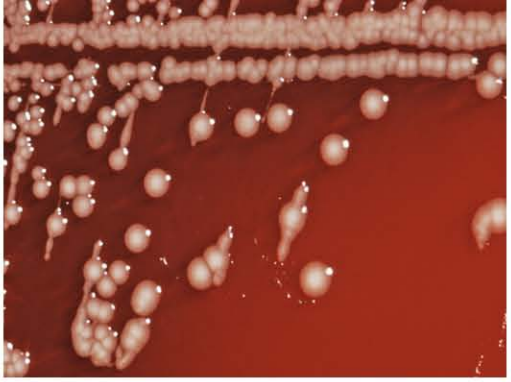


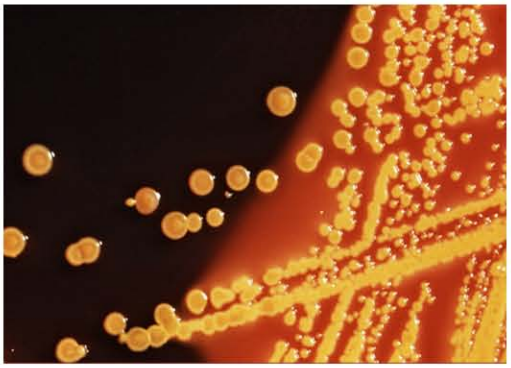
NARMS

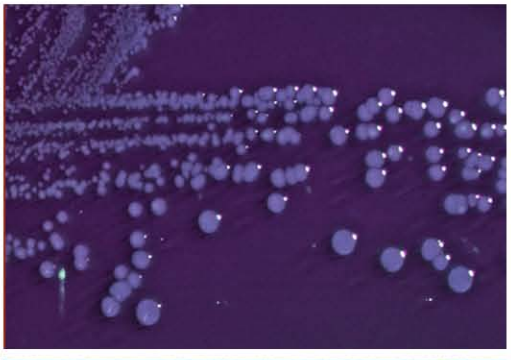
National Antimicrobial Resistance Monitoring System: Enteric Bacteria

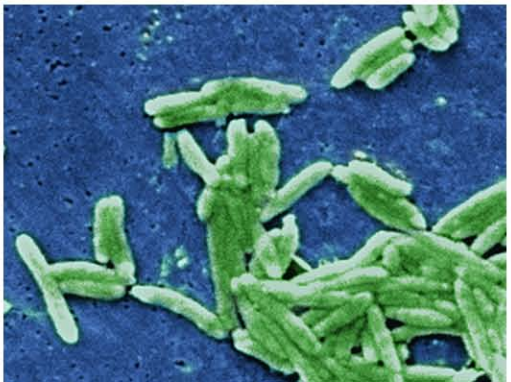
NARMS

2005

Human Isolates Final Report







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NARMS Working Group

Centers for Disease Control and Prevention

Enteric Diseases Epidemiology Branch
Division of Foodborne Bacterial and Mycotic Diseases
Coordinating Center for Infectious Diseases

Frederick Angulo
Timothy Barrett
Ezra Barzilay
Richard Bishop
Cheryl Bopp
Tom Chiller
Patricia Fields
Jason Folster
Kathryn Gay
Lewis Graves
Sharon Greene
Patricia Griffin
Robert Michael Hoekstra
Rebecca Howie
Kevin Joyce
Katie Joyce
Amy Krueger
Ewelina Lyszkowicz
Amie May ThurdeKoos
Felicita Medalla
Terrell Miller
Michael Omondi
Gary Pecic
Regan Rickert
Lauren Stancik Rosenthal
Jillian Schwenk
Maria Sjölund
Jacinta Smith
Jennifer Stevenson
Andrew Stuart
Robert Tauxe
Jean Whichard
Jennifