, NARMS conducted nationwide surveillance among approximately 307 million persons (2009 U.S. Census Bureau estimates). Public health laboratories systematically selected every 20th non-typhoidal *Salmonella, Shigella*, and *Escherichia coli* O157 isolate as well as every *Salmonella* ser. Typhi, *Salmonella* ser. Paratyphi A and *Salmonella* ser. Paratyphi C isolate received at their laboratories and forwarded these isolates to CDC for antimicrobial susceptibility testing. *Salmonella* ser. Paratyphi B was included in the every 20th sampling for non-typhoidal *Salmonella* because available laboratory methods do not always allow for consistent distinction between serotype Paratyphi B (which typically causes typhoidal illness) and serotype Paratyphi B var. L(+)tartrate+ (which does not typically cause typhoidal illness).

Since 2005, public health laboratories of the 10 state health departments that participated in CDC's Foodborne Diseases Active Surveillance Network (FoodNet) have forwarded a representative sample of *Campylobacter* isolates to CDC for susceptibility testing. The FoodNet sites, representing approximately 47 million persons (2009 U.S. Census Bureau estimates), include California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee. Depending on the burden of *Campylobacter* in each FoodNet site, one of the following 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) according to manufacturer's instructions to determine the minimum inhibitory concentration (MIC) for each of 15 antimicrobial agents: amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole (Table 3). Before 2004, sulfamethoxazole was used instead of sulfisoxazole to represent the sulfonamides. Interpretive criteria defined by CLSI were used when available. The resistance breakpoint for amikacin, according to CLSI guidelines, is ≥64 µg/mL. In 2002 and 2003, a truncated broth microdilution series was used for amikacin testing (0.5-4 µg/mL). For isolates that grew in all amikacin dilutions on the Sensititre panel (MIC>4 µg/mL), ETest® (AB BIODISK, Solna, Sweden) was performed to determine amikacin MIC. The amikacin ETest® strip range of dilutions was 0.016-256 µg/mL. Since 2004, amikacin had a full range of dilutions (0.5-64 µg/mL) on the Sensititre panel (CMV1AGNF).

In January 2010, CLSI published revised interpretive criteria for ceftriaxone and *Enterobacteriaceae;* the revised resistance breakpoint for ceftriaxone is MIC ≥4 µg/mL. In this report, NARMS has applied the revised CLSI breakpoint for ceftriaxone resistance to data from all years.

Table 3. Antimicrobial agents used for susceptibility testing for *Salmonella*, *Shigella*, and *Escherichia coli* O157 isolates, NARMS, 2009

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

* No CLSI breakpoints; resistance breakpoint used in NARMS is ≥64 µg/mL.
† CLSI updated the ceftriaxone interpretive standards in January, 2010. Previous standards that were used for NARMS Human Isolate reports from 1996-2008 were susceptible ≤8 µg/mL, intermediate 16-32 µg/mL, and resistant ≥64 µg/mL.
‡ Cephalothin was tested from 1996 to 2003 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 used for reporting with few exceptions. Serotype 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 2009 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 2009 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 four 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. State public health laboratories within FoodNet sites receive *Campylobacter* isolates from reference and clinical laboratories within their state. In 2005, FoodNet sites changed from submitting the first isolate received each week to submitting every isolate (Georgia, Maryland, New Mexico, Oregon, and Tennessee), every other isolate (California, Colorado, Connecticut, and New York), or every fifth isolate received (Minnesota). The number of laboratories submitting isolates ranged from two to all. Second, the method of species identification was updated to parallel what is used by the CDC National *Campylobacter* Laboratory. Third, the susceptibility testing method changed from Etest® (AB bioMerieux , Solna, Sweden) to broth microdilution. Fourth, there were changes in the antimicrobial agents tested. Florfenicol replaced chloramphenicol as the phenicol class representative drug, and telithromycin was added to the NARMS panel of agents tested. These methods began in 2005 and continue through the current year's report.

Identification/Speciation and Antimicrobial Susceptibility Testing

From 2005 through 2009, isolates were confirmed as *Campylobacter* by determination of typical morphology and motility using dark-field microscopy and a positive oxidase test reaction. 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) assays with specific targets for *C. jejuni (mapA* or *hipO* gene*)*, *C. coli*-specific *ceuE* gene (Linton *et al.* 1997, Gonzales et al. 1997, Pruckler *et al*. 2006), or other species specific primers. From 2003 to 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 National *Campylobacter* Reference Laboratory. From 1997 to 2002, methodology similar to that used from 2005 to 2009 was used.

The methods for susceptibility testing *Campylobacter* and criteria for interpreting the results have changed during the course of NARMS surveillance. Beginning in 2005, broth microdilution using the Sensititre® system (Trek Diagnostics, Cleveland, OH) was performed according to manufacturer's instructions to determine the MICs for nine antimicrobial agents: azithromycin, ciprofloxacin, clindamycin, erythromycin, florfenicol, gentamicin, nalidixic acid, telithromycin, and tetracycline (Table 4). CLSI recommendations for quality control were followed. From 1997 to 2004, Etest® (AB bioMerieux, Solna, Sweden) was used for susceptibility testing of *Campylobacter* isolates. *Campylobacter*-specific CLSI interpretive criteria were used for erythromycin, ciprofloxacin, and tetracycline beginning with the 2004 NARMS annual report. NARMS breakpoints were used when CLSI breakpoints were not available. Beginning in 2004, NARMS breakpoints were established based on the MIC distributions of NARMS isolates and the presence of known resistance genes or mutations. In pre-2004 annual reports, NARMS breakpoints used were based on those available for other organisms. Establishment of breakpoints based on MIC distributions resulted in higher MIC definitions for azithromycin and erythromycin resistance compared withthose reported in pre-2004 annual reports. The breakpoints listed in Table 4 have been applied to MIC data collected for all years so that resistance prevalence is comparable over time.

Table 4. Antimicrobial agents used for susceptibility testing of *Campylobacter* isolates, NARMS, 1997–2009

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

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

Retesting

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

Data Analysis

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

When describing results for several years, multidrug resistance for *Salmonella, Shigella,* and *E. coli* O157 isolates was limited to the eight CLSI classes (Table 3) tested in all years from 1996 through 2009 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 2009, represented by ciprofloxacin, chloramphenicol/florfenicol, clindamycin, erythromycin, nalidixic acid, and tetracycline.

Logistic regression was used to compare the prevalence of antimicrobial resistance among *Salmonella* and *Campylobacter* isolates tested in 2009 with the reference, which was the average prevalence of resistance in the first five years that NARMS surveillance was nationwide (2003–07). The analysis included the following:

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

To account for site-to-site variation in the prevalence of antimicrobial resistance, we included main effects adjustments for site in the analysis. The final regression models for *Salmonella* adjusted for the submitting site using the nine geographic regions described in the Public Health Laboratory Information System (PHLIS): East North Central, East South Central, Mid-Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central. For *Campylobacter*, the final regression models adjusted for the submitting FoodNet site. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using unconditional maximum likelihood estimation. The adequacy of model fit was assessed in several ways. The significance of the main effect of year was assessed using the likelihood ratio test. The likelihood ratio test was also used to test for significance of interaction between site and year, although the power of the test to detect a single site-specific interaction was low. The Hosmer and Lemeshow goodness-of-fit test was also used. Finally, residual analysis was performed to examine the influence of individual observations. Having assessed that the main effect of year was significant, we reported ORs with 95% CIs (for 2009 compared with reference) that did not include 1.00 as statistically significant.

MIC Distribution Tables and Proportional Figures

An explanation on “how to read a squashtogram” has been provided to assist the reader with the different parts of each table (Figure 11). A squashtogram shows the distribution of MICs for antimicrobial agents tested. 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 12).

Figure 11. How to read a squashtogram

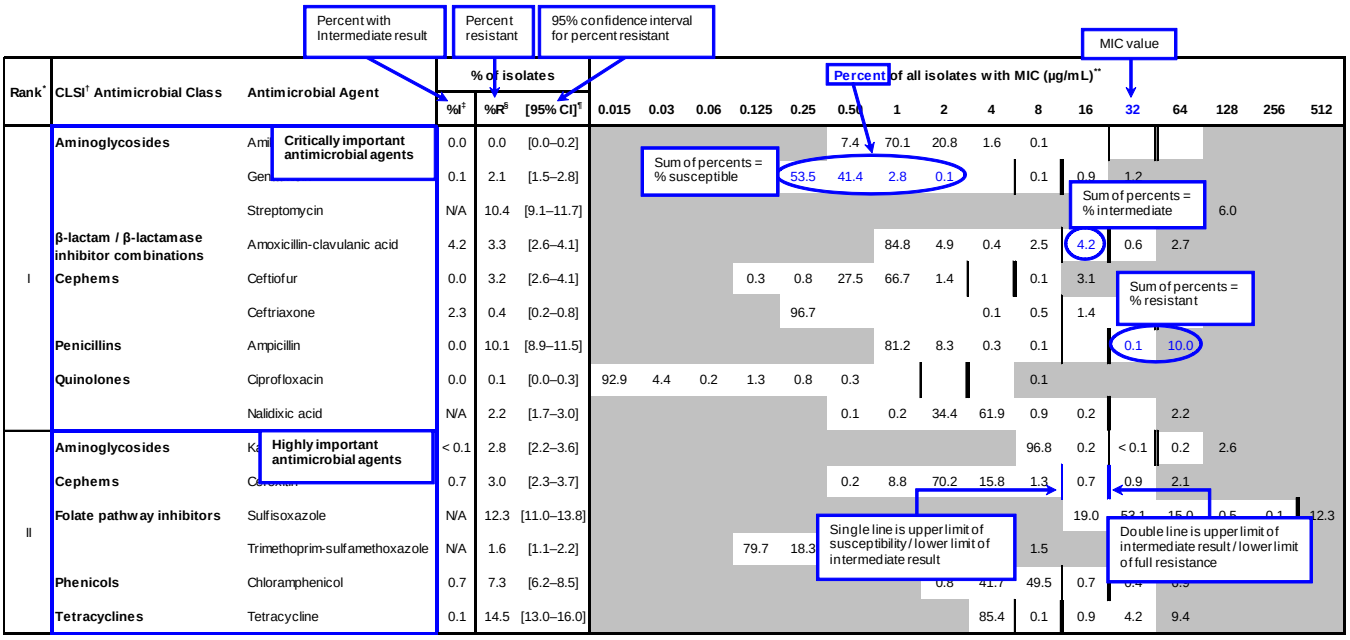


Figure 12. Proportional chart, a categorical graph of a squashtogram

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]						7.8	74.6	15.9	1.6	< 0.1						
		Gentamicin	0.2	1.3	[0.9 - 1.8]					64.2	32.8	1.3	0.1		0.2	0.7	0.6				
		Streptomycin	N/A	8.9	[7.8 - 10.2]												91.1	4.2	4.8		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	3.6	3.4	[2.7 - 4.3]							87.5	2.5	0.4	2.6	3.6	0.8	2.6			
	Cephems	Ceftiofur	< 0.1	3.4	[2.7 - 4.3]				0.1	0.8	21.1	73.2	1.3	< 0.1	0.2	3.2					
		Ceftriaxone	0.0	3.4	[2.7 - 4.3]					96.5	< 0.1			0.2	0.7	1.4	0.6	0.4	0.2		
	Penicillins	Ampicillin	< 0.1	9.9	[8.6 - 11.2]							83.7	5.9	0.3	0.2	< 0.1		9.9			
	Quinolones	Ciprofloxacin	0.1	< 0.1	[0.0 - 0.3]	92.9	4.6	0.2	0.7	1.0	0.4	0.1	0.1		< 0.1						
		Nalidixic acid	N/A	1.8	[1.3 - 2.4]							0.3	39.6	57.0	0.9	0.4	0.1	1.6			
II	**Aminoglycosides**	Kanamycin	< 0.1	2.5	[1.9 - 3.2]										97.3	0.2	< 0.1	< 0.1	2.4		
	Cephems	Cefoxitin	0.3	3.2	[2.5 - 4.1]						0.1	36.1	47.4	11.8	1.0	0.3	1.4	1.9			
	Folate pathway inhibitors	Sulfisoxazole	N/A	9.9	[8.7 - 11.2]											5.0	35.2	47.0	2.8	0.1	9.9
		Trimethoprim-sulfamethoxazole	N/A	1.7	[1.2 - 2.4]				95.8	2.2	0.2	< 0.1			1.7						
	Phenicols	Chloramphenicol	1.0	5.7	[4.8 - 6.8]								0.7	49.0	43.6	1.0	< 0.1	5.6			
	Tetracyclines	Tetracycline	0.2	11.9	[10.6 - 13.3]									87.9	0.2	0.2	2.9	8.8			

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

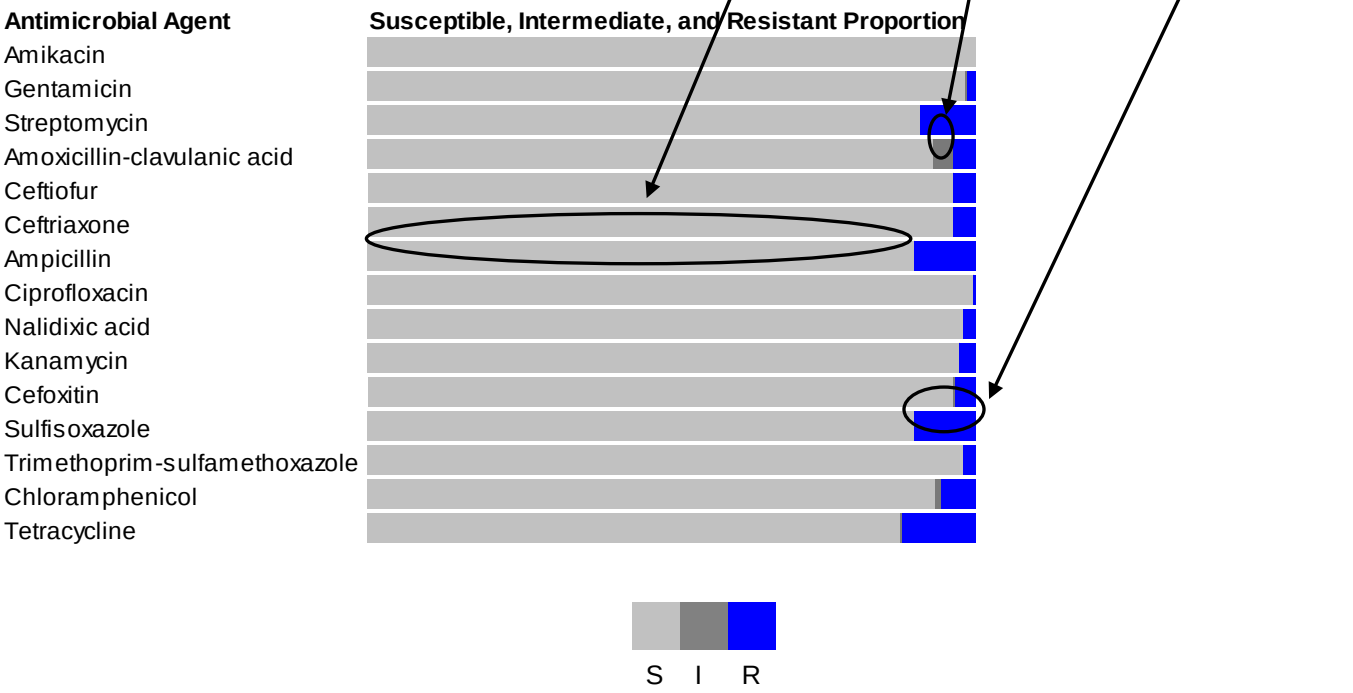
† CLSI: Clinical and Laboratory Standards Institute

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

§ Percent of isolates that were resistant

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

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



Results

1. Non-typhoidal *Salmonella*

Table 5. Minimum inhibitory concentrations (MICs) and resistance of non-typhoidal *Salmonella* isolates to antimicrobial agents, 2009 (N=2192)

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]						7.8	74.6	15.9	1.6	< 0.1						
		Gentamicin	0.2	1.3	[0.9 - 1.8]					64.2	32.8	1.3	0.1		0.2	0.7	0.6				
		Streptomycin	N/A	8.9	[7.8 - 10.2]												91.1	4.2	4.8		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	3.6	3.4	[2.7 - 4.3]							87.5	2.5	0.4	2.6	3.6	0.8	2.6			
	Cephems	Ceftiofur	< 0.1	3.4	[2.7 - 4.3]				0.1	0.8	21.1	73.2	1.3	< 0.1	0.2	3.2					
		Ceftriaxone	0.0	3.4	[2.7 - 4.3]					96.5	< 0.1			0.2	0.7	1.4	0.6	0.4	0.2		
	Penicillins	Ampicillin	< 0.1	9.9	[8.6 - 11.2]							83.7	5.9	0.3	0.2	< 0.1		9.9			
	Quinolones	Ciprofloxacin	0.1	< 0.1	[0.0 - 0.3]	92.9	4.6	0.2	0.7	1.0	0.4	0.1	0.1		< 0.1						
		Nalidixic acid	N/A	1.8	[1.3 - 2.4]							0.3	39.6	57.0	0.9	0.4	0.1	1.6			
II	**Aminoglycosides**	Kanamycin	< 0.1	2.5	[1.9 - 3.2]										97.3	0.2	< 0.1	< 0.1	2.4		
	Cephems	Cefoxitin	0.3	3.2	[2.5 - 4.1]						0.1	36.1	47.4	11.8	1.0	0.3	1.4	1.9			
	Folate pathway inhibitors	Sulfisoxazole	N/A	9.9	[8.7 - 11.2]											5.0	35.2	47.0	2.8	0.1	9.9
		Trimethoprim-sulfamethoxazole	N/A	1.7	[1.2 - 2.4]				95.8	2.2	0.2	< 0.1			1.7						
	Phenicols	Chloramphenicol	1.0	5.7	[4.8 - 6.8]								0.7	49.0	43.6	1.0	< 0.1	5.6			
	Tetracyclines	Tetracycline	0.2	11.9	[10.6 - 13.3]									87.9	0.2	0.2	2.9	8.8			

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

† CLSI: Clinical and Laboratory Standards Institute

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

§ Percent of isolates that were resistant

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

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

Figure 13. Antimicrobial resistance pattern for non-typhoidal *Salmonella*, 2009

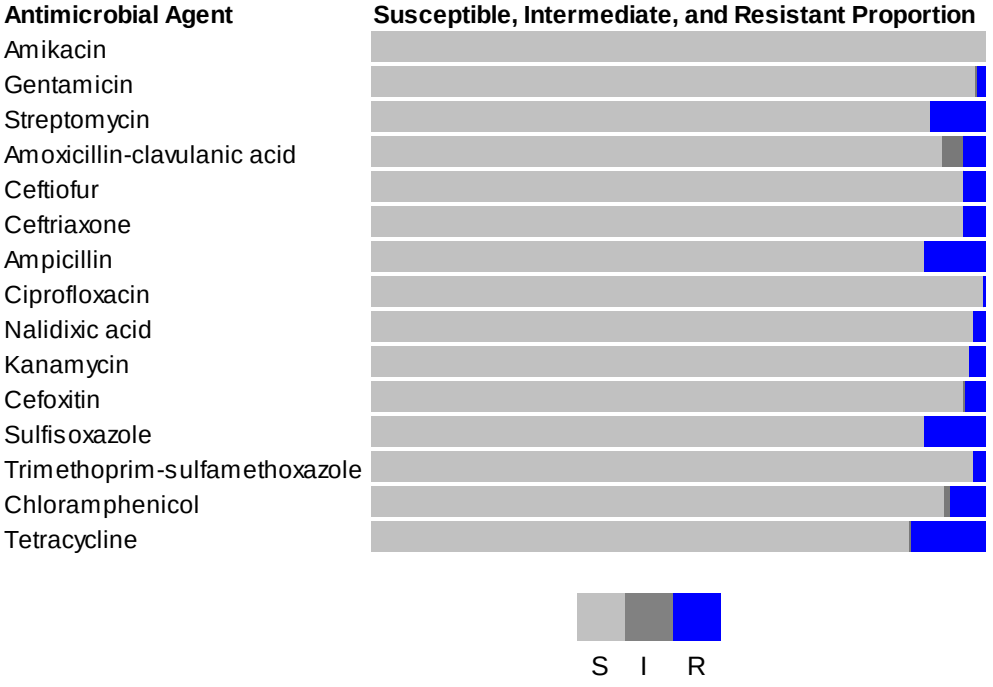


Table 6. Percentage and number of non-typhoidal *Salmonella* isolates resistant to antimicrobial agents, 2000–2009

Year Total Isolates			2000 1372	2001 1410	2002 1998	2003 1855	2004 1782	2005 2034	2006 2173	2007 2144	2008 2380	2009 2192
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% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.7% 37	1.9% 27	1.4% 27	1.4% 26	1.3% 24	2.2% 44	2.0% 44	2.1% 45	1.5% 35	1.3% 28
		Streptomycin (MIC ≥ 64)	16.3% 223	17.1% 241	13.2% 264	15.0% 279	12.0% 213	11.1% 225	10.7% 233	10.4% 222	10.0% 239	8.9% 196
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	3.9% 54	4.7% 66	5.3% 106	4.6% 86	3.7% 66	3.2% 65	3.7% 81	3.3% 70	3.1% 73	3.4% 75
	Cephems	Ceftiofur (MIC ≥ 8)	3.2% 44	4.1% 58	4.4% 87	4.5% 83	3.4% 60	2.9% 60	3.6% 79	3.3% 70	3.0% 72	3.4% 75
		Ceftriaxone (MIC ≥ 64)	3.2% 44	3.7% 52	4.4% 87	4.4% 81	3.3% 59	2.9% 59	3.7% 80	3.3% 70	3.0% 72	3.4% 75
	Penicillins	Ampicillin (MIC ≥ 32)	15.9% 218	17.5% 247	13.0% 259	13.6% 253	12.1% 216	11.4% 232	11.0% 238	10.1% 217	9.7% 231	9.9% 216
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.4% 5	0.2% 3	0.1% 1	0.2% 3	0.2% 4	0.0% 1	0.1% 2	0.1% 2	0.1% 2	0.0% 1
		Nalidixic acid (MIC ≥ 32)	2.3% 32	2.3% 32	1.6% 32	1.9% 36	2.2% 39	1.9% 38	2.4% 52	2.3% 49	2.0% 47	1.8% 39
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	5.6% 77	4.8% 68	3.8% 76	3.5% 64	2.8% 50	3.4% 70	2.9% 63	2.8% 61	2.1% 50	2.5% 54
	Cephems	Cefoxitin (MIC ≥ 32)	3.2% 44	3.4% 48	4.3% 86	4.3% 79	3.4% 61	3.0% 62	3.5% 77	2.9% 63	3.0% 72	3.2% 71
		Cephalothin (MIC ≥ 32)	4.0% 55	4.0% 57	5.1% 101	5.3% 99	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	17.1% 234	17.8% 251	12.9% 258	15.1% 280	13.3% 237	12.6% 256	12.1% 263	12.3% 264	10.1% 241	9.9% 217
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	2.0% 28	2.0% 28	1.4% 28	1.9% 36	1.7% 31	1.7% 34	1.7% 36	1.5% 33	1.6% 37	1.7% 38
	Phenicols	Chloramphenicol (MIC ≥ 32)	10.1% 138	11.6% 164	8.6% 172	10.1% 187	7.6% 136	7.8% 159	6.4% 139	7.3% 156	6.2% 147	5.7% 125
	Tetracyclines	Tetracycline (MIC ≥ 16)	18.7% 256	19.9% 280	14.9% 298	16.3% 303	13.6% 242	13.9% 282	13.5% 293	14.5% 310	11.6% 275	11.9% 261

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

Table 7. Resistance patterns of non-typhoidal *Salmonella* isolates, 2000–2009

Year Total Isolates	2000 1372	2001 1410	2002 1998	2003 1855	2004 1782	2005 2034	2006 2173	2007 2144	2008 2380	2009 2192
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	74.5% 1022	72.5% 1022	79.1% 1580	78.0% 1447	80.0% 1425	80.9% 1646	80.5% 1749	81.1% 1738	84.0% 1999	83.2% 1823
Resistance ≥ 1 CLSI class*	25.5% 350	27.5% 388	20.9% 418	22.0% 408	20.0% 357	19.1% 388	19.5% 424	18.9% 406	16.0% 381	16.8% 369
Resistance ≥ 2 CLSI classes*	20.0% 275	22.1% 311	15.8% 315	17.5% 325	15.0% 267	14.8% 302	14.7% 319	14.2% 305	12.4% 295	13.0% 284
Resistance ≥ 3 CLSI classes*	15.6% 214	16.7% 236	12.3% 245	14.2% 263	11.4% 204	12.0% 244	11.8% 256	11.1% 239	9.4% 224	9.5% 209
Resistance ≥ 4 CLSI classes*	12.7% 174	13.5% 191	9.8% 195	11.4% 211	9.3% 165	9.1% 185	8.1% 177	8.2% 176	7.4% 177	7.3% 159
Resistance ≥ 5 CLSI classes*	9.5% 131	10.3% 145	8.2% 164	9.8% 182	8.0% 142	7.2% 146	6.3% 137	6.9% 149	6.6% 157	6.3% 137
At least ACSSuT†	8.9% 122	10.1% 142	7.8% 156	9.3% 173	7.2% 129	6.9% 141	5.6% 121	6.3% 136	5.8% 138	5.1% 112
At least ACT/S‡	0.9% 13	0.5% 7	1.1% 21	1.2% 23	0.6% 10	0.9% 18	0.7% 15	0.7% 16	0.5% 11	0.7% 15
At least ACSSuTAuCx§	2.6% 35	2.6% 36	3.4% 67	3.2% 60	2.4% 42	2.0% 41	2.0% 43	2.1% 46	1.8% 44	1.4% 30
At least ceftriaxone and nalidixic acid resistant	0.1% 1	0.1% 2	0.2% 4	0.1% 2	0.1% 2	0.1% 2	0.1% 3	0.2% 5	0.0% 0	0.2% 4

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

Table 8. Twenty most common non-typhoidal *Salmonella* serotypes in NARMS, 2009

NARMS		Isolates	
Rank	**Serotype**	**n**	**(%)**
1	Enteritidis	410	(18.7%)
2	Typhimurium	371	(16.9%)
3	Newport	236	(10.8%)
4	Javiana	105	(4.8%)
5	Heidelberg	86	(3.9%)
6	I 4,[5],12:i:-	72	(3.3%)
7	Oranienburg	64	(2.9%)
8	Saintpaul	57	(2.6%)
9	Montevideo	56	(2.6%)
10	Braenderup	46	(2.1%)
11	Infantis	44	(2.0%)
12	Muenchen	42	(1.9%)
13	Mississippi	28	(1.3%)
14	Thompson	27	(1.2%)
15	Agona	21	(1.0%)
16	Bareilly	20	(0.9%)
17	Litchfield	20	(0.9%)
18	Paratyphi B var. L(+) tartrate+	20	(0.9%)
19	Hadar	19	(0.9%)
20	Poona	16	(0.7%)
	Subtotal	**1760**	**(80.3%)**
	All other serotypes	373	(17.0%)
	Unknown serotype	19	(0.9%)
	Partially serotyped	20	(0.9%)
	Rough/Nonmotile isolates	20	(0.9%)
	Subtotal	**432**	**(19.7%)**
	Grand Total	**2192**	**(100.0%)**

A. *Salmonella* ser. Enteritidis

Table 9. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Enteritidis isolates to antimicrobial agents, 2009 (N=410)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.9]						20.0	70.5	7.6	1.7	0.2						
		Gentamicin	0.0	0.0	[0.0 - 0.9]					82.7	15.9	1.0	0.5								
		Streptomycin	N/A	1.2	[0.4 - 2.8]												98.8	0.2	1.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.2	0.0	[0.0 - 0.9]							93.7	2.4		3.7	0.2					
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 0.9]					0.2	7.1	91.7	1.0								
		Ceftriaxone	0.0	0.0	[0.0 - 0.9]					100.0											
	Penicillins	Ampicillin	0.0	3.9	[2.2 - 6.3]							79.5	16.1	0.5				3.9			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 0.9]	82.9	13.4		2.2	1.5											
		Nalidixic acid	N/A	3.7	[2.1 - 6.0]								17.6	78.3	0.5			3.7			
II	**Aminoglycosides**	Kanamycin	0.0	0.2	[0.00 - 1.3]										99.8				0.2		
	Cephems	Cefoxitin	0.0	0.0	[0.0 - 0.9]							27.3	68.8	2.7	1.2						
	Folate pathway inhibitors	Sulfisoxazole	N/A	1.7	[0.7 - 3.5]											2.2	25.1	68.0	2.9		1.7
		Trimethoprim-sulfamethoxazole	N/A	0.7	[0.1 - 2.1]				98.8	0.5					0.7						
	Phenicols	Chloramphenicol	0.2	0.0	[0.0 - 0.9]								0.7	60.5	38.5	0.2					
	Tetracyclines	Tetracycline	0.2	1.2	[0.4 - 2.8]									98.5	0.2			1.2			

* 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

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

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

Figure 14. Antimicrobial resistance pattern for *Salmonella ser.* Enteritidis, 2009

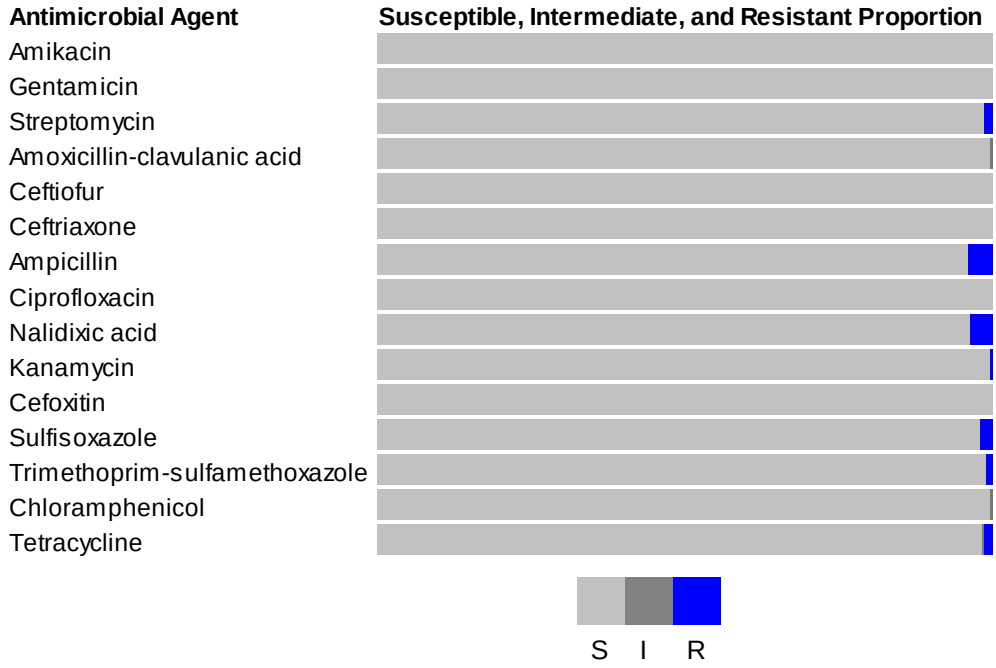


Table 10. Percentage and number of *Salmonella ser.* Enteritidis isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			319	277	337	257	271	384	413	385	439	410
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.3% 1	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.8% 3	0.2% 1	0.0% 0	0.2% 1	0.0% 0
		Streptomycin (MIC ≥ 64)	0.0% 0	1.4% 4	1.5% 5	1.2% 3	2.2% 6	1.0% 4	1.2% 5	0.5% 2	0.5% 2	1.2% 5
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	1.4% 4	0.6% 2	0.0% 0	0.0% 0	0.8% 3	0.5% 2	0.5% 2	0.0% 0	0.0% 0
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	2.2% 6	0.0% 0	0.0% 0	0.0% 0	0.5% 2	0.5% 2	0.3% 1	0.0% 0	0.0% 0
		Ceftriaxone (MIC ≥ 64)	0.0% 0	1.4% 4	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.3% 1	0.0% 0	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	7.5% 24	8.7% 24	6.8% 23	2.3% 6	4.1% 11	2.9% 11	4.4% 18	2.1% 8	3.6% 16	3.9% 16
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	2.2% 7	4.3% 12	3.9% 13	4.7% 12	6.6% 18	4.7% 18	7.0% 29	5.7% 22	6.6% 29	3.7% 15
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.3% 1	0.7% 2	0.3% 1	0.0% 0	0.7% 2	0.3% 1	0.2% 1	0.5% 2	0.0% 0	0.2% 1
	Cephems	Cefoxitin (MIC ≥ 32)	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.0% 0	1.0% 4	0.5% 2	0.3% 1	0.0% 0	0.0% 0
		Cephalothin (MIC ≥ 32)	0.9% 3	1.1% 3	0.6% 2	1.2% 3	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	0.9% 3	2.2% 6	1.5% 5	1.2% 3	1.8% 5	1.6% 6	1.5% 6	1.6% 6	1.1% 5	1.7% 7
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.0% 0	0.7% 2	0.6% 2	0.8% 2	0.0% 0	0.5% 2	0.5% 2	1.0% 4	0.9% 4	0.7% 3
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.5% 2	0.0% 0	0.5% 2	0.5% 2	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	1.9% 6	1.8% 5	4.2% 14	1.6% 4	3.3% 9	2.3% 9	1.7% 7	3.9% 15	1.6% 7	1.2% 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
† CLSI: Clinical and Laboratory Standards Institute
‡ Sulfamethoxazole, which was tested during 1996-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 11. Resistance patterns of *Salmonella* ser. Enteritidis isolates, 2000–2009

Year Total Isolates	2000 319	2001 277	2002 337	2003 257	2004 271	2005 384	2006 413	2007 385	2008 439	2009 410
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	89.0% 284	86.6% 240	87.5% 295	91.8% 236	87.1% 236	91.4% 351	88.6% 366	90.4% 348	87.9% 386	92.0% 377
Resistance ≥ 1 CLSI class*	11.0% 35	13.4% 37	12.5% 42	8.2% 21	12.9% 35	8.6% 33	11.4% 47	9.6% 37	12.1% 53	8.0% 33
Resistance ≥ 2 CLSI classes*	1.9% 6	4.7% 13	3.9% 13	2.3% 6	3.0% 8	3.6% 14	2.9% 12	3.4% 13	1.6% 7	2.4% 10
Resistance ≥ 3 CLSI classes*	0.3% 1	2.9% 8	2.1% 7	0.4% 1	1.1% 3	1.6% 6	1.7% 7	1.0% 4	0.2% 1	1.0% 4
Resistance ≥ 4 CLSI classes*	0.0% 0	1.1% 3	0.6% 2	0.4% 1	0.7% 2	1.0% 4	0.7% 3	0.3% 1	0.0% 0	0.5% 2
Resistance ≥ 5 CLSI classes*	0.0% 0	0.4% 1	0.0% 0	0.4% 1	0.7% 2	0.5% 2	0.2% 1	0.3% 1	0.0% 0	0.2% 1
At least ACSSuT†	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.4% 1	0.5% 2	0.0% 0	0.3% 1	0.0% 0	0.0% 0
At least ACT/S‡	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCx§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.0% 0	0.0% 0
At least ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.0% 0	0.0% 0

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

B. *Salmonella* ser. Typhimurium

Table 12. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhimurium isolates to antimicrobial agents, 2009 (N=371)

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]						4.9	73.6	20.5	1.1							
		Gentamicin	0.3	1.9	[0.8 - 3.8]					51.2	44.5	2.2			0.3	1.1	0.8				
		Streptomycin	N/A	25.9	[21.5 - 30.6]												74.1	14.6	11.3		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	15.6	6.2	[4.0 - 9.2]							69.5	2.2	0.3	6.2	15.6	0.8	5.4			
	Cephems	Ceftiofur	0.3	6.5	[4.2 - 9.5]					1.6	12.9	77.1	1.6	0.3	1.1	5.4					
		Ceftriaxone	0.0	6.5	[4.2 - 9.5]					93.5				1.1	1.3	2.7	0.8	0.3	0.3		
	Penicillins	Ampicillin	0.0	28.0	[23.5 - 32.9]							67.9	3.5	0.5				28.0			
	Quinolones	Ciprofloxacin	0.5	0.0	[0.0 - 1.0]	94.3	3.0	0.3		1.1	0.5	0.3	0.5								
		Nalidixic acid	N/A	2.2	[0.9 - 4.2]								46.6	49.6	1.3	0.3	0.5	1.6			
II	**Aminoglycosides**	Kanamycin	0.0	4.9	[2.9 - 7.6]										94.9	0.3			4.9		
	Cephems	Cefoxitin	0.8	5.4	[3.3 - 8.2]						0.5	33.2	53.4	5.9	0.8	0.8	2.7	2.7			
	Folate pathway inhibitors	Sulfisoxazole	N/A	29.9	[25.3 - 34.9]											2.2	48.2	19.4	0.3		29.9
		Trimethoprim-sulfamethoxazole	N/A	3.0	[1.5 - 5.2]				91.1	5.7	0.3				3.0						
	Phenicols	Chloramphenicol	0.8	20.5	[16.5 - 25.0]								0.3	41.0	37.5	0.8		20.5			
	Tetracyclines	Tetracycline	0.0	28.8	[24.3 - 33.7]									71.2		0.8	13.2	14.8			

* 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 15. Antimicrobial resistance pattern for *Salmonella* ser. Typhimurium, 2009

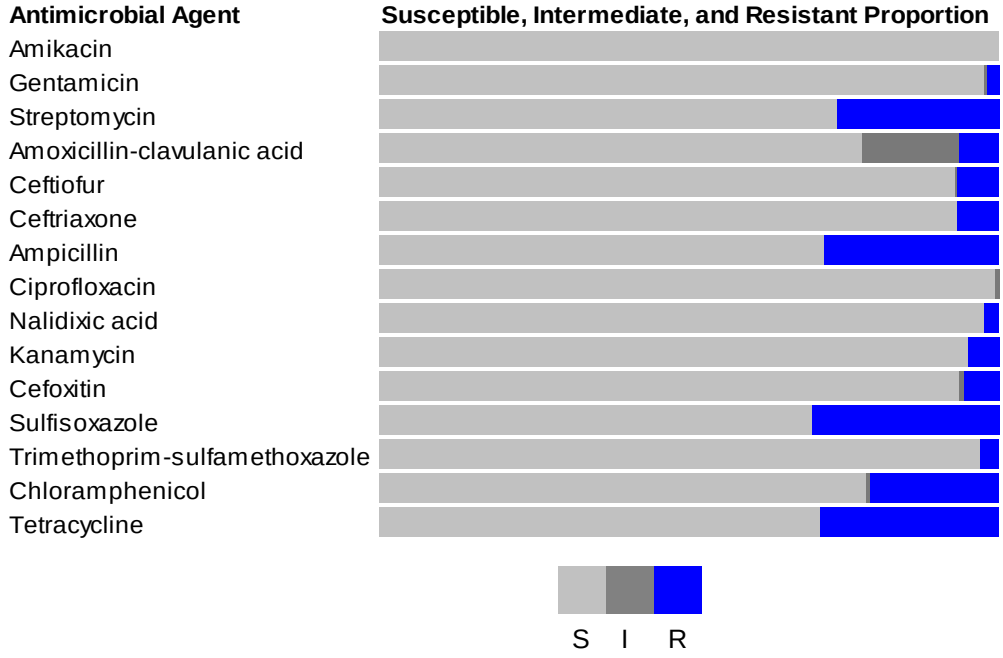


Table 13. Percentage and number of *Salmonella* ser. Typhimurium isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			304	325	394	408	383	438	409	404	397	371
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.6% 8	1.5% 5	2.3% 9	2.0% 8	2.1% 8	1.8% 8	2.7% 11	2.5% 10	1.5% 6	1.9% 7
		Streptomycin (MIC ≥ 64)	39.5% 120	40.0% 130	32.0% 126	35.5% 145	31.9% 122	28.1% 123	29.3% 120	32.4% 131	28.5% 113	25.9% 96
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	6.3% 19	6.2% 20	7.6% 30	5.6% 23	4.7% 18	3.2% 14	4.4% 18	6.7% 27	3.3% 13	6.2% 23
	Cephems	Ceftiofur (MIC ≥ 8)	3.6% 11	3.1% 10	4.3% 17	4.9% 20	4.4% 17	2.5% 11	4.2% 17	6.4% 26	3.3% 13	6.5% 24
		Ceftriaxone (MIC ≥ 64)	3.3% 10	3.1% 10	4.3% 17	4.9% 20	4.4% 17	2.5% 11	4.2% 17	6.4% 26	3.3% 13	6.5% 24
	Penicillins	Ampicillin (MIC ≥ 32)	42.1% 128	42.5% 138	33.8% 133	36.3% 148	32.1% 123	29.0% 127	28.1% 115	31.7% 128	26.2% 104	28.0% 104
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	1.3% 4	0.6% 2	1.3% 5	1.2% 5	0.5% 2	0.9% 4	0.7% 3	1.5% 6	1.3% 5	2.2% 8
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	13.2% 40	8.3% 27	7.6% 30	7.1% 29	5.7% 22	5.7% 25	5.1% 21	5.9% 24	2.3% 9	4.9% 18
	Cephems	Cefoxitin (MIC ≥ 32)	3.6% 11	3.1% 10	4.3% 17	4.4% 18	4.7% 18	2.5% 11	3.9% 16	5.7% 23	3.3% 13	5.4% 20
		Cephalothin (MIC ≥ 32)	4.3% 13	3.1% 10	5.6% 22	6.1% 25	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	45.4% 138	43.1% 140	32.2% 127	38.7% 158	36.0% 138	32.0% 140	33.3% 136	37.4% 151	30.2% 120	29.9% 111
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	3.6% 11	2.5% 8	2.3% 9	3.4% 14	2.6% 10	2.7% 12	2.2% 9	2.5% 10	1.8% 7	3.0% 11
	Phenicols	Chloramphenicol (MIC ≥ 32)	30.9% 94	31.7% 103	23.4% 92	28.2% 115	24.3% 93	24.4% 107	22.0% 90	25.5% 103	23.2% 92	20.5% 76
	Tetracyclines	Tetracycline (MIC ≥ 16)	43.4% 132	43.4% 141	32.0% 126	38.2% 156	30.3% 116	30.4% 133	31.5% 129	36.9% 149	27.5% 109	28.8% 107

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

Table 14. Resistance patterns of *Salmonella* ser. Typhimurium isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	304	325	394	408	383	438	409	404	397	371
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	49.3% 150	49.2% 160	59.9% 236	54.7% 223	60.6% 232	65.1% 285	62.6% 256	57.4% 232	68.0% 270	63.6% 236
Resistance ≥ 1 CLSI class*	50.7% 154	50.8% 165	40.1% 158	45.3% 185	39.4% 151	34.9% 153	37.4% 153	42.6% 172	32.0% 127	36.4% 135
Resistance ≥ 2 CLSI classes*	46.4% 141	47.4% 154	36.3% 143	41.4% 169	37.1% 142	33.3% 146	34.0% 139	39.4% 159	31.2% 124	33.2% 123
Resistance ≥ 3 CLSI classes*	43.4% 132	41.5% 135	32.5% 128	37.3% 152	31.6% 121	30.1% 132	30.3% 124	34.4% 139	27.7% 110	28.0% 104
Resistance ≥ 4 CLSI classes*	39.8% 121	37.8% 123	28.4% 112	32.4% 132	27.7% 106	27.4% 120	26.9% 110	30.0% 121	24.7% 98	24.0% 89
Resistance ≥ 5 CLSI classes*	29.6% 90	29.5% 96	23.1% 91	27.7% 113	24.3% 93	22.8% 100	20.8% 85	25.0% 101	23.7% 94	22.1% 82
At least ACSSuT†	28.0% 85	29.5% 96	21.6% 85	26.5% 108	23.5% 90	22.4% 98	19.6% 80	22.8% 92	22.9% 91	19.4% 72
At least ACT/S‡	1.6% 5	0.9% 3	2.0% 8	3.2% 13	1.6% 6	2.1% 9	0.7% 3	2.0% 8	0.5% 2	2.2% 8
At least ACSSuTAuCx§	1.6% 5	1.2% 4	1.8% 7	2.2% 9	2.6% 10	1.8% 8	2.9% 12	3.7% 15	2.0% 8	1.6% 6
At least ceftriaxone and nalidixic acid resistant	0.3% 1	0.3% 1	0.5% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.5% 2

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

C. *Salmonella* ser. Newport

Table 15. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Newport isolates to antimicrobial agents, 2009 (N=236)

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 - 1.6]						3.0	83.5	12.3	0.8	0.4						
		Gentamicin	0.0	0.4	[0.01 - 2.3]					68.6	30.1	0.8				0.4					
		Streptomycin	N/A	7.6	[4.6 - 11.8]												92.4		7.6		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	6.8	[3.9 - 10.8]							89.8	2.5		0.8		2.5	4.2			
	Cephems	Ceftiofur	0.0	6.4	[3.6 - 10.3]					0.4	16.1	76.7	0.4			6.4					
		Ceftriaxone	0.0	6.4	[3.6 - 10.3]					93.6					1.3	1.3	1.7	1.7	0.4		
	Penicillins	Ampicillin	0.0	7.6	[4.6 - 11.8]							88.1	4.2					7.6			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 1.6]	98.7	0.8	0.4													
		Nalidixic acid	N/A	0.0	[0.0 - 1.6]								34.3	65.3	0.4						
II	Aminoglycosides	Kanamycin	0.0	1.3	[0.3 - 3.7]										98.7				1.3		
	Cephems	Cefoxitin	0.4	5.9	[3.3 - 9.8]							40.7	48.3	3.0	1.7	0.4	0.8	5.1			
	Folate pathway inhibitors	Sulfisoxazole	N/A	8.1	[4.9 - 12.3]											0.8	17.8	71.2	2.1		8.1
		Trimethoprim-sulfamethoxazole	N/A	0.4	[0.01 - 2.3]				97.0	2.5					0.4						
	Phenicols	Chloramphenicol	0.4	6.8	[3.9 - 10.8]								0.8	71.2	20.8	0.4		6.8			
	Tetracyclines	Tetracycline	0.4	8.1	[4.9 - 12.3]									91.5	0.4		0.4	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
† 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 16. Antimicrobial resistance pattern for *Salmonella* ser. Newport, 2009

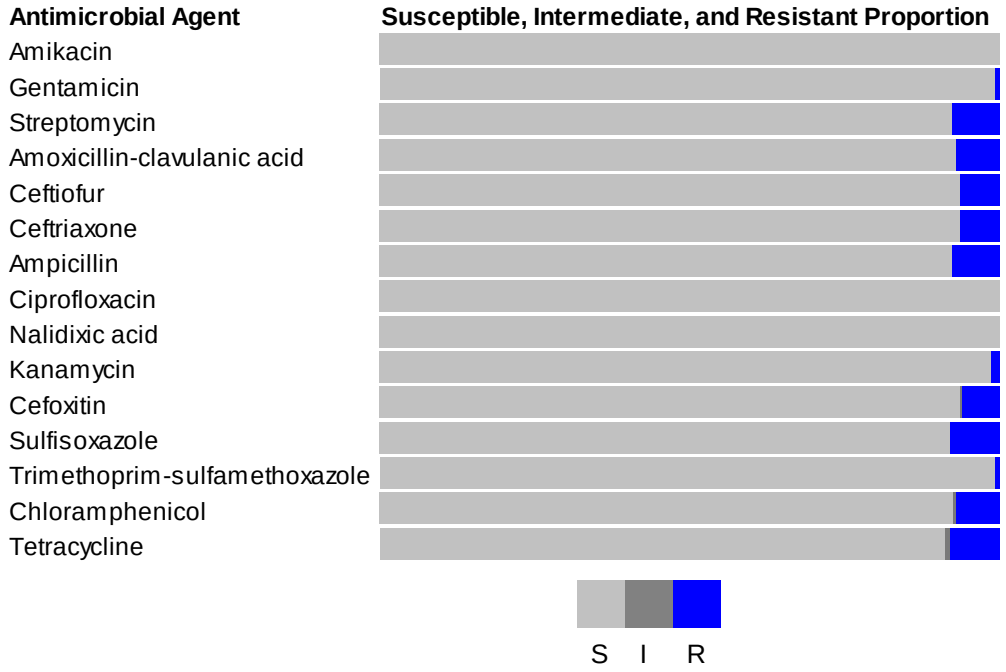


Table 16. Percentage and number of *Salmonella* ser. Newport isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			121	124	241	223	191	207	217	221	253	236
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	2.5% 3	3.2% 4	3.3% 8	3.1% 7	0.5% 1	1.0% 2	0.9% 2	0.9% 2	0.4% 1	0.4% 1
		Streptomycin (MIC ≥ 64)	24.0% 29	31.5% 39	25.3% 61	24.2% 54	15.7% 30	14.0% 29	13.8% 30	10.4% 23	14.2% 36	7.6% 18
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	22.3% 27	26.6% 33	22.8% 55	21.5% 48	15.2% 29	12.6% 26	12.4% 27	8.1% 18	13.0% 33	6.8% 16
	Cephems	Ceftiofur (MIC ≥ 8)	22.3% 27	27.4% 34	22.8% 55	22.0% 49	15.2% 29	12.6% 26	12.4% 27	8.1% 18	13.0% 33	6.4% 15
		Ceftriaxone (MIC ≥ 64)	22.3% 27	25.8% 32	22.8% 55	21.5% 48	14.7% 28	12.6% 26	12.9% 28	8.1% 18	13.0% 33	6.4% 15
	Penicillins	Ampicillin (MIC ≥ 32)	23.1% 28	29.8% 37	24.9% 60	22.9% 51	15.7% 30	14.0% 29	15.2% 33	10.0% 22	15.0% 38	7.6% 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)	0.8% 1	0.0% 0	0.8% 2	0.4% 1	0.5% 1	0.0% 0	0.5% 1	0.0% 0	0.4% 1	0.0% 0
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	5.0% 6	7.3% 9	10.0% 24	4.5% 10	2.6% 5	1.9% 4	2.3% 5	0.9% 2	3.6% 9	1.3% 3
	Cephems	Cefoxitin (MIC ≥ 32)	22.3% 27	25.8% 32	22.4% 54	21.5% 48	15.2% 29	12.6% 26	12.9% 28	8.1% 18	13.0% 33	5.9% 14
		Cephalothin (MIC ≥ 32)	22.3% 27	26.6% 33	22.8% 55	22.4% 50	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	23.1% 28	32.3% 40	25.7% 62	24.7% 55	16.8% 32	15.5% 32	15.2% 33	10.4% 23	13.8% 35	8.1% 19
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	4.1% 5	1.6% 2	4.1% 10	0.9% 2	2.1% 4	1.9% 4	3.2% 7	1.8% 4	3.2% 8	0.4% 1
	Phenicols	Chloramphenicol (MIC ≥ 32)	23.1% 28	28.2% 35	25.3% 61	22.4% 50	15.2% 29	13.5% 28	12.4% 27	9.5% 21	12.6% 32	6.8% 16
	Tetracyclines	Tetracycline (MIC ≥ 16)	23.1% 28	30.6% 38	25.7% 62	24.2% 54	16.8% 32	14.5% 30	14.3% 31	10.0% 22	14.6% 37	8.1% 19

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

Table 17. Resistance patterns of *Salmonella* ser. Newport isolates, 2000–2009

Year Total Isolates	2000 121	2001 124	2002 241	2003 223	2004 191	2005 207	2006 217	2007 221	2008 253	2009 236
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	75.2% 91	65.3% 81	72.2% 174	73.5% 164	82.2% 157	84.1% 174	82.9% 180	89.1% 197	85.0% 215	89.8% 212
Resistance ≥ 1 CLSI class*	24.8% 30	34.7% 43	27.8% 67	26.5% 59	17.8% 34	15.9% 33	17.1% 37	10.9% 24	15.0% 38	10.2% 24
Resistance ≥ 2 CLSI classes*	23.1% 28	32.3% 40	25.3% 61	25.1% 56	17.3% 33	15.0% 31	16.6% 36	10.9% 24	13.8% 35	8.5% 20
Resistance ≥ 3 CLSI classes*	23.1% 28	31.5% 39	25.3% 61	23.3% 52	16.2% 31	14.5% 30	15.2% 33	10.9% 24	13.8% 35	7.6% 18
Resistance ≥ 4 CLSI classes*	23.1% 28	31.5% 39	25.3% 61	22.9% 51	15.7% 30	14.0% 29	13.4% 29	9.5% 21	13.8% 35	6.8% 16
Resistance ≥ 5 CLSI classes*	23.1% 28	26.6% 33	23.7% 57	22.4% 50	14.7% 28	12.6% 26	12.9% 28	8.6% 19	13.0% 33	6.4% 15
At least ACSSuT†	23.1% 28	25.8% 32	23.7% 57	22.0% 49	14.7% 28	12.6% 26	12.0% 26	8.6% 19	11.9% 30	6.4% 15
At least ACT/S‡	4.1% 5	0.8% 1	3.7% 9	0.9% 2	1.0% 2	1.9% 4	2.3% 5	0.5% 1	2.8% 7	0.4% 1
At least ACSSuTAuCx§	22.3% 27	25.0% 31	22.8% 55	21.1% 47	14.7% 28	12.6% 26	10.6% 23	8.1% 18	11.9% 30	6.4% 15
At least ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0

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

D. *Salmonella* ser. Heidelberg

Table 18. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Heidelberg isolates to antimicrobial agents, 2009 (N=86)

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 - 4.2]						11.6	79.1	9.3								
		Gentamicin	2.3	2.3	[0.3 - 8.1]					74.4	20.9				2.3	1.2	1.2				
		Streptomycin	N/A	23.3	[14.8 - 33.6]												76.7	9.3	14.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	2.3	20.9	[12.9 - 31.0]							72.1			4.7	2.3	4.7	16.3			
	Cephems	Ceftiofur	0.0	20.9	[12.9 - 31.0]					2.3	24.4	51.2	1.2			20.9					
		Ceftriaxone	0.0	20.9	[12.9 - 31.0]					79.1					5.8	12.8	2.3				
	Penicillins	Ampicillin	0.0	27.9	[18.8 - 38.6]							70.9	1.2					27.9			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 4.2]	100.0															
		Nalidixic acid	N/A	0.0	[0.0 - 4.2]							2.3	22.1	75.6							
II	Aminoglycosides	Kanamycin	0.0	20.9	[12.9 - 31.0]										79.1				20.9		
	Cephems	Cefoxitin	1.2	19.8	[12.0 - 29.8]							62.8	12.8	3.5		1.2	14.0	5.8			
	Folate pathway inhibitors	Sulfisoxazole	N/A	7.0	[2.6 - 14.6]											16.3	52.3	24.4			7.0
		Trimethoprim-sulfamethoxazole	N/A	3.5	[0.7 - 9.9]				96.5						3.5						
	Phenicols	Chloramphenicol	0.0	4.7	[1.3 - 11.5]								1.2	27.9	66.3			4.7			
	Tetracyclines	Tetracycline	0.0	27.9	[18.8 - 38.6]									72.1				27.9			

* 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 17. Antimicrobial resistance pattern for *Salmonella* ser. Heidelberg, 2009

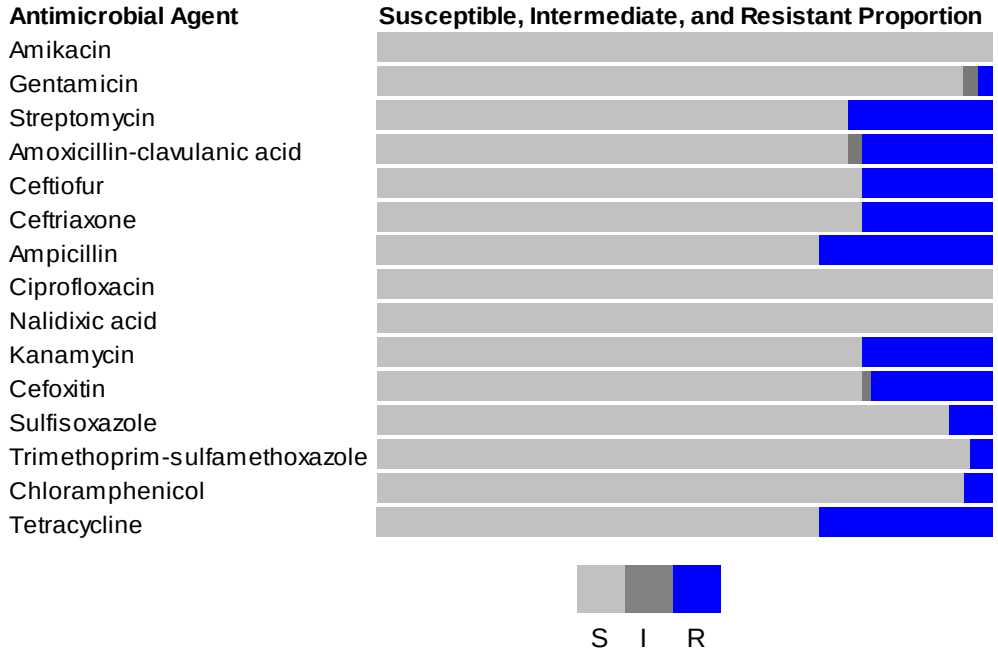


Table 19. Percentage and number of *Salmonella* ser. Heidelberg isolates resistant to antimicrobial agents, 2000–2009

Year / Total Isolates			2000 79	2001 102	2002 105	2003 96	2004 92	2005 125	2006 102	2007 98	2008 75	2009 86
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)	8.9% 7	7.8% 8	3.8% 4	5.2% 5	4.3% 4	6.4% 8	4.9% 5	16.3% 16	14.7% 11	2.3% 2
		Streptomycin (MIC ≥ 64)	22.8% 18	25.5% 26	17.1% 18	12.5% 12	15.2% 14	13.6% 17	11.8% 12	12.2% 12	30.7% 23	23.3% 20
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	3.8% 3	2.9% 3	9.5% 10	5.2% 5	9.8% 9	8.8% 11	9.8% 10	7.1% 7	8.0% 6	20.9% 18
	Cephems	Ceftiofur (MIC ≥ 8)	3.8% 3	2.9% 3	7.6% 8	5.2% 5	8.7% 8	8.8% 11	9.8% 10	7.1% 7	8.0% 6	20.9% 18
		Ceftriaxone (MIC ≥ 64)	3.8% 3	2.9% 3	7.6% 8	5.2% 5	8.7% 8	8.8% 11	9.8% 10	7.1% 7	8.0% 6	20.9% 18
	Penicillins	Ampicillin (MIC ≥ 32)	10.1% 8	9.8% 10	12.4% 13	10.4% 10	25.0% 23	20.0% 25	18.6% 19	18.4% 18	28.0% 21	27.9% 24
	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)	1.3% 1	0.0% 0	0.0% 0	1.0% 1	0.0% 0	0.8% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	15.2% 12	19.6% 20	10.5% 11	8.3% 8	8.7% 8	12.8% 16	8.8% 9	11.2% 11	26.7% 20	20.9% 18
	Cephems	Cefoxitin (MIC ≥ 32)	2.5% 2	2.9% 3	8.6% 9	5.2% 5	7.6% 7	8.8% 11	8.8% 9	7.1% 7	8.0% 6	19.8% 17
		Cephalothin (MIC ≥ 32)	5.1% 4	3.9% 4	10.5% 11	7.3% 7	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	11.4% 9	8.8% 9	6.7% 7	7.3% 7	7.6% 7	8.0% 10	4.9% 5	18.4% 18	12.0% 9	7.0% 6
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	1.3% 1	2.0% 2	1.0% 1	2.1% 2	0.0% 0	0.8% 1	0.0% 0	0.0% 0	2.7% 2	3.5% 3
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.3% 1	1.0% 1	1.0% 1	0.0% 0	1.1% 1	0.8% 1	0.0% 0	3.1% 3	1.3% 1	4.7% 4
	Tetracyclines	Tetracycline (MIC ≥ 16)	21.5% 17	24.5% 25	19.0% 20	16.7% 16	19.6% 18	18.4% 23	13.7% 14	22.4% 22	36.0% 27	27.9% 24

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

Table 20. Resistance patterns of *Salmonella* ser. Heidelberg isolates, 2000–2009

Year Total Isolates	2000 79	2001 102	2002 105	2003 96	2004 92	2005 125	2006 102	2007 98	2008 75	2009 86
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	63.3% 50	64.7% 66	67.6% 71	68.8% 66	56.5% 52	62.4% 78	67.6% 69	58.2% 57	57.3% 43	60.5% 52
Resistance ≥ 1 CLSI class*	36.7% 29	35.3% 36	32.4% 34	31.3% 30	43.5% 40	37.6% 47	32.4% 33	41.8% 41	42.7% 32	39.5% 34
Resistance ≥ 2 CLSI classes*	26.6% 21	28.4% 29	25.7% 27	17.7% 17	22.8% 21	24.8% 31	23.5% 24	28.6% 28	40.0% 30	34.9% 30
Resistance ≥ 3 CLSI classes*	7.6% 6	7.8% 8	12.4% 13	10.4% 10	13.0% 12	15.2% 19	12.7% 13	17.3% 17	28.0% 21	25.6% 22
Resistance ≥ 4 CLSI classes*	3.8% 3	2.0% 2	1.9% 2	0.0% 0	4.3% 4	4.8% 6	2.0% 2	5.1% 5	13.3% 10	17.4% 15
Resistance ≥ 5 CLSI classes*	2.5% 2	1.0% 1	1.9% 2	0.0% 0	3.3% 3	1.6% 2	2.0% 2	4.1% 4	6.7% 5	15.1% 13
At least ACSSuT†	1.3% 1	1.0% 1	1.0% 1	0.0% 0	1.1% 1	0.0% 0	0.0% 0	3.1% 3	1.3% 1	3.5% 3
At least ACT/S‡	0.0% 0	0.0% 0	1.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	3.5% 3
At least ACSSuTAuCx§	1.3% 1	1.0% 1	1.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.2% 1
At least ceftriaxone 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
§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

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

Table 21. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. I 4,[5],12:i:- isolates to antimicrobial agents, 2009 (N=72)

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 - 5.0]							87.5	11.1	1.4							
		Gentamicin	0.0	2.8	[0.3 - 9.7]					52.8	44.4					1.4	1.4				
		Streptomycin	N/A	12.5	[5.9 - 22.4]												87.5	8.3	4.2		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	4.2	4.2	[0.8 - 11.7]							88.9			2.8	4.2	1.4	2.8			
	Cephems	Ceftiofur	0.0	2.8	[0.3 - 9.7]						20.8	76.4				2.8					
		Ceftriaxone	0.0	2.8	[0.3 - 9.7]					97.2						2.8					
	Penicillins	Ampicillin	0.0	11.1	[4.9 - 20.7]							86.1	2.8					11.1			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 5.0]	100.0															
		Nalidixic acid	N/A	0.0	[0.0 - 5.0]								68.1	31.9							
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 5.0]										100.0						
	Cephems	Cefoxitin	0.0	2.8	[0.3 - 9.7]							50.0	40.3	5.6	1.4		1.4	1.4			
	Folate pathway inhibitors	Sulfisoxazole	N/A	13.9	[6.9 - 24.1]											1.4	52.8	31.9			13.9
		Trimethoprim-sulfamethoxazole	N/A	1.4	[0.02 - 7.5]				95.8	2.8					1.4						
	Phenicols	Chloramphenicol	0.0	8.3	[3.1 - 17.3]									62.5	29.2			8.3			
	Tetracyclines	Tetracycline	0.0	16.7	[8.9 - 27.3]									83.3		1.4	2.8	12.5			

* 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
† 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 18. Antimicrobial resistance pattern for *Salmonella* ser. I 4,[5],12:i:-, 2009

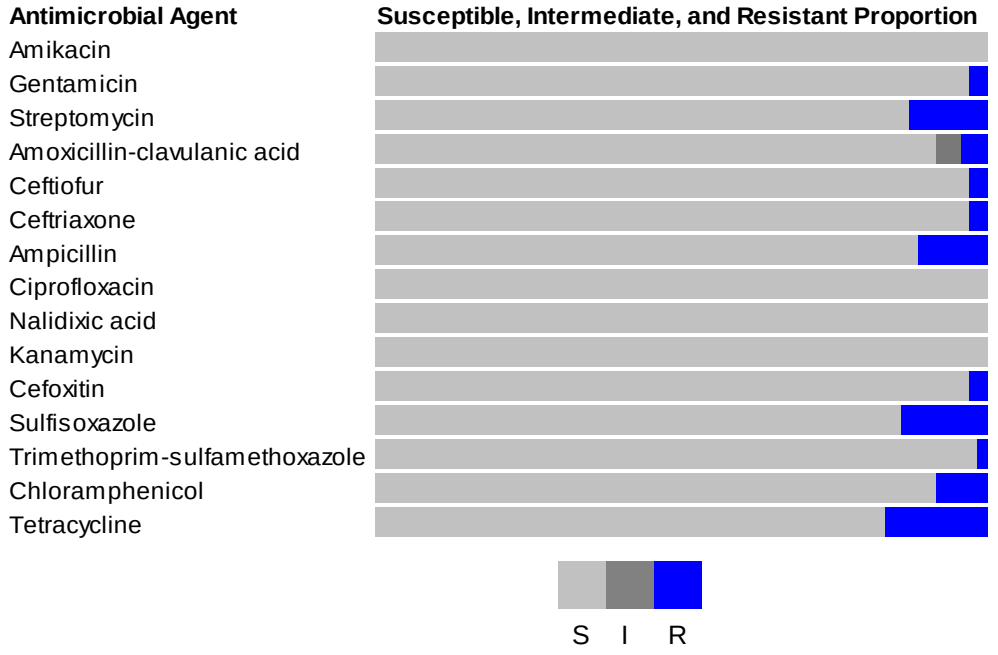


Table 22. Percentage and number of *Salmonella* ser. I 4,[5],12:i:- isolates resistant to antimicrobial agents, 2000–2009

Year / Total Isolates			2000 13	2001 14	2002 35	2003 37	2004 36	2005 33	2006 105	2007 73	2008 83	2009 72
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	7.1% 1	0.0% 0	5.4% 2	5.6% 2	0.0% 0	4.8% 5	1.4% 1	3.6% 3	2.8% 2
		Streptomycin (MIC ≥ 64)	7.7% 1	14.3% 2	2.9% 1	8.1% 3	5.6% 2	3.0% 1	3.8% 4	8.2% 6	10.8% 9	12.5% 9
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	1.4% 1	3.6% 3	4.2% 3
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	7.1% 1	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	2.7% 2	3.6% 3	2.8% 2
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	2.7% 2	3.6% 3	2.8% 2
	Penicillins	Ampicillin (MIC ≥ 32)	7.7% 1	7.1% 1	8.6% 3	8.1% 3	5.6% 2	6.1% 2	6.7% 7	5.5% 4	8.4% 7	11.1% 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)	0.0% 0	0.0% 0	0.0% 0	2.7% 1	2.8% 1	0.0% 0	1.0% 1	1.4% 1	1.2% 1	0.0% 0
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	7.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.4% 1	1.2% 1	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	Not Tested	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1	3.8% 4	1.4% 1	3.6% 3	2.8% 2
		Cephalothin (MIC ≥ 32)	0.0% 0	7.1% 1	2.9% 1	5.4% 2	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	0.0% 0	14.3% 2	2.9% 1	5.4% 2	11.1% 4	0.0% 0	8.6% 9	4.1% 3	13.3% 11	13.9% 10
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	0.0% 0	1.4% 1	4.8% 4	1.4% 1
	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	1.9% 2	1.4% 1	6.0% 5	8.3% 6
	Tetracyclines	Tetracycline (MIC ≥ 16)	7.7% 1	7.1% 1	5.7% 2	0.0% 0	11.1% 4	3.0% 1	8.6% 9	9.6% 7	16.9% 14	16.7% 12

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

Table 23. Resistance patterns of *Salmonella* ser. I 4,[5],12:i:- isolates, 2000–2009

Year Total Isolates	2000 13	2001 14	2002 35	2003 37	2004 36	2005 33	2006 105	2007 73	2008 83	2009 72
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	92.3% 12	78.6% 11	91.4% 32	78.4% 29	80.6% 29	87.9% 29	85.7% 90	82.2% 60	77.1% 64	76.4% 55
Resistance ≥ 1 CLSI class*	7.7% 1	21.4% 3	8.6% 3	21.6% 8	19.4% 7	12.1% 4	14.3% 15	17.8% 13	22.9% 19	23.6% 17
Resistance ≥ 2 CLSI classes*	7.7% 1	14.3% 2	8.6% 3	10.8% 4	13.9% 5	3.0% 1	11.4% 12	6.8% 5	16.9% 14	16.7% 12
Resistance ≥ 3 CLSI classes*	7.7% 1	7.1% 1	5.7% 2	5.4% 2	8.3% 3	3.0% 1	9.5% 10	5.5% 4	9.6% 8	12.5% 9
Resistance ≥ 4 CLSI classes*	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	3.8% 4	2.7% 2	7.2% 6	9.7% 7
Resistance ≥ 5 CLSI classes*	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	2.9% 3	1.4% 1	4.8% 4	6.9% 5
At least ACSSuT†	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0	1.9% 2	1.4% 1	3.6% 3	6.9% 5
At least ACT/S‡	0.0% 0	7.1% 1	2.9% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCx§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.4% 2	0.0% 0
At least ceftriaxone 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
§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

F. Specific Drug Resistance Phenotypes

Table 24. Number and percentage of isolates with resistance to at least ACSSuT, ACSSuTAuCx, nalidixic acid, and ceftriaxone among the 20 most common non-typhoidal *Salmonella* serotypes isolated in NARMS, 2009

Rank	Serotype	N	ACSSuT*		ACSSuTAuCx†		Nalidixic Acid		Ceftriaxone	
			n	(%)	n	(%)	n	(%)	n	(%)
1	Enteritidis	410	0	(0.0%)	0	(0.0%)	**15**	**(38.5%)**	0	(0.0%)
2	Typhimurium	371	**72**	**(64.3%)**	**6**	**(20.0%)**	**8**	**(20.5%)**	**24**	**(32.0%)**
3	Newport	236	**15**	**(13.4%)**	**15**	**(50.0%)**	0	(0.0%)	**15**	**(20.0%)**
4	Javiana	105	0	(0.0%)	0	(0.0%)	**1**	**(2.6%)**	**1**	**(1.3%)**
5	Heidelberg	86	**3**	**(2.7%)**	**1**	**(3.3%)**	0	(0.0%)	**18**	**(24.0%)**
6	I 4,[5],12:i:-	72	**5**	**(4.5%)**	0	(0.0%)	0	(0.0%)	**2**	**(2.7%)**
7	Oranienburg	64	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
8	Saintpaul	57	**1**	**(0.9%)**	0	(0.0%)	**1**	**(2.6%)**	0	(0.0%)
9	Montevideo	56	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
10	Braenderup	55	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
11	Infantis	44	**2**	**(1.8%)**	**2**	**(6.7%)**	**1**	**(2.6%)**	**5**	**(6.7%)**
12	Muenchen	42	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
13	Mississippi	28	**1**	**(0.9%)**	0	(0.0%)	0	(0.0%)	0	(0.0%)
14	Thompson	27	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
15	Agona	21	**2**	**(1.8%)**	**2**	**(6.7%)**	**1**	**(2.6%)**	**2**	**(2.7%)**
16	Bareilly	20	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
17	Litchfield	20	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
18	Paratyphi B var. L(+) tartrate+	20	**2**	**(1.8%)**	0	(0.0%)	0	(0.0%)	**1**	**(1.3%)**
19	Hadar	19	0	(0.0%)	0	(0.0%)	**1**	**(2.6%)**	0	(0.0%)
20	Poona	16	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	Subtotal	**1769**	**103**	**(92.0%)**	**26**	**(86.7%)**	**28**	**(71.8%)**	**68**	**(90.7%)**
	All other serotypes	364	5	(4.5%)	3	(10.0%)	8	(20.5%)	6	(8.0%)
	Unknown serotype	19	1	(0.9%)	1	(3.3%)	2	(5.1%)	1	(1.3%)
	Partially serotyped	20	2	(1.8%)	0	(0.0%)	1	(2.6%)	0	(0.0%)
	Rough/Nonmotile isolates	20	1	(0.9%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	Total	**2192**	**112**	**(100.0%)**	**30**	**(100.0%)**	**39**	**(100.0%)**	**75**	**(100.0%)**

* ACSSuT: at least resistant to ampicillin, chloramphenicol, streptomycin, sulfisoxazole, tetracycline

† ACSSuTAuCx: at least resistant to ACSSuT, amoxicillin-clavulanic acid, and ceftriaxone

Box 2. Four major multidrug-resistant patterns among non-typhoidal *Salmonella*

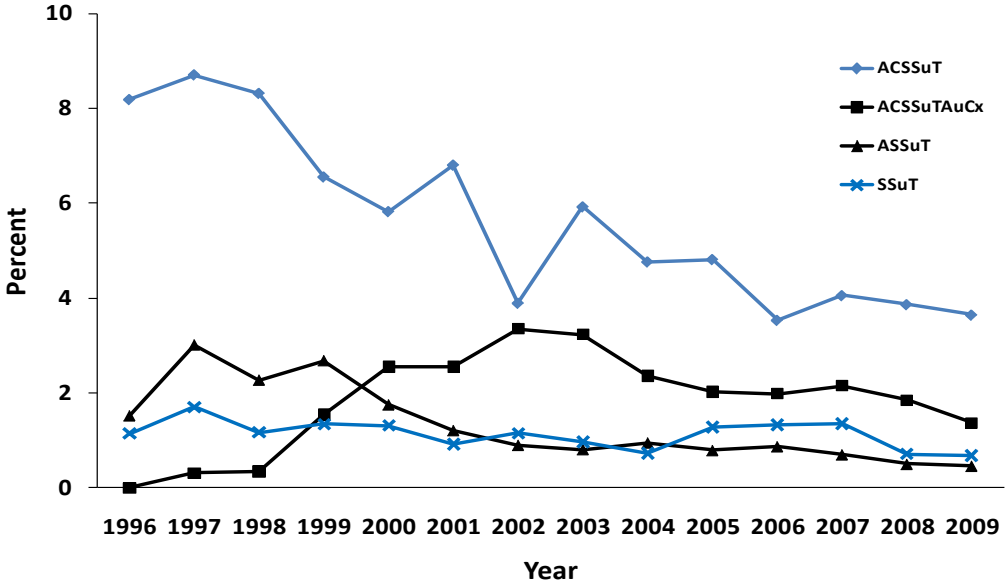
During 1996–2009, 3,243 (13.0%) of 24,903 non-typhoidal *Salmonella* isolates tested in NARMS were resistant to ≥3 classes of antimicrobial agents. Among the 3,243 isolates, we identified the 4 most common multidrug-resistant (MDR) patterns based on resistance to 7 of the 15 agents currently tested in NARMS: ampicillin (A), chloramphenicol (C), streptomycin (S), sulfonamide (Su), tetracycline (T), amoxicillin-clavulanic acid (Au), and ceftriaxone (Cx). Unlike MDR criteria used for tables in the rest of this report, which defined "at least ACSSuT" as resistant to at least A, C, S, Su, and T, we used mutually exclusive criteria in this section: ACSSuT was defined as resistant to A, C, S, Su, and T, not resistant to Au and Cx; ACSSuTAuCx as resistant to all 7 agents; ASSuT as resistant to A, S, Su, and T, not resistant to C, Au, and Cx; and SSuT as resistant to S, Su, and T, not resistant to A, C, Au, and Cx. Use of mutually exclusive criteria is important in monitoring major and emerging patterns, which may be driven by different resistance mechanisms.

ACSSuT, ACSSuTAuCx, ASSuT, and SSuT isolates accounted for 73.1% of the 3,243 isolates resistant to ≥3 classes: 1,323 (40.8%) were ACSSuT, 476 (14.7%) ACSSuTAuCx, 295 (9.1%) ASSUT, and 275 (8.5%) SSuT. Serotype Typhimurium accounted for 90.0% of ACSSuT and 74.6% of ASSuT isolates. Of the ACSSuTAuCx isolates, 67.0% were serotype Newport and 19.8% were serotype Typhimurium. More than half of SSuT isolates were serotypes Typhimurium (26.6%), Stanley (12.7%), Derby (10.2%), and Heidelberg (9.8%).

Figure 1 below shows the percentage of the 4 MDR patterns by year among all non-typhoidal *Salmonella* isolates tested from 1996 through 2009. ACSSuT declined from 8.2% in 1996 to 3.7% in 2009. ACSSuTAuCx, first detected in 1997, peaked at 3.4% in 2002 before declining to 1.4% in 2009. ASSuT was ≤3.0% and SSuT was ≤1.7% from 1996 through 2009.

Refer to Table 7 in the Results section of this report for the percentage of "at least ACSSuT" by year (2000–09) among non-typhoidal *Salmonella* isolates, which includes ACSSuT and ACSSuTAuCx. Since "at least ACSSuTAuCX" in Table 7 includes resistance to all 7 agents, percentages are the same as in Figure 1.

Figure 1. Percentage of 4 major MDR patterns* among non-typhoidal *Salmonella* isolates, by year, 1996-2009



*Four most common multidrug-resistant MDR) patterns that include resistance to ≥3 antimicrobial classes and any of the following agents: ampicillin (A), chloramphenicol (C), streptomycin (S), sulfonamide (Su), tetracycline (T), amoxicillin-clavulanic acid (Au), and ceftriaxone (Cx).

2. Typhoidal *Salmonella*

A. *Salmonella* ser. Typhi

Table 25. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Typhi isolates to antimicrobial agents, 2009 (N=361)

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]						19.4	63.2	16.6	0.6	0.3						
		Gentamicin	0.0	0.0	[0.0 - 1.0]					80.9	18.6	0.6									
		Streptomycin	N/A	10.5	[7.6 - 14.2]												89.5	0.6	10.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.9	0.3	[0.00 - 1.5]							87.5	0.6	0.3	9.4	1.9	0.3				
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 1.0]				0.8	4.7	54.0	40.4									
		Ceftriaxone	0.0	0.0	[0.0 - 1.0]					100.0											
	Penicillins	Ampicillin	0.0	12.2	[9.0 - 16.0]							85.6	2.2					12.2			
	Quinolones	Ciprofloxacin	0.3	3.3	[1.7 - 5.7]	37.7	0.8	1.4	6.1	35.7	14.4	0.3	0.3	1.1	2.2						
		Nalidixic acid	N/A	60.1	[54.9 - 65.2]							2.5	29.9	6.9	0.6		0.6	59.6			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 1.0]										100.0						
	Cephems	Cefoxitin	1.1	0.0	[0.0 - 1.0]						4.7	26.9	16.1	31.0	20.2	1.1					
	Folate pathway inhibitors	Sulfisoxazole	N/A	13.3	[10.0 - 17.2]											15.5	33.5	26.6	11.1		13.3
		Trimethoprim-sulfamethoxazole	N/A	12.2	[9.0 - 16.0]				87.0	0.8				0.6	11.6						
	Phenicols	Chloramphenicol	1.4	11.4	[8.3 - 15.1]								5.8	54.6	26.9	1.4		11.4			
	Tetracyclines	Tetracycline	0.0	5.5	[3.4 - 8.4]									94.5			0.3	5.3			

* 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 19. Antimicrobial resistance pattern for *Salmonella* ser. Typhi, 2009

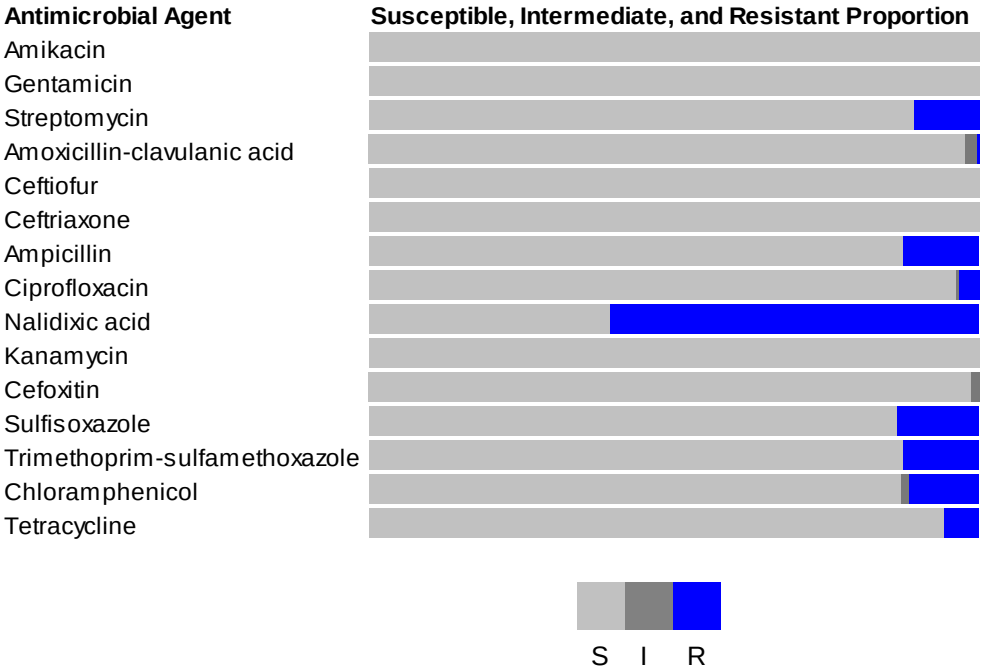


Table 26. Percentage and number of *Salmonella* ser. Typhi isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			177	197	195	332	304	318	322	401	410	361
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)	9.0% 16	20.3% 40	7.2% 14	14.5% 48	11.8% 36	13.2% 42	18.9% 61	15.7% 63	11.5% 47	10.5% 38
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-Clavulanic Acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.2% 1	0.0% 0	0.3% 1
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Ceftriaxone (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	9.0% 16	20.3% 40	5.6% 11	16% 53	11.8% 36	13.2% 42	20.5% 66	17% 68	13.2% 54	12.2% 44
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.9% 3	1.0% 4	0.0% 0	3.3% 12
		Nalidixic Acid (MIC ≥ 32)	22% 39	29.9% 59	23.6% 46	37.7% 125	41.8% 127	48.4% 154	54.7% 176	61.8% 248	59.0% 242	60.1% 217
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Cephems	Cefoxitin (MIC ≥ 32)	0.6% 1	0.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.0% 0	0.0% 0
		Cephalothin (MIC ≥ 32)	1.1% 2	0.5% 1	1.5% 3	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfisoxazole (MIC ≥ 512)	11.3% 20	20.8% 41	6.2% 12	16.9% 56	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Trimethoprim-Sulfamethoxazole (MIC ≥ 4)	9.0% 16	20.8% 41	6.7% 13	16.9% 56	13.2% 40	14.5% 46	20.8% 67	16.2% 65	12.7% 52	12.2% 44
	Phenicols	Chloramphenicol (MIC ≥ 32)	10.7% 19	20.8% 41	6.2% 12	16.6% 55	13.2% 40	13.2% 42	19.6% 63	15.7% 63	12.9% 53	11.4% 41
	Tetracyclines	Tetracycline (MIC ≥ 16)	9.6% 17	20.8% 41	6.7% 13	15.4% 51	8.9% 27	10.1% 32	8.4% 27	6.2% 25	4.6% 19	5.5% 20

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

Table 27. Resistance patterns of *Salmonella* ser. Typhi isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	177	197	195	332	304	318	323	401	410	361
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	72.3% 128	58.9% 116	74.4% 145	56.6% 188	56.6% 172	48.1% 153	40.2% 130	35.7% 143	38.0% 156	37.7% 136
Resistance ≥ 1 CLSI class*	27.7% 49	41.1% 81	25.6% 50	43.4% 144	43.4% 132	51.9% 165	59.8% 193	64.3% 258	62.0% 254	62.3% 225
Resistance ≥ 2 CLSI classes*	10.7% 19	22.8% 45	7.2% 14	17.5% 58	13.2% 40	14.5% 46	21.7% 70	18.0% 72	14.4% 59	14.1% 51
Resistance ≥ 3 CLSI classes*	9.6% 17	21.8% 43	6.7% 13	16.6% 55	12.8% 39	13.8% 44	20.7% 67	17.5% 70	13.4% 55	12.7% 46
Resistance ≥ 4 CLSI classes*	9.0% 16	21.3% 42	6.2% 12	16.3% 54	12.5% 38	12.9% 41	19.2% 62	17.0% 68	12.9% 53	12.2% 44
Resistance ≥ 5 CLSI classes*	7.9% 14	16.8% 33	5.6% 11	14.2% 47	11.8% 36	11.9% 38	16.7% 54	14.7% 59	10.7% 44	10.0% 36
At least ACSSuT†	7.9% 14	16.8% 33	5.6% 11	12.7% 42	7.9% 24	9.1% 29	5.9% 19	3.7% 15	2.4% 10	2.5% 9
At least ACT/S‡	9.0% 16	17.8% 35	5.6% 11	15.7% 52	11.8% 36	12.9% 41	18.6% 60	15.2% 61	12.2% 50	10.5% 38
At least ACSSuTAuCx§	0.0% 0	0.0% 0	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 ceftriaxone 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
§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

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

Table 28. Frequency of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolated in NARMS, 2009

Species	2009	
	n	(%)
Paratyphi A	100	(98.0%)
Paratyphi B	1	(1.0%)
Paratyphi C	1	(1.0%)
Total	**102**	**(100.0%)**

Table 29. Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates to antimicrobial agents, 2009 (N=102)

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 - 3.6]						89.2	9.8	1.0							
		Gentamicin	0.0	0.0	[0.0 - 3.6]					98.0	1.0	1.0								
		Streptomycin	N/A	1.0	[0.01 - 5.3]												99.0		1.0		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	1.0	0.0	[0.0 - 3.6]							35.3	61.8	2.0		1.0					
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 3.6]						1.0	98.0	1.0								
		Ceftriaxone	0.0	0.0	[0.0 - 3.6]					100.0											
	Penicillins	Ampicillin	0.0	1.0	[0.01 - 5.3]							4.9	93.1	1.0				1.0			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 3.6]	9.8	2.9		1.0	1.0	85.3										
		Nalidixic acid	N/A	86.3	[78.0 - 92.3]								1.0	11.8		1.0		86.3			
II	Aminoglycosides	Kanamycin	0.0	0.0	[0.0 - 3.6]										100.0						
	Cephems	Cefoxitin	1.0	0.0	[0.0 - 3.6]								8.8	81.4	8.8	1.0					
	Folate pathway inhibitors	Sulfisoxazole	N/A	1.0	[0.01 - 5.3]											53.9	35.3	7.8	2.0		1.0
		Trimethoprim-sulfamethoxazole	N/A	1.0	[0.01 - 5.3]				91.2	7.8					1.0						
	Phenicols	Chloramphenicol	5.9	1.0	[0.01 - 5.3]									2.0	91.2	5.9		1.0			
	Tetracyclines	Tetracycline	0.0	1.0	[0.01 - 5.3]									99.0				1.0			

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

† 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

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

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

Figure 20. Antimicrobial resistance pattern for *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C, 2009

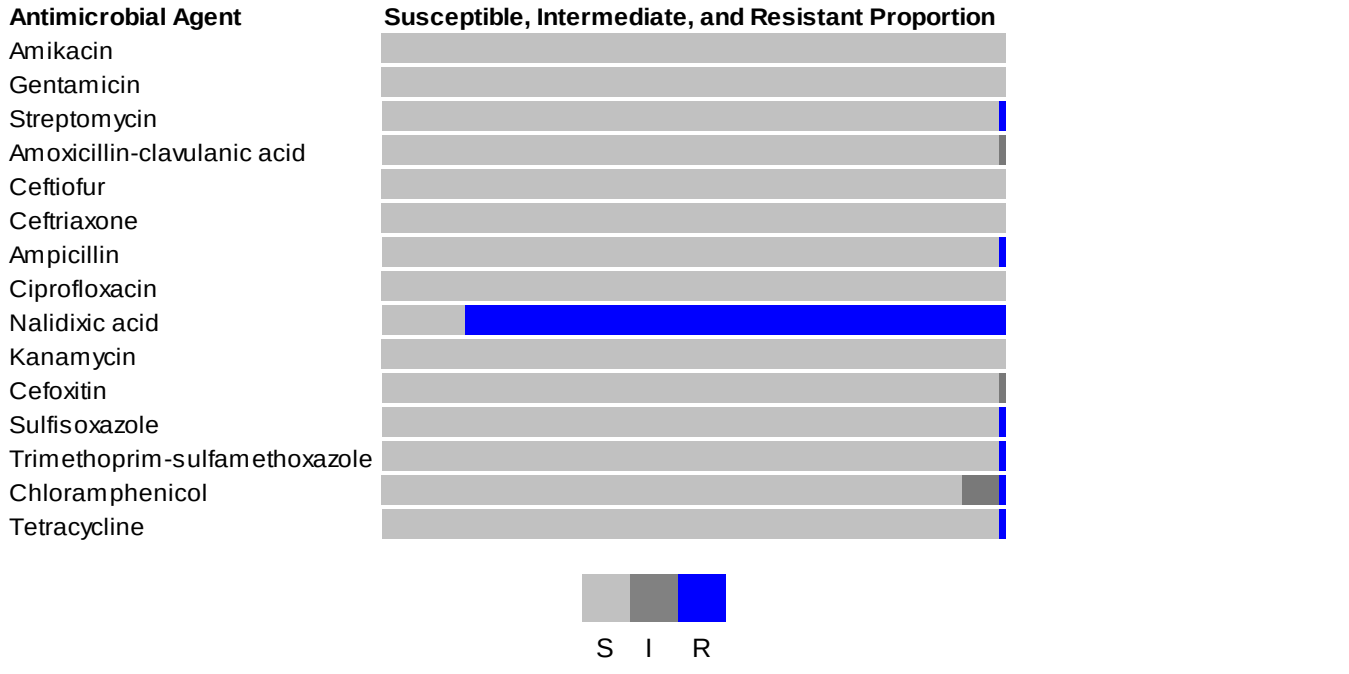


Table 30. Percentage and number of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			5	9	10	8	11	18	16	17	92	102
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)	20.0% 1	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	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	1.1% 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	1.1% 1	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	20.0% 1	0.0% 0	0.0% 0	12.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Nalidixic acid (MIC ≥ 32)	40.0% 2	55.6% 5	40.0% 4	75.0% 6	72.7% 8	66.7% 12	50.0% 8	94.1% 16	85.9% 79	86.3% 88
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)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	0.0% 0
		Cephalothin (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 1
	Phenicols	Chloramphenicol (MIC ≥ 32)	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
	Tetracyclines	Tetracycline (MIC ≥ 16)	0.0% 0	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.2% 2	1.0% 1

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

Table 31. Resistance patterns of *Salmonella* ser. Paratyphi A, Paratyphi B, and Paratyphi C isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	5	9	10	8	11	18	16	17	92	102
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	40.0% 2	44.4% 4	50.0% 5	12.5% 1	27.3% 3	33.3% 6	50.0% 8	5.9% 1	12.0% 11	12.7% 13
Resistance ≥ 1 CLSI class*	60.0% 3	55.6% 5	50.0% 5	87.5% 7	72.7% 8	66.7% 12	50.0% 8	94.1% 16	88.0% 81	87.3% 89
Resistance ≥ 2 CLSI classes*	20.0% 1	0.0% 0	10.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
Resistance ≥ 3 CLSI classes*	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
Resistance ≥ 4 CLSI classes*	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
Resistance ≥ 5 CLSI classes*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
At least ACSSuT†	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	1.0% 1
At least ACT/S‡	20.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 1
At least ACSSuTAuCx§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.1% 1	0.0% 0
At least ceftriaxone 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
§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

Box 3. Molecular characterization of Non-Typhi *Salmonella enterica* that show decreased susceptibility to extended-spectrum cephalosporins

Although most *Salmonella* infections are self-limited and treated symptomatically, antimicrobial therapy is necessary for the management of invasive infections. The recommended regimen used to include either amoxicillin or trimethoprim-sulphamethoxazole, but due to increased resistance levels to these drugs, current recommendations suggest using a fluoroquinolone, such as ciprofloxacin, or an extended-spectrum cephalosporin, such as ceftriaxone.

Among 4,236 isolates of non-typhi *Salmonella* (NTS) submitted to NARMS in 2005 and 2006, 175 (4.1%) displayed decreased susceptibility (MIC ≥ 2 mg/L) to the extended-spectrum cephalosporins ceftriaxone or ceftiofur. Among these, thirty different serotypes were represented and the three most prevalent serotypes were Newport (33.1%), Typhimurium (13.7%) and Heidelberg (13.1%).

Among the 175 isolates, 172 were available for molecular analysis. For each isolate, genomic DNA was prepared and the presence of β-lactamase genes investigated by polymerase chain reaction (PCR) amplification targeting six different genes: bla_{TEM}, bla_{OXA}, bla_{SHV}, bla_{CTX-M}, bla_{PSE} and bla_{CMY}.

One or more β-lactamase genes were detected in 139 (80.8%) isolates. The most prevalent resistance mechanisms were AmpC β-lactamase genes (bla_{CMY}) which were identified in 133 (95.7%) of the 139 β-lactamase-carrying isolates. The ceftriaxone MIC-values for the bla_{CMY}-containing isolates ranged from 4 to 64 mg/L; all bla_{CMY}-bearing isolates were thereby classified as ceftriaxone resistant according to current CLSI guidelines.

Other β-lactamase genes detected included eleven bla_{TEM-1}, three bla_{PSE-1}, two bla_{OXA-1} and one $bla_{CTX-M-15}$. The latter is an extended-spectrum β-lactamase (ESBL) that exhibits increased activity against cefotaxime and confers cross-resistance to the fourth generation cephalosporin cefepime. The $bla_{CTX-M-15}$ gene was found in an isolate of serotype Concord and is the second CTX-M-producing *Salmonella* identified in the NARMS human isolate collection (the first case was a CTX-M-5-producing *Salmonella* ser. Typhimurium isolated from a 3-month old child in 2003). The source of the CTX-M-15-producing *Salmonella* remains unknown, but it is likely that the infection was acquired abroad since the patient reported international travel to Ethiopia in conjunction with illness onset.

In conclusion, among NTS isolated from humans in 2005-2006, CMY β-lactamases were the predominant cause of decreased susceptibility and resistance to extended-spectrum cephalosporins. To limit further spread of these genes, prudent use of antimicrobial agents in both human and veterinary medicine will be crucial. Continued surveillance for cephalosporin-resistant bacteria among humans remains critical.

Box 4. Reduced azithromycin susceptibility in *Shigella sonnei,* United States

Shigella spp. are a major cause of gastroenteritis in the United States, transmitted most commonly by the fecal-oral route. It occurs most often in children 5 years old and younger in child care settings. While treatment with antimicrobial agents may shorten the duration of clinical symptoms for this usually self-limiting disease, emergence of antimicrobial resistance has recently made drug selection difficult. Previous drugs of choice for treatment of shigellosis were ampicillin and trimethoprim-sulfamethoxazole, but resistance to these drugs is high, especially in *Shigella sonnei.* Because of resistance to these agents, the macrolide azithromycin has been recommended by the American Academy of Pediatrics for treatment of shigellosis in children. Azithromycin resistance in *Shigella sonnei* is now being reported, but there are currently no CLSI criteria for interpretation of azithromycin susceptibility test results for *Shigella*. To explore azithromycin susceptibility in the United States, we determined MIC distributions for *Shigella sonnei* isolated from humans in the United States.

Azithromycin MICs were determined by broth microdilution for *Shigella sonnei* isolates from 11 recognized outbreaks in 10 states in 2006-2007 (n=56) and for those submitted routinely to NARMS in 2005 (the most recently completed year at the time, n=336) from 44 states. Five isolates collected from 1969-1974 (before approval of azithromycin) were also tested for historical perspective, but were not included in the MIC distribution analysis. Each isolate that demonstrated an azithromycin MIC>64 mg/L was screened for the *mphA* gene by PCR, and the gene was sequenced to confirm positives.

The resulting distribution was log-normal and spanned three doubling dilution steps (4-16 mg/L) with an MIC_{50} and MIC_{90} of 8 mg/L. Five isolates collected from 1969-1974 exhibited azithromycin MICs of either 4 mg/L (n=1) or 8 mg/L (n=4). One outbreak isolate and two routine isolates showed MICs at least four-fold higher than the MIC_{90} for the overall group of isolates; the outbreak isolate displayed an MIC of 256 mg/L and the routine isolates showed MICs of 256 and 128 mg/L. These isolates were PCR-positive for *mphA,* which encodes a macrolide-2'-phosphotransferase. In all three isolates, the gene was on a transferrable plasmid, with plasmid sizes ranging from 15-150kb.

Decreased azithromycin susceptibility for *Shigella sonnei* in the face of high levels of ampicillin and trimethoprim-sulfamethoxazole resistance is particularly worrisome for children because the remaining options for treatment are ceftriaxone, which is administered by injection and fluoroquinolones such as ciprofloxacin, which are not approved for use in children. Continued surveillance will be needed to examine antimicrobial use practices for *Shigella* infections and to determine whether azithromycin use leads to decreased susceptibility to the agent. Clinical outcome studies are needed to establish clinical breakpoints for azithromycin in treating *Shigella*.

3. *Shigella*

Table 32. Frequency of *Shigella* species isolated in NARMS, 2009

Species	2009	
	n	(%)
Shigella sonnei	410	(86.3%)
Shigella flexneri	57	(12.0%)
Shigella boydii	5	(1.1%)
Other	3	(0.6%)
Total	**475**	**(100.0%)**

Table 33. Minimum inhibitory concentrations (MICs) and resistance of *Shigella* isolates to antimicrobial agents, 2009 (N=475)

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]						0.4	2.1	33.5	59.6	4.2	0.2					
		Gentamicin	0.0	0.6	[0.1 - 1.8]					1.7	16.0	76.8	4.4	0.4		0.2	0.4				
		Streptomycin	N/A	89.1	[85.9 - 91.7]												10.9	43.4	45.7		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	19.4	2.1	[1.0 - 3.8]							2.5	4.8	45.3	25.9	19.4	1.7	0.4			
	Cephems	Ceftiofur	0.0	0.6	[0.1 - 1.8]				10.1	78.5	8.2	2.5			0.4	0.2					
		Ceftriaxone	0.0	0.6	[0.1 - 1.8]					99.2	0.2				0.4		0.2				
	Penicillins	Ampicillin	0.0	46.3	[41.8 - 50.9]							7.2	42.3	3.6	0.6		0.2	46.1			
	Quinolones	Ciprofloxacin	0.0	0.6	[0.1 - 1.8]	97.1	0.4	1.1	0.2	0.6				0.4	0.2						
		Nalidixic acid	N/A	2.1	[1.0 - 3.8]						4.4	81.5	9.9	2.1			0.8	1.3			
II	**Aminoglycosides**	Kanamycin	0.0	0.4	[0.05 - 1.5]										99.4	0.2			0.4		
	Cephems	Cefoxitin	0.0	0.6	[0.1 - 1.8]						0.4	17.1	70.7	10.1	1.1		0.4	0.2			
	Folate pathway inhibitors	Sulfisoxazole	N/A	30.5	[26.4 - 34.9]											60.2	6.3	1.9	1.1		30.5
		Trimethoprim-sulfamethoxazole	N/A	40.4	[36.0 - 45.0]				8.2	1.9	5.3	18.5	25.7	8.8	31.6						
	Phenicols	Chloramphenicol	0.2	9.3	[6.8 - 12.2]								22.1	66.3	2.1	0.2	1.9	7.4			
	Tetracyclines	Tetracycline	0.6	29.5	[25.4 - 33.8]									69.9	0.6	0.4	8.6	20.4			

* 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

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

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

Figure 21. Antimicrobial resistance pattern for *Shigella*, 2009

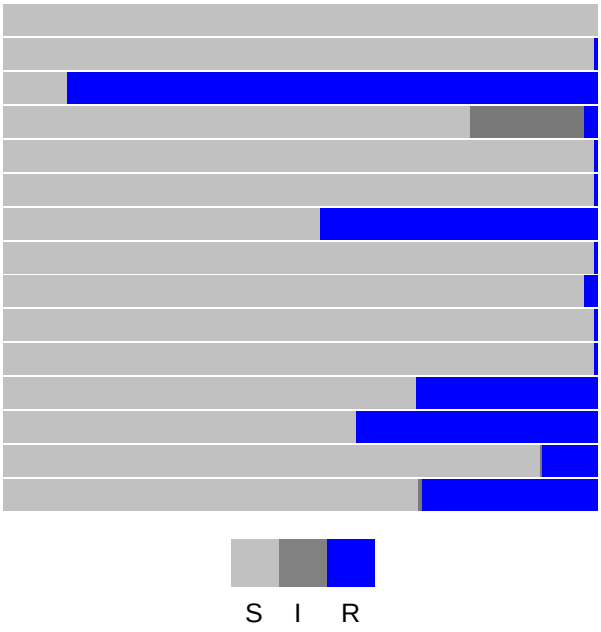


Table 34. Percentage and number of *Shigella* isolates resistant to antimicrobial agents, 2000–2009

Year Total Isolates			2000 450	2001 344	2002 620	2003 495	2004 316	2005 396	2006 402	2007 480	2008 549	2009 475
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)	0.2% 1	0.0% 0	0.2% 1	0.0% 0	0.0% 0	1.0% 4	0.2% 1	0.8% 4	0.4% 2	0.6% 3
		Streptomycin (MIC ≥ 64)	57.1% 257	53.2% 183	54.4% 337	57.0% 282	59.8% 189	68.7% 272	60.7% 244	73.3% 352	80.7% 443	89.1% 423
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	2.2% 10	4.4% 15	2.6% 16	1.4% 7	1.6% 5	1.0% 4	1.5% 6	0.4% 2	3.3% 18	2.1% 10
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.3% 1	0.5% 2	0.2% 1	0.0% 0	0.0% 0	0.6% 3
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.3% 1	0.5% 2	0.2% 1	0.0% 0	0.0% 0	0.6% 3
	Penicillins	Ampicillin (MIC ≥ 32)	79.1% 356	79.7% 274	76.6% 475	79.4% 393	77.5% 245	70.7% 280	62.4% 251	63.8% 306	62.5% 343	46.3% 220
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.7% 4	0.6% 3
		Nalidixic acid (MIC ≥ 32)	0.9% 4	1.7% 6	1.6% 10	1.0% 5	1.6% 5	1.5% 6	3.5% 14	1.7% 8	1.6% 9	2.1% 10
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	1.3% 6	0.6% 2	0.8% 5	0.4% 2	0.0% 0	0.8% 3	0.0% 0	0.2% 1	0.5% 3	0.4% 2
	Cephems	Cefoxitin (MIC ≥ 32)	0.2% 1	1.2% 4	0.3% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.6% 3
		Cephalothin (MIC ≥ 32)	8.0% 36	9.0% 31	6.6% 41	9.3% 46	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	55.8% 251	56.4% 194	31.8% 197	33.9% 168	52.5% 166	57.6% 228	40.3% 162	25.8% 124	28.6% 157	30.5% 145
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	52.9% 238	46.8% 161	37.3% 231	38.6% 191	46.8% 148	53.3% 211	46.0% 185	25.8% 124	31.3% 172	40.4% 192
	Phenicols	Chloramphenicol (MIC ≥ 32)	14.0% 63	21.5% 74	7.6% 47	8.5% 42	15.2% 48	10.9% 43	10.9% 44	8.3% 40	6.9% 38	9.3% 44
	Tetracyclines	Tetracycline (MIC ≥ 16)	44.9% 202	59.3% 204	30.6% 190	29.1% 144	49.4% 156	38.4% 152	34.6% 139	25.6% 123	24.2% 133	29.5% 140

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

Table 35. Resistance patterns of *Shigella* isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	450	344	620	495	316	396	402	480	549	475
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	7.3% 33	4.9% 17	8.2% 51	8.5% 42	4.7% 15	4.5% 18	6.5% 26	7.1% 34	4.4% 24	4.0% 19
Resistance ≥ 1 CLSI class*	92.7% 417	95.1% 327	91.8% 569	91.5% 453	95.3% 301	95.5% 378	93.5% 376	92.9% 446	95.6% 525	96.0% 456
Resistance ≥ 2 CLSI classes*	64.7% 291	68.6% 236	55.2% 342	57.8% 286	64.2% 203	71.7% 284	64.7% 260	65.4% 314	68.3% 375	67.8% 322
Resistance ≥ 3 CLSI classes*	61.3% 276	59.9% 206	41.5% 257	40.2% 199	59.2% 187	58.6% 232	43.8% 176	27.7% 133	35.2% 193	36.4% 173
Resistance ≥ 4 CLSI classes*	31.8% 143	45.3% 156	24.4% 151	24.8% 123	32.9% 104	19.4% 77	15.4% 62	11.7% 56	10.4% 57	13.3% 63
Resistance ≥ 5 CLSI classes*	6.4% 29	7.6% 26	2.7% 17	3.6% 18	7.0% 22	4.8% 19	5.2% 21	4.6% 22	2.7% 15	6.3% 30
At least ACSSuT†	5.6% 25	6.4% 22	1.8% 11	3.2% 16	6.0% 19	4.0% 16	5.0% 20	3.8% 18	2.2% 12	5.9% 28
At least ACT/S‡	6.9% 31	7.0% 24	2.7% 17	3.6% 18	6.6% 21	6.3% 25	6.0% 24	4.0% 19	2.9% 16	6.7% 32
At least AT/S§	44.4% 200	37.5% 129	29.8% 185	33.7% 167	34.5% 109	35.6% 141	26.6% 107	12.9% 62	16.0% 88	17.5% 83
At least ANT/S¶	0.0% 0	0.6% 2	0.3% 2	0.8% 4	0.6% 2	0.5% 2	0.5% 2	0.8% 4	0.0% 0	0.2% 1
At least ACSSuTAuCx**	0.0% 0	0.0% 0	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 ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.3% 1	0.3% 1	0.2% 1	0.0% 0	0.0% 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
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

Table 36. Minimum inhibitory concentrations (MICs) and resistance of *Shigella sonnei* isolates to antimicrobial agents, 2009 (N=410)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 0.9]						0.5	2.0	35.1	59.5	2.9						
		Gentamicin	0.0	0.7	[0.1 - 2.1]					1.5	14.9	78.0	4.4	0.5		0.2	0.5				
		Streptomycin	N/A	91.5	[88.3 - 94.0]												8.5	48.3	43.2		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	14.6	2.0	[0.8 - 3.8]							2.4	2.7	50.5	27.8	14.6	1.5	0.5			
	Cephems	Ceftiofur	0.0	0.5	[0.05 - 1.7]				5.6	83.4	8.3	2.2			0.5						
		Ceftriaxone	0.0	0.5	[0.05 - 1.7]					99.3	0.2				0.5						
	Penicillins	Ampicillin	0.0	43.2	[38.3 - 48.1]							4.4	47.8	4.1	0.5		0.2	42.9			
	Quinolones	Ciprofloxacin	0.0	0.0	[0.0 - 0.9]	98.0	0.2	1.0	0.2	0.5											
		Nalidixic acid	N/A	1.7	[0.7 - 3.5]						4.6	83.7	8.3	1.7			1.0	0.7			
II	**Aminoglycosides**	Kanamycin	0.0	0.2	[0.00 - 1.3]										99.5	0.2			0.2		
	Cephems	Cefoxitin	0.0	0.7	[0.1 - 2.1]						0.5	18.8	73.7	5.9	0.5		0.5	0.2			
	Folate pathway inhibitors	Sulfisoxazole	N/A	23.9	[19.9 - 28.3]											65.6	7.1	2.2	1.2		23.9
		Trimethoprim-sulfamethoxazole	N/A	36.1	[31.4 - 41.0]				5.6	1.5	5.9	21.5	29.5	10.2	25.9						
	Phenicols	Chloramphenicol	0.0	1.2	[0.4 - 2.8]								20.2	76.3	2.2			1.2			
	Tetracyclines	Tetracycline	0.5	20.7	[16.9 - 25.0]									78.8	0.5	0.2	9.0	11.5			

* 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
† 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 22. Antimicrobial resistance pattern for *Shigella sonnei*, 2009

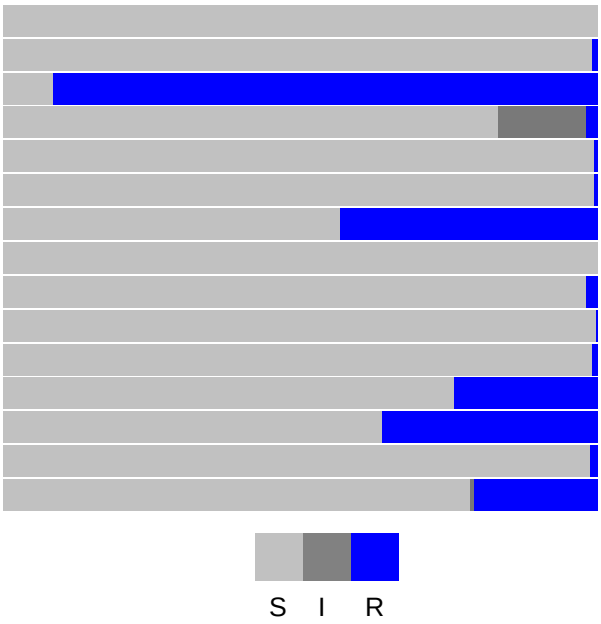


Table 37. Percentage and number of *Shigella sonnei* isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			366	239	536	434	241	340	321	414	496	410
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.2% 4	0.0% 0	1.0% 4	0.4% 2	0.7% 3
		Streptomycin (MIC ≥ 64)	56.0% 205	54.0% 129	55.4% 297	56.5% 245	56.8% 137	70.3% 239	61.7% 198	76.8% 318	82.5% 409	91.5% 375
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.9% 7	4.6% 11	2.2% 12	1.4% 6	1.7% 4	1.2% 4	1.9% 6	0.5% 2	3.2% 16	2.0% 8
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2	0.0% 0	0.0% 0	0.0% 0	0.5% 2
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2	0.0% 0	0.0% 0	0.0% 0	0.5% 2
	Penicillins	Ampicillin (MIC ≥ 32)	80.6% 295	82.8% 198	77.6% 416	79.7% 346	79.3% 191	70.6% 240	62.6% 201	64.0% 265	61.5% 305	43.2% 177
	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	0.6% 3	0.0% 0
		Nalidixic acid (MIC ≥ 32)	1.1% 4	0.8% 2	1.5% 8	0.5% 2	1.7% 4	1.2% 4	2.8% 9	1.2% 5	1.6% 8	1.7% 7
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	1.6% 6	0.4% 1	0.4% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.6% 3	0.2% 1
	Cephems	Cefoxitin (MIC ≥ 32)	0.3% 1	1.7% 4	0.4% 2	0.0% 0	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.7% 3
		Cephalothin (MIC ≥ 32)	8.7% 32	12.6% 30	7.3% 39	10.1% 44	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	56.0% 205	54.4% 130	29.9% 160	31.3% 136	49.0% 118	57.9% 197	33.3% 107	20.0% 83	25.0% 124	23.9% 98
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	54.9% 201	50.6% 121	37.9% 203	38.5% 167	46.9% 113	55.0% 187	42.7% 137	22.0% 91	29.4% 146	36.1% 148
	Phenicols	Chloramphenicol (MIC ≥ 32)	2.7% 10	1.3% 3	0.2% 1	1.2% 5	2.5% 6	2.4% 8	0.9% 3	1.2% 5	1.0% 5	1.2% 5
	Tetracyclines	Tetracycline (MIC ≥ 16)	34.4% 126	44.8% 107	23.5% 126	22.1% 96	36.1% 87	29.4% 100	22.7% 73	16.2% 67	17.3% 86	20.7% 85

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

Table 38. Resistance patterns of *Shigella sonnei* isolates, 2000–2009

Year Total Isolates	2000 366	2001 239	2002 536	2003 434	2004 241	2005 340	2006 321	2007 414	2008 496	2009 410
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	7.7% 28	5.4% 13	7.1% 38	8.5% 37	5.4% 13	4.4% 15	6.2% 20	6.8% 28	4.4% 22	3.7% 15
Resistance ≥ 1 CLSI class*	92.3% 338	94.6% 226	92.9% 498	91.5% 397	94.6% 228	95.6% 325	93.8% 301	93.2% 386	95.6% 474	96.3% 395
Resistance ≥ 2 CLSI classes*	60.7% 222	59.8% 143	51.9% 278	54.1% 235	56.4% 136	70.3% 239	59.8% 192	63.0% 261	65.7% 326	65.1% 267
Resistance ≥ 3 CLSI classes*	56.8% 208	51.5% 123	36.4% 195	35.3% 153	50.6% 122	55.3% 188	35.8% 115	21.3% 88	29.8% 148	29.8% 122
Resistance ≥ 4 CLSI classes*	25.4% 93	37.7% 90	19.8% 106	20.5% 89	25.7% 62	12.4% 42	8.1% 26	5.1% 21	5.6% 28	5.9% 24
Resistance ≥ 5 CLSI classes*	1.4% 5	0.0% 0	0.6% 3	0.5% 2	0.8% 2	0.9% 3	0.0% 0	1.2% 5	0.4% 2	0.2% 1
At least ACSSuT†	0.8% 3	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.3% 1	0.0% 0	0.5% 2	0.2% 1	0.0% 0
At least ACT/S‡	1.9% 7	0.8% 2	0.2% 1	0.9% 4	1.7% 4	2.4% 8	0.9% 3	0.5% 2	0.8% 4	1.0% 4
At least AT/S§	46.2% 169	41.0% 98	30.2% 162	33.6% 146	35.3% 85	35.6% 121	22.7% 73	9.4% 39	14.3% 71	12.2% 50
At least ANT/S¶	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.8% 2	0.3% 1	0.0% 0	0.7% 3	0.0% 0	0.0% 0
At least ACSSuTAuCx**	0.0% 0	0.0% 0	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 ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 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
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

Table 39. Minimum inhibitory concentrations and resistance of *Shigella flexneri* isolates to antimicrobial agents, 2009 (N=57)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**														
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
	Aminoglycosides	Amikacin	0.0	0.0	[0.0 - 6.3]							1.8	22.8	59.6	14.0	1.8					
		Gentamicin	0.0	0.0	[0.0 - 6.3]					1.8	24.6	68.4	5.3								
		Streptomycin	N/A	73.7	[60.3 - 84.5]												26.3	12.3	61.4		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	54.4	3.5	[0.4 - 12.1]							1.8	19.3	8.8	12.3	54.4	3.5				
I	**Cephems**	Ceftiofur	0.0	1.8	[0.02 - 9.4]				38.6	47.4	8.8	3.5				1.8					
		Ceftriaxone	0.0	1.8	[0.02 - 9.4]					98.2							1.8				
	Penicillins	Ampicillin	0.0	70.2	[56.6 - 81.6]							24.6	5.3					70.2			
	Quinolones	Ciprofloxacin	0.0	3.5	[0.4 - 12.1]	94.7	1.8							1.8	1.8						
		Nalidixic acid	N/A	3.5	[0.4 - 12.1]						1.8	71.9	19.3	3.5				3.5			
	Aminoglycosides	Kanamycin	0.0	1.8	[0.02 - 9.4]										98.2				1.8		
	Cephems	Cefoxitin	0.0	0.0	[0.0 - 6.3]							3.5	52.6	40.4	3.5						
II	**Folate pathway inhibitors**	Sulfisoxazole	N/A	73.7	[60.3 - 84.5]											24.6	1.8				73.7
		Trimethoprim-sulfamethoxazole	N/A	68.4	[54.8 - 80.1]				26.3	3.5	1.8				68.4						
	Phenicols	Chloramphenicol	0.0	66.7	[52.9 - 78.6]								29.8	1.8	1.8		15.8	50.9			
	Tetracyclines	Tetracycline	1.8	87.7	[76.3 - 94.9]									10.5	1.8	1.8	5.3	80.7			

* 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to the Clopper-Pearson exact method. The 95% CI is presented to summarize uncertainly in the observed resistance (R%).
** The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure 23. Antimicrobial resistance pattern for *Shigella flexneri*, 2009

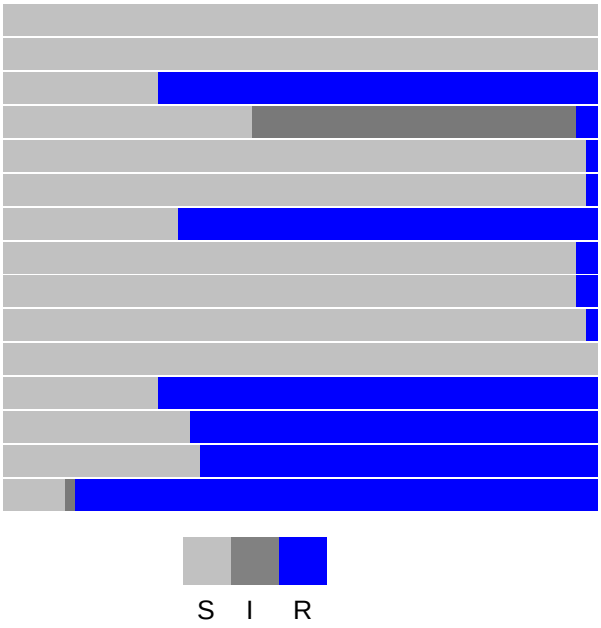


Table 40. Percentage and number of *Shigella flexneri* isolates resistant to antimicrobial agents, 2000–2009

Year Total Isolates			2000 75	2001 91	2002 73	2003 51	2004 62	2005 52	2006 74	2007 61	2008 45	2009 57
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
		Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	61.3% 46	47.3% 43	43.8% 32	60.8% 31	71.0% 44	57.7% 30	58.1% 43	52.5% 32	62.2% 28	73.7% 42
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	4.0% 3	4.4% 4	5.5% 4	2.0% 1	1.6% 1	0.0% 0	0.0% 0	0.0% 0	4.4% 2	3.5% 2
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	1.4% 1	2.0% 1	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	1.8% 1
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	1.4% 1	2.0% 1	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	1.8% 1
	Penicillins	Ampicillin (MIC ≥ 32)	77.3% 58	72.5% 66	75.3% 55	84.3% 43	80.6% 50	75.0% 39	63.5% 47	63.9% 39	75.6% 34	70.2% 40
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	1.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.4% 1	1.6% 1	2.2% 1	3.5% 2
		Nalidixic acid (MIC ≥ 32)	0.0% 0	3.3% 3	2.7% 2	5.9% 3	1.6% 1	3.8% 2	5.4% 4	4.9% 3	2.2% 1	3.5% 2
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	1.1% 1	4.1% 3	3.9% 2	0.0% 0	3.8% 2	0.0% 0	0.0% 0	0.0% 0	1.8% 1
	Cephems	Cefoxitin (MIC ≥ 32)	0.0% 0	0.0% 0	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)	2.7% 2	1.1% 1	2.7% 2	3.9% 2	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	53.3% 40	57.1% 52	41.1% 30	52.9% 27	66.1% 41	55.8% 29	68.9% 51	62.3% 38	62.2% 28	73.7% 42
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	42.7% 32	34.1% 31	28.8% 21	39.2% 20	46.8% 29	44.2% 23	59.5% 44	49.2% 30	48.9% 22	68.4% 39
	Phenicols	Chloramphenicol (MIC ≥ 32)	69.3% 52	74.7% 68	63.0% 46	68.6% 35	61.3% 38	65.4% 34	54.1% 40	55.7% 34	68.9% 31	66.7% 38
	Tetracyclines	Tetracycline (MIC ≥ 16)	92.0% 69	94.5% 86	78.1% 57	82.4% 42	95.2% 59	94.2% 49	83.8% 62	83.6% 51	86.7% 39	87.7% 50

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

Table 41. Resistance patterns of *Shigella flexneri* isolates, 2000–2009

Year Total Isolates	2000 75	2001 91	2002 73	2003 51	2004 62	2005 52	2006 74	2007 61	2008 45	2009 57
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	4.0% 3	3.3% 3	15.1% 11	7.8% 4	0.0% 0	5.8% 3	5.4% 4	9.8% 6	4.4% 2	5.3% 3
Resistance ≥ 1 CLSI class*	96.0% 72	96.7% 88	84.9% 62	92.2% 47	100.0% 62	94.2% 49	94.6% 70	90.2% 55	95.6% 43	94.7% 54
Resistance ≥ 2 CLSI classes*	82.7% 62	89.0% 81	76.7% 56	86.3% 44	93.5% 58	80.8% 42	85.1% 63	80.3% 49	93.3% 42	86.0% 49
Resistance ≥ 3 CLSI classes*	81.3% 61	79.1% 72	75.3% 55	80.4% 41	90.3% 56	78.8% 41	75.7% 56	68.9% 42	84.4% 38	82.5% 47
Resistance ≥ 4 CLSI classes*	64.0% 48	62.6% 57	57.5% 42	62.7% 32	64.5% 40	65.4% 34	47.3% 35	55.7% 34	57.8% 26	63.2% 36
Resistance ≥ 5 CLSI classes*	32.0% 24	25.3% 23	19.2% 14	31.4% 16	29.0% 18	30.8% 16	28.4% 21	27.9% 17	28.9% 13	49.1% 28
At least ACSSuT†	29.3% 22	22.0% 20	15.1% 11	29.4% 15	27.4% 17	28.8% 15	27.0% 20	26.2% 16	24.4% 11	47.4% 27
At least ACT/S‡	32.0% 24	23.1% 21	21.9% 16	27.5% 14	24.2% 15	32.7% 17	28.4% 21	26.2% 16	26.7% 12	47.4% 27
At least AT/S§	38.7% 29	25.3% 23	27.4% 20	37.3% 19	35.5% 22	38.5% 20	43.2% 32	36.1% 22	33.3% 15	52.6% 30
At least ANT/S¶	0.0% 0	1.1% 1	1.4% 1	5.9% 3	0.0% 0	1.9% 1	2.7% 2	1.6% 1	0.0% 0	1.8% 1
At least ACSSuTAuCx**	0.0% 0	0.0% 0	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 ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	2.0% 1	0.0% 0	0.0% 0	1.4% 1	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
§ AT/S: resistance to ampicillin, trimethoprim-sulfamethoxazole
¶ ANT/S: resistance to AT/S, naladixic acid
** ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

4. Escherichia coli O157

Table 42. Minimum inhibitory concentrations (MICs) and resistance of *Escherichia coli* O157 isolates to antimicrobial agents, 2009 (N=188)

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]						2.1	55.3	39.9	2.7							
		Gentamicin	0.0	0.5	[0.01 - 2.9]					29.8	63.3	6.4					0.5				
		Streptomycin	N/A	4.8	[2.2 - 8.9]												95.2	3.7	1.1		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	0.0	0.5	[0.01 - 2.9]							1.1	8.5	85.6	4.3		0.5				
	Cephems	Ceftiofur	0.0	0.0	[0.0 - 1.9]				1.6	8.0	87.8	2.7									
		Ceftriaxone	0.0	0.0	[0.0 - 1.9]					100.0											
	Penicillins	Ampicillin	0.5	4.3	[1.9 - 8.2]							3.2	81.9	10.1		0.5		4.3			
	Quinolones	Ciprofloxacin	0.0	0.5	[0.01 - 2.9]	97.3	0.5			1.6					0.5						
		Nalidixic acid	N/A	2.1	[0.6 - 5.4]							1.1	87.2	9.6				2.1			
II	**Aminoglycosides**	Kanamycin	0.0	0.5	[0.01 - 2.9]										98.9	0.5			0.5		
	Cephems	Cefoxitin	1.1	0.5	[0.01 - 2.9]							2.1	3.7	85.6	6.9	1.1		0.5			
	Folate pathway inhibitors	Sulfisoxazole	N/A	6.4	[3.3 - 10.9]											36.2	52.1	5.3			6.4
		Trimethoprim-sulfamethoxazole	N/A	4.3	[1.9 - 8.2]				94.1	1.1	0.5				4.3						
	Phenicols	Chloramphenicol	0.0	1.1	[0.1 - 3.8]								1.1	23.4	74.5			1.1			
	Tetracyclines	Tetracycline	0.0	7.4	[4.1 - 12.2]									92.6				7.4			

* 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

¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to 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 24. Antimicrobial resistance pattern for *Escherichia coli* O157, 2009

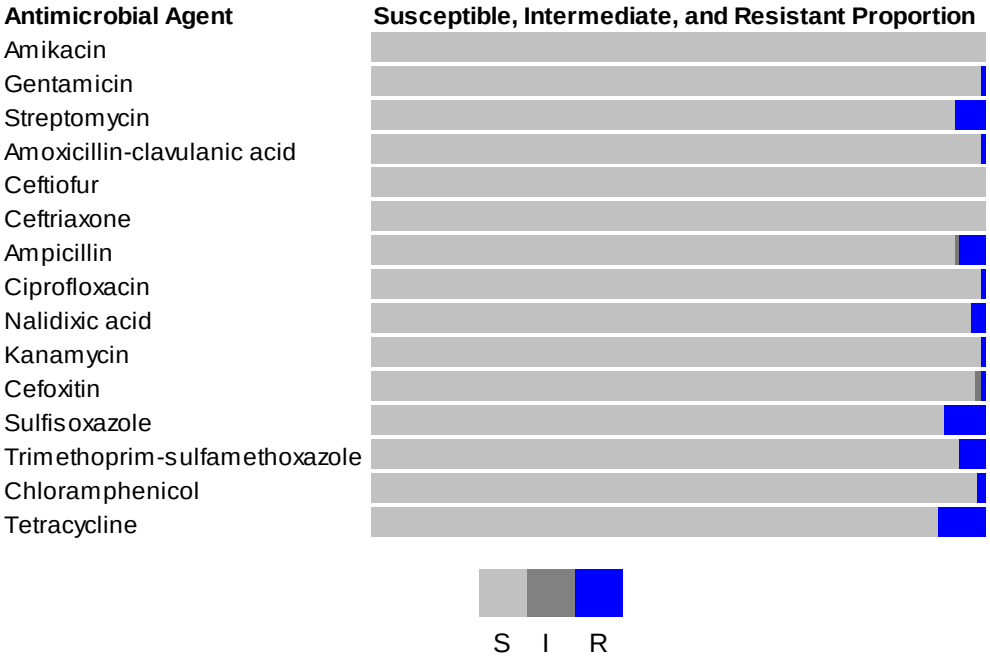


Table 43. Percentage and number of *Escherichia coli* O157 isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			407	277	399	158	169	194	233	190	159	188
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)	0.5% 2	0.4% 1	0.0% 0	0.0% 0	0.6% 1	0.5% 1	0.0% 0	0.0% 0	1.3% 2	0.5% 1
		Streptomycin (MIC ≥ 64)	5.2% 21	1.8% 5	2.3% 9	1.9% 3	1.8% 3	2.1% 4	2.6% 6	2.1% 4	1.9% 3	4.8% 9
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32/16)	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.5% 1	0.6% 1	0.5% 1
	Cephems	Ceftiofur (MIC ≥ 8)	1.0% 4	1.1% 3	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.0% 0	0.6% 1	0.0% 0
		Ceftriaxone (MIC ≥ 64)	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.0% 0	0.0% 0	1.3% 3	0.0% 0	0.6% 1	0.0% 0
	Penicillins	Ampicillin (MIC ≥ 32)	2.7% 11	2.2% 6	1.5% 6	3.2% 5	1.2% 2	4.1% 8	2.6% 6	2.1% 4	3.8% 6	4.3% 8
	Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.5% 1	0.0% 0	0.5% 1
		Nalidixic acid (MIC ≥ 32)	0.5% 2	1.1% 3	1.0% 4	0.6% 1	1.8% 3	1.5% 3	2.1% 5	2.1% 4	1.3% 2	2.1% 4
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	1.0% 4	0.0% 0	0.5% 2	0.0% 0	0.0% 0	0.5% 1	0.4% 1	0.0% 0	0.0% 0	0.5% 1
	Cephems	Cefoxitin (MIC ≥ 32)	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.6% 1	0.0% 0	1.3% 3	0.0% 0	1.3% 2	0.5% 1
		Cephalothin (MIC ≥ 32)	1.2% 5	1.4% 4	1.5% 6	3.2% 5	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
	Folate pathway inhibitors	Sulfamethoxazole/Sulfisoxazole‡ (MIC ≥ 512)	5.9% 24	5.1% 14	3.5% 14	3.8% 6	1.8% 3	6.7% 13	3.0% 7	2.6% 5	3.1% 5	6.4% 12
		Trimethoprim-sulfamethoxazole (MIC ≥ 4/76)	0.7% 3	0.7% 2	0.5% 2	0.6% 1	0.0% 0	0.5% 1	0.4% 1	1.1% 2	1.3% 2	4.3% 8
	Phenicols	Chloramphenicol (MIC ≥ 32)	3.7% 15	1.4% 4	1.3% 5	1.3% 2	0.6% 1	1.0% 2	1.3% 3	0.5% 1	0.6% 1	1.1% 2
	Tetracyclines	Tetracycline (MIC ≥ 16)	7.1% 29	5.4% 15	3.0% 12	5.7% 9	1.8% 3	8.8% 17	4.7% 11	4.7% 9	1.9% 3	7.4% 14

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

Table 44. Resistance patterns of *Escherichia coli* O157 isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	407	277	399	158	169	194	233	190	159	188
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	90.4% 368	91.3% 253	94.0% 375	90.5% 143	94.7% 160	87.6% 170	91.8% 214	92.1% 175	91.8% 146	89.9% 169
Resistance ≥ 1 CLSI class*	9.6% 39	8.7% 24	6.0% 24	9.5% 15	5.3% 9	12.4% 24	8.2% 19	7.9% 15	8.2% 13	10.1% 19
Resistance ≥ 2 CLSI classes*	6.6% 27	5.4% 15	3.8% 15	5.1% 8	2.4% 4	6.7% 13	4.7% 11	3.2% 6	3.1% 5	7.4% 14
Resistance ≥ 3 CLSI classes*	4.7% 19	2.2% 6	2.0% 8	3.2% 5	1.2% 2	5.2% 10	3.4% 8	2.1% 4	2.5% 4	5.9% 11
Resistance ≥ 4 CLSI classes*	3.4% 14	1.4% 4	0.8% 3	1.3% 2	0.6% 1	1.0% 2	2.1% 5	1.1% 2	1.3% 2	4.3% 8
Resistance ≥ 5 CLSI classes*	1.2% 5	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.9% 2	0.5% 1	0.0% 0	0.5% 1
At least ACSSuT†	1.2% 5	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.9% 2	0.0% 0	0.0% 0	0.0% 0
At least ACT/S‡	0.2% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.6% 1	0.0% 0
At least ACSSuTAuCx§	1.0% 4	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.0% 0	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
§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone

5. *Campylobacter*

Table 45. Frequency of *Campylobacter* species isolated in NARMS, 2009

Species	2009	
	N	(%)
Campylobacter jejuni	1355	(90.2%)
Campylobacter coli	143	(9.5%)
Other	4	(0.3%)
Total	**1502**	**(100.0%)**

Table 46. Minimum inhibition concentrations (MICs) and resistance of *Campylobacter* isolates to antimicrobial agents, 2009 (N=1502)

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	0.9	[0.5 - 1.5]				1.1	21.4	61.7	14.4	0.5					0.9			
	Ketolide	Telithromycin	0.9	1.5	[0.9 - 2.2]			0.1	0.2	8.3	32.1	36.7	16.7	3.5	0.9	1.5					
	Macrolides	Azithromycin	0.0	1.7	[1.1 - 2.4]	0.7	15.4	45.0	28.8	7.7	0.7	< 0.1							1.7		
		Erythromycin	0.0	1.7	[1.1 - 2.4]			< 0.1	1.6	23.3	47.2	19.8	5.0	1.3	< 0.1			< 0.1	1.6		
	Quinolones	Ciprofloxacin	< 0.1	22.9	[20.8 - 25.1]		1.1	27.8	40.3	5.9	1.7	0.2	< 0.1	1.5	9.1	7.4	3.1	1.4	0.4		
		Nalidixic acid	< 0.1	23.2	[21.1 - 25.4]									62.1	12.8	1.9	< 0.1	3.1	20.1		
II	**Phenicols**	Florfenicol††	0.0	0.5	[0.2 - 1.0]					< 0.1	14.0	69.1	13.8	2.5	0.5	< 0.1					
	Tetracyclines	Tetracycline	0.1	43.5	[40.9 - 46.0]			4.3	26.3	16.5	6.0	2.7	0.5	< 0.1	0.1	0.4	2.5	9.9	30.6		
III	**Lincosamides**	Clindamycin	0.3	1.4	[0.9 - 2.1]		1.4	16.2	42.5	27.9	7.5	2.3	0.5	0.3	0.3	0.5	0.7				

* 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; 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

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

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

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

Figure 25. Antimicrobial resistance pattern for *Campylobacter*, 2009

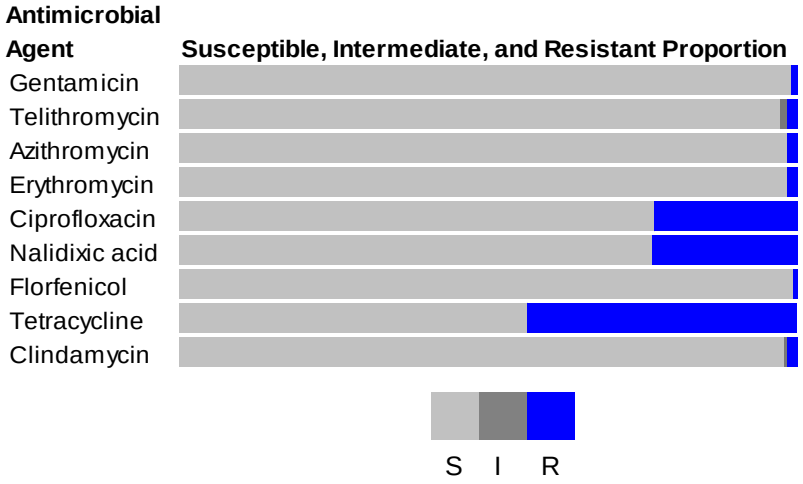


Table 47. Percentage and number of *Campylobacter* isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			324	384	354	328	347	890	816	1100	1159	1502
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin	0.3%	0.0%	0.0%	0.3%	0.3%	0.7%	0.1%	0.6%	1.1%	0.9%
		(MIC ≥ 8)	1	0	0	1	1	6	1	7	13	13
	Ketolides	Telithromycin	Not	Not	Not	Not	Not	1.0%	1.6%	1.5%	2.5%	1.5%
		(MIC ≥ 16)	Tested	Tested	Tested	Tested	Tested	9	13	16	29	22
	Macrolides	Azithromycin	1.9%	2.1%	2.0%	0.9%	0.6%	1.9%	1.7%	2.0%	3.0%	1.7%
		(MIC ≥ 8)	6	8	7	3	2	17	14	22	35	25
		Erythromycin	1.2%	2.1%	1.4%	0.9%	0.3%	1.8%	1.7%	2.0%	3.0%	1.7%
		(MIC ≥ 32)	4	8	5	3	1	16	14	22	35	25
	Quinolones	Ciprofloxacin	14.8%	19.5%	20.1%	17.7%	19.0%	21.7%	19.6%	26.0%	23.0%	22.9%
		(MIC ≥ 4)	48	75	71	58	66	193	160	286	267	344
		Nalidixic acid	16.7%	20.3%	20.6%	18.9%	19.6%	22.4%	20.1%	26.5%	23.6%	23.2%
		(MIC ≥ 64)	54	78	73	62	68	199	164	291	273	348
II	Phenicols	Chloramphenicol	0.0%	0.3%	0.3%	0.0%	1.4%	Not	Not	Not	Not	Not
		(MIC ≥ 32)	0	1	1	0	5	Tested	Tested	Tested	Tested	Tested
		Florfenicol‡	Not	Not	Not	Not	Not	0.6%	0.0%	0.0%	0.5%	0.5%
		Susceptible breakpoint: (MIC ≤ 4)	Tested	Tested	Tested	Tested	Tested	5	0	0	6	8
	Tetracyclines	Tetracycline	38.3%	40.9%	41.2%	38.4%	46.1%	40.6%	46.0%	44.4%	43.7%	43.5%
		(MIC ≥ 16)	124	157	146	126	160	361	375	488	507	653
III	Lincosamides	Clindamycin	0.9%	2.1%	2.0%	0.6%	2.0%	1.5%	2.0%	1.7%	2.8%	1.4%
		(MIC ≥ 8)	3	8	7	2	7	13	16	19	32	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; Rank 3, Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Table 48. Resistance patterns of *Campylobacter* isolates, 2000–2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates	324	384	354	328	347	890	816	1100	1159	1502
	%	%	%	%	%	%	%	%	%	%
	n	n	n	n	n	n	n	n	n	n
No resistance detected	52.2%	49.2%	48.3%	50.9%	46.1%	48.4%	43.9%	45.2%	45.8%	46.4%
	169	189	171	167	160	431	358	497	531	697
Resistance ≥ 1 CLSI class*	47.8%	50.8%	51.7%	49.1%	53.9%	51.6%	56.1%	54.8%	54.2%	53.6%
	155	195	183	161	187	459	458	603	628	805
Resistance ≥ 2 CLSI classes*	8.0%	13.3%	12.7%	8.5%	14.1%	13.6%	12.0%	17.5%	15.6%	13.8%
	26	51	45	28	49	121	98	192	181	207
Resistance ≥ 3 CLSI classes*	0.9%	1.6%	1.1%	0.9%	1.2%	1.5%	1.5%	1.7%	2.5%	1.6%
	3	6	4	3	4	13	12	19	29	24
Resistance ≥ 4 CLSI classes*	0.3%	0.3%	0.0%	0.3%	0.3%	0.3%	0.5%	0.9%	1.1%	1.0%
	1	1	0	1	1	3	4	10	13	15
Resistance ≥ 5 CLSI classes*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%
	0	0	0	0	0	0	0	0	3	4

* CLSI: Clinical and Laboratory Standards Institute

Table 49. Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter jejuni* isolates to antimicrobial agents, 2009 (N=1355)

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	0.7	[0.3 - 1.3]				1.1	23.0	63.2	11.7	0.3					0.7			
	Ketolide	Telithromycin	0.5	1.4	[0.8 - 2.2]			< 0.1	0.1	8.0	33.6	38.4	16.2	1.8	0.5	1.4					
	Macrolides	Azithromycin	0.0	1.5	[1.0 - 2.4]	0.7	16.8	48.0	26.7	5.8	0.4	< 0.1							1.5		
		Erythromycin	0.0	1.5	[1.0 - 2.4]				1.7	25.2	48.7	18.7	3.6	0.4					1.5		
	Quinolones	Ciprofloxacin	0.0	23.0	[20.8 - 25.4]		1.3	29.2	40.6	4.9	1.0	0.1		1.3	9.4	7.1	3.3	1.4	0.4		
		Nalidixic acid	0.0	23.2	[21.0 - 25.5]									64.1	11.1	1.6		2.6	20.6		
II	Phenicols	Florfenicol††	0.0	0.6	[0.3 - 1.2]					< 0.1	14.8	70.3	12.2	2.0	0.5	< 0.1					
	Tetracyclines	Tetracycline	0.1	43.4	[40.7 - 46.1]			4.6	27.6	16.3	5.3	2.1	0.4	< 0.1	0.1	0.4	2.8	10.6	29.5		
III	Lincosamides	Clindamycin	0.2	1.3	[0.8 - 2.1]		1.5	17.3	45.4	27.8	5.0	1.3	0.1	0.2	0.3	0.4	0.7				

* 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; 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

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

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

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

Figure 26. Antimicrobial resistance pattern for *Campylobacter jejuni*, 2009

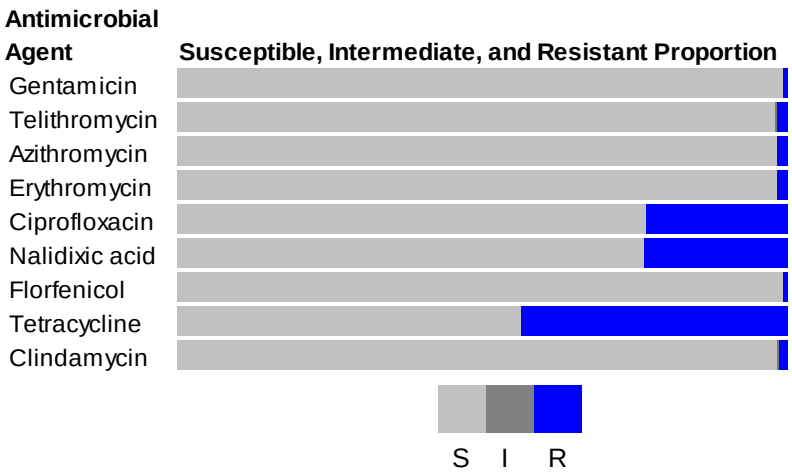


Table 50. Percentage and number of *Campylobacter jejuni* isolates resistant to antimicrobial agents, 2000–2009

Year			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Isolates			306	365	329	303	320	791	709	992	1046	1355
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 4	0.0% 0	0.7% 7	1.1% 12	0.7% 9
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5	0.8% 6	1.0% 10	2.2% 23	1.4% 19
	Macrolides	Azithromycin (MIC ≥ 8)	1.6% 5	1.9% 7	1.8% 6	0.3% 1	0.6% 2	1.8% 14	0.8% 6	1.6% 16	2.3% 24	1.5% 21
		Erythromycin (MIC ≥ 32)	1.0% 3	1.9% 7	1.2% 4	0.3% 1	0.3% 1	1.6% 13	0.8% 6	1.6% 16	2.3% 24	1.5% 21
	Quinolones	Ciprofloxacin (MIC ≥ 4)	14.7% 45	18.4% 67	20.7% 68	17.2% 52	18.1% 58	21.5% 170	19.5% 138	25.8% 256	22.4% 234	23.0% 312
		Nalidixic acid (MIC ≥ 64)	16.0% 49	18.9% 69	21.3% 70	17.8% 54	18.4% 59	21.9% 173	19.0% 135	26.1% 259	22.8% 239	23.2% 314
II	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.6% 5	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.5% 4	0.0% 0	0.0% 0	0.6% 6	0.6% 8
	Tetracyclines	Tetracycline (MIC ≥ 16)	39.2% 120	40.3% 147	41.3% 136	38.3% 116	46.9% 150	41.8% 331	47.4% 336	44.8% 444	44.3% 463	43.4% 588
III	Lincosamides	Clindamycin (MIC ≥ 8)	0.7% 2	1.9% 7	1.8% 6	0.0% 0	2.2% 7	1.1% 9	1.0% 7	1.3% 13	2.1% 22	1.3% 18

* Rank of antimicrobials based on World Health Organization's categorization of critical importance in human medicine (Table I): Rank 1, Critically Important; Rank 2, Highly Important; Rank 3, Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

Table 51. Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter coli* isolates to antimicrobial agents, 2009 (N=143)

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	2.8	[0.8 - 7.0]				0.7	5.6	48.3	39.9	2.8					2.8			
	Ketolide	Telithromycin	4.9	2.1	[0.4 - 6.0]			0.7	0.7	11.2	18.9	21.0	21.0	19.6	4.9	2.1					
	Macrolides	Azithromycin	0.0	2.8	[0.8 - 7.0]	0.7	2.1	18.2	47.6	25.2	3.5								2.8		
		Erythromycin	0.0	2.8	[0.8 - 7.0]			0.7	0.7	5.6	34.3	29.4	16.8	9.1	0.7			0.7	2.1		
	Quinolones	Ciprofloxacin	0.7	21.7	[15.2 - 29.3]			15.4	37.8	15.4	8.4	0.7	0.7	3.5	5.6	9.8	1.4	1.4			
		Nalidixic acid	0.7	23.1	[16.4 - 30.9]									43.4	28.0	4.9	0.7	7.0	16.1		
II	**Phenicols**	Florfenicol††	0.0	0.0	[0.0 - 2.5]						7.0	56.6	29.4	7.0							
	Tetracyclines	Tetracycline	0.0	44.8	[36.4 - 53.3]			1.4	14.7	17.5	12.6	8.4	0.7					3.5	41.3		
III	**Lincosamides**	Clindamycin	1.4	2.1	[0.4 - 6.0]		0.7	5.6	16.8	28.7	29.4	11.9	3.5	1.4		1.4	0.7				

* 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; 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
¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to 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 27. Antimicrobial resistance pattern for *Campylobacter coli*, 2009

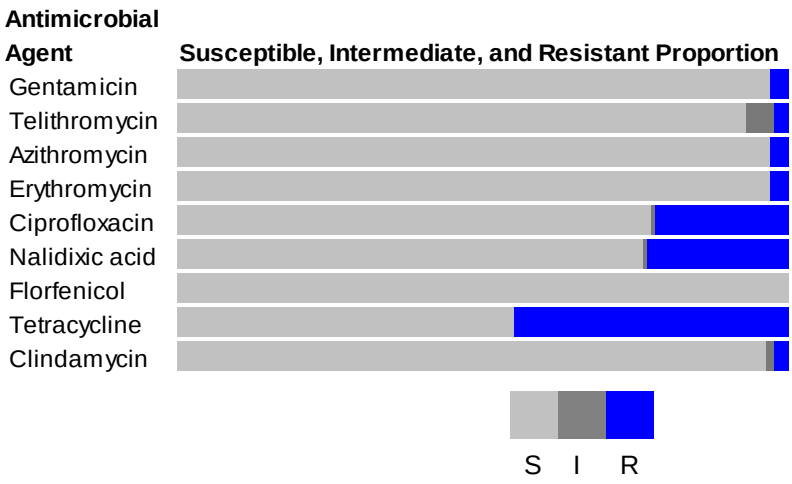


Table 52. Percentage and number of *Campylobacter coli* isolates resistant to antimicrobial agents, 2000–2009

Year / Total Isolates			2000 12	2001 17	2002 25	2003 22	2004 26	2005 98	2006 97	2007 105	2008 110	2009 143
Rank*	CLSI† Antimicrobial Class	Antibiotic (Resistance breakpoint)										
I	Aminoglycosides	Gentamicin (MIC ≥ 8)	8.3% 1	0.0% 0	0.0% 0	4.5% 1	0.0% 0	2.0% 2	1.0% 1	0.0% 0	0.9% 1	2.8% 4
	Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	4.1% 4	7.2% 7	5.7% 6	5.5% 6	2.1% 3
	Macrolides	Azithromycin (MIC ≥ 8)	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3	8.2% 8	5.7% 6	10.0% 11	2.8% 4
		Erythromycin (MIC ≥ 32)	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3	8.2% 8	5.7% 6	10.0% 11	2.8% 4
	Quinolones	Ciprofloxacin (MIC ≥ 4)	25.0% 3	47.1% 8	12.0% 3	22.7% 5	30.8% 8	23.5% 23	21.6% 21	28.6% 30	30.0% 33	21.7% 31
		Nalidixic acid (MIC ≥ 64)	25.0% 3	47.1% 8	12.0% 3	22.7% 5	34.6% 9	26.5% 26	23.7% 23	30.5% 32	30.0% 33	23.1% 33
II	Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested
		Florfenicol‡ Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Tetracyclines	Tetracycline (MIC ≥ 16)	25.0% 3	58.8% 10	40.0% 10	45.5% 10	38.5% 10	30.6% 30	39.2% 38	41.9% 44	40.0% 44	44.8% 64
III	Lincosamides	Clindamycin (MIC ≥ 8)	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	4.1% 4	9.3% 9	5.7% 6	9.1% 10	2.1% 3

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; Rank 3, Important
† CLSI: Clinical and Laboratory Standards Institute
‡ Only a susceptible breakpoint (≤ 4 µg/ml) has been established. In this report, isolates with an MIC ≥ 8 µg/ml are categorized as resistant

References

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

Clinical and Laboratory Standards Institute. Methods for Antimicrobial Dilution and Disk Susceptibility Testing of Infrequently Isolated or Fastidious Bacteria: Approved Guideline. CLSI Document M45-A2. CLSI, Wayne, Pennsylvania, 2010.

Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; Twentieth Informational Supplement. CLSI Document M100-S20-. CLSI, Wayne, Pennsylvania, 2010.

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

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

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

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

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

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

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

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

NARMS Publications in 2009

Folster JP, Rickert R, Barzilay EJ, Whichard JM. Identification of the aminoglycoside resistance determinants, armA and rmtC among non-Typhi *Salmonella* isolates from humans in the United States. Antimicrob Agents Chemother. 2009 Oct;53(10): 4563-4.

Hendricksen RS, Mikoleit M, Kornschober C, Rickert RL, Van Duyne S, Kjelso C, Hasman H, Cormican M, Mevius D, Threlfall EJ, Angulo FJ. Emergence of multidrug-resistant *Salmonella* Concord infections in Europe and the United States in children adopted from Ethiopia, 2003-2007. Pediatr Infect Dis J. 2009 Sept;28(9):814-8.

Hendricksen RS, Seyfarth AM, Jensen AB, Whichard JM, Karlsmose S, Joyce K, Mikoleit M, DeLong SM, Weill FX, Aidara-Kane A, Lo Fo Wong DM, Angulo FJ, Wegener HC, Aarestrup FM. Results of use of WHO Global Salm-Surv external quality assurance system for antimicrobial susceptibility testing of *Salmonella* isolates from 2000-2007. J Clin Microbiol. 2009 Jan;47(1):79-85.

Lynch M, Blanton EM, Bulens S, Polyak C, Stevenson J, Medalla F, Barzilay E, Joyce K, Barrett T, Mintz ED. Typhoid fever in the United States, 1999-2006. JAMA. 2009 Aug;302(8): 859-65.

Petrov P, Hendricksen RS, Kantardjev T, Asseva G, Sorensen G, Fields P, Mikoleit M, Whichard JM, McQuiston JR, Torpdahi M, Aarestrup FM, Angulo FJ. Occurrence and characterization of *Salmonella enterica* subspecies *enterica* serovar 9,12:I,v:- strains from Bulgaria, Denmark, and the United States. Eur J Clin Microbiol Infect Dis. 2009

Sjolund-Karlsson M, Folster JP, Pecic G, Joyce K, Medalla F, Rickert R, Whichard JM. Emergence of plasmid-mediated quinolone resistance among non-Typhi *Salmonella enterica* isolates from humans in the United States. Antimicrob Agents Chemother. 2009 May; 53(5):2142-4.

Appendix A

Summary of *Escherichia coli* Resistance Surveillance Pilot Study, 2009

***Escherichia coli* working group**

Centers for Disease Control and Prevention

Frederick Angulo, Ezra Barzilay, Patricia Griffin, Amy Krueger, Rebecca Howie, Kathryn Lupoli, Andre McCullough, Kevin Joyce, Felicita Medalla
Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases
National Center for Infectious Diseases

Michigan Department of Community Health and William Beaumont Hospital
Sue Donabedian, Mary Beth Perry, Mary Thill, Mark Zervos

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 2009 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 2009, 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 and subsequent biochemical confirmation. 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.

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

RESULTS

In 2009, CDC received 45 isolates; of these, 45 (100.0%) were viable *E. coli* isolates. MIC was determined for *E. coli* isolates for 15 antimicrobial agents (Table 54). Of the 45 *E. coli* isolates, 22.2% (10/45) were resistant to ampicillin, 17.8% (8/45) to sulfisoxazole, 17.8% (8/45) to tetracycline, and 8.9% (4/45) to nalidixic acid (Table 55).

Multidrug-Resistant *E. coli*

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

- 11.1% (5/45) of *E. coli* isolates were resistant to three or more classes of antimicrobial agents (Table 56).
- 8.9% (4/45) of *E. coli* isolates were resistant to five or more classes of antimicrobial agents (Table 56).

Clinically Important Resistance

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

- 2.2% (1/45) of *E. coli* isolates were resistant to ceftriaxone (Table 55).
- 8.9% (4/45) of *E. coli* isolates were resistant to ciprofloxacin (Table 55).

REFERENCES

1. Levy SB, Fitzgerald GB, Macone AB. Changes in intestinal flora of farm personnel after introduction of a tetracycline-supplemented feed on a farm. The New England Journal of Medicine 1976;295:583–8.
2. Schaberg DR, Culver DH, Gaynes RP. Major trends in the microbial etiology of nosocomial infection. The American Journal of Medicine 1991;91(Suppl 3B):3B-72S–5S.
3. Van den Bogaard AE, Stobberingh EE. Epidemiology of resistance to antibiotics: links between animals and humans. International Journal of Antimicrobial Agents 2000;14:327–35.
4. Corpet DE. Antibiotic resistance from food. The New England Journal of Medicine 1988;318:1206–7.
5. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; Twentieth Informational Supplement. CLSI Document M100-S20. CLSI, Wayne, Pennsylvania, 2010.

Table 53. Antimicrobial agents used for susceptibility testing of *Escherichia coli*, 2009

CLSI class	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	MIC Interpretive Standard (µg/mL)		
			Susceptible	Intermediate	Resistant
Aminoglycosides	Amikacin	0.5 – 64	≤16	32	≥64
	Gentamicin	0.25 – 16	≤4	8	≥16
	Kanamycin	8 – 64	≤16	32	≥64
	Streptomycin	32 – 64	≤32		≥64
β –lactam / β-lactamase inhibitor combinations	Amoxicillin–Clavulanic acid	1/0.5 – 32/16	≤8/4	16/8	≥32/16
Cephems	Cefoxitin	0.5 – 32	≤8	16	≥32
	Ceftiofur	0.12– 8	≤2	4	≥8
	Ceftriaxone	0.25 – 64	≤1	2	≥4
Folate pathway inhibitors	Sulfisoxazole	16 – 256	≤256		≥512
	Trimethoprim–Sulfamethoxazole	0.12/2.4 – 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 54. Minimum inhibition concentrations (MICs) and resistance of *Escherichia coli* isolates to antimicrobial agents, 2009 (N=45)

Rank*	CLSI† Antimicrobial Class	Antimicrobial Agent	% of isolates			Percent of all isolates with MIC (µg/mL)**													
			%I‡	%R§	[95% CI]¶	0.015	0.03	0.06	0.125	0.25	0.50	1	2	4	8	16	32	64	128	256	512
I	**Aminoglycosides**	Amikacin	0.0	0.0	[0.0 - 7.9]						6.7	31.1	57.8	4.4							
		Gentamicin	0.0	0.0	[0.0 - 7.9]					15.6	75.6	6.7	2.2								
		Streptomycin	N/A	8.9	[2.4 - 21.2]												91.1	4.4	4.4		
	β-lactam / β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid	2.2	2.2	[0.03 - 11.8]							8.9	22.2	44.4	20.0	2.2	2.2				
	Cephems	Ceftiofur	0.0	2.2	[0.03 - 11.8]					8.9	71.1	15.6	2.2			2.2					
		Ceftriaxone	0.0	2.2	[0.03 - 11.8]					97.8							2.2				
	Penicillins	Ampicillin	0.0	22.2	[11.2 - 37.1]							6.7	66.7	2.2	2.2			22.2			
	Quinolones	Ciprofloxacin	0.0	8.9	[2.4 - 21.2]	88.9	2.2								8.9						
		Nalidixic acid	N/A	8.9	[2.4 - 21.2]							33.3	46.7	8.9		2.2		8.9			
II	**Aminoglycosides**	Kanamycin	0.0	6.7	[1.4 - 18.3]										93.3				6.7		
	Cephems	Cefoxitin	0.0	6.7	[1.4 - 18.3]						2.2	15.6	44.4	28.9	2.2		4.4	2.2			
	Folate pathway inhibitors	Sulfisoxazole	N/A	17.8	[8.0 - 32.1]											33.3	44.4	4.4			17.8
		Trimethoprim-sulfamethoxazole	N/A	8.9	[2.4 - 21.2]					86.7	4.4				8.9						
	Phenicols	Chloramphenicol	4.4	2.2	[0.03 - 11.8]								8.9	66.7	17.8	4.4		2.2			
	Tetracyclines	Tetracycline	2.2	17.8	[8.0 - 32.1]									80.0	2.2		2.2	15.6			

* 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

¶ The 95% confidence intervals (CI) for percent resistant (%R) were calculated using the Paulson-Camp-Pratt approximation to 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 28. Antibiotic resistance pattern for *Escherichia coli*, 2009

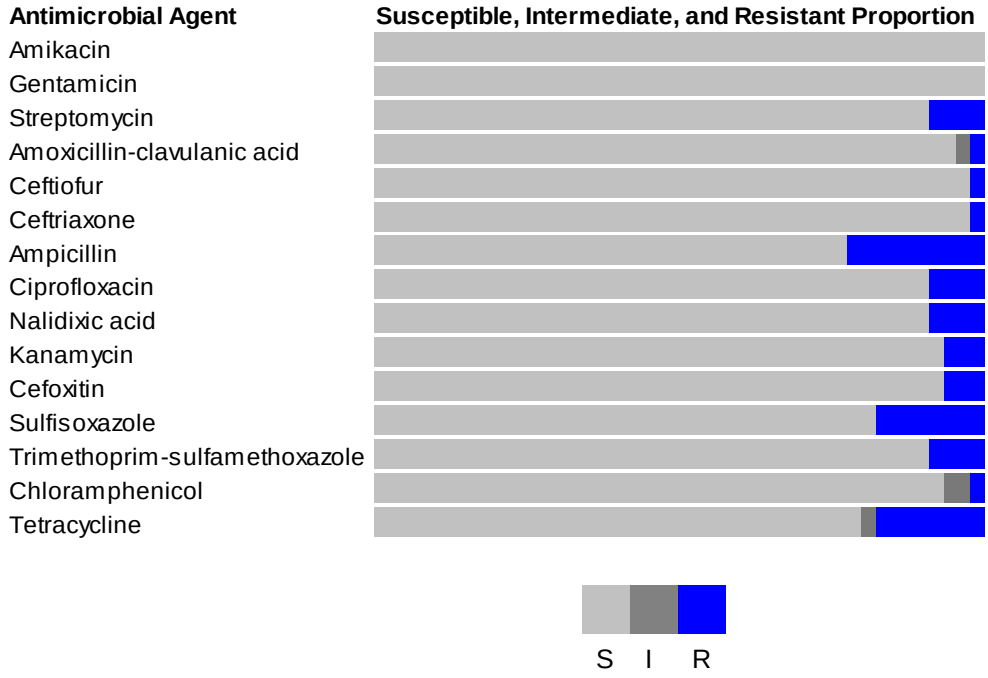


Table 55. Percentage and number of *Escherichia coli* isolates resistant to antimicrobial agents, 2004–2009

Year			2004	2005	2006	2007	2008	2009
Total Isolates			151	119	82	66	57	45
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
		Gentamicin (MIC ≥ 16)	2.0% 3	3.4% 4	3.7% 3	3.0% 2	0.0% 0	0.0% 0
		Streptomycin (MIC ≥ 64)	10.6% 16	14.3% 17	7.3% 6	13.6% 9	8.8% 5	8.9% 4
	β-lactam/β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.6% 4	4.2% 5	3.7% 3	0.0% 0	3.5% 2	2.2% 1
	Cephems	Ceftiofur (MIC ≥ 8)	0.0% 0	0.8% 1	0.0% 0	0.0% 0	1.8% 1	2.2% 1
		Ceftriaxone (MIC ≥ 64)	0.0% 0	0.8% 1	0.0% 0	0.0% 0	1.8% 1	2.2% 1
	Penicillins	Ampicillin (MIC ≥ 32)	24.5% 37	26.1% 31	28.0% 23	21.2% 14	26.3% 15	22.2% 10
	Quinolones	Ciprofloxacin (MIC ≥ 4)	3.3% 5	7.6% 9	4.9% 4	7.6% 5	10.5% 6	8.9% 4
		Nalidixic Acid (MIC ≥ 32)	9.3% 14	9.2% 11	11.0% 9	10.6% 7	12.3% 7	8.9% 4
II	Aminoglycosides	Kanamycin (MIC ≥ 64)	2.0% 3	0.0% 0	0.0% 0	1.5% 1	1.8% 1	6.7% 3
	Cephems	Cefoxitin (MIC ≥ 32)	2.6% 4	0.8% 1	1.2% 1	0.0% 0	0.0% 0	6.7% 3
	Folate pathway inhibitors	Sulfisoxazole‡ (MIC ≥ 512)	17.9% 27	18.4% 21	17.1% 14	24.2% 16	14.0% 8	17.8% 8
		Trimethoprim-sulfamethoxazole‡ (MIC ≥ 4)	11.3% 17	14.9% 17	12.2% 10	15.2% 10	12.3% 7	8.9% 4
	Phenicols	Chloramphenicol (MIC ≥ 32)	1.3% 2	2.5% 3	3.7% 3	3.0% 2	5.3% 3	2.2% 1
	Tetracyclines	Tetracycline (MIC ≥ 16)	13.2% 20	19.3% 23	14.6% 12	21.2% 14	14.0% 8	17.8% 8

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

† CLSI: Clinical and Laboratory Standards Institute

‡ Results unavailable for 5 isolates

Table 56. Resistance patterns of *Escherichia coli* isolates, 2004–2009

Year Total Isolates	2004 151	2005 119	2006 82	2007 66	2008 57	2009 45
	% n	% n	% n	% n	% n	% n
No resistance detected	62.9% 95	63.0% 75	63.4% 52	65.2% 43	64.9% 37	68.9% 31
Resistance ≥1CLSI class*	37.7% 57	37.0% 44	36.6% 30	34.8% 23	35.1% 20	31.1% 14
Resistance ≥2 CLSI classes*	17.9% 27	22.7% 27	22.0% 18	21.2% 14	21.1% 12	13.3% 6
Resistance ≥3 CLSI classes*	9.9% 15	14.3% 17	15.9% 13	15.2% 10	12.3% 7	11.1% 5
Resistance ≥4 CLSI classes*	5.3% 8	9.2% 11	8.5% 7	9.1% 6	8.8% 5	8.9% 4
Resistance ≥5 CLSI classes*	3.3% 5	7.6% 9	1.2% 1	4.5% 3	7.0% 4	8.9% 4
At least ACSSuT†	1.3% 2	0.8% 1	0.0% 0	0.0% 0	1.8% 1	0.0% 0
At least ACT/S‡	1.3% 2	0.8% 1	1.2% 1	1.5% 1	3.5% 2	0.0% 0
At least ACSSuTAuCx§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ceftriaxone and nalidixic acid resistant	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.8% 1	2.2% 1

* CLSI: Clinical and Laboratory Standards Institute

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

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

§ ACSSuTAuCx: resistance to ACSSuT, amoxicillin-clavulanic acid, ceftriaxone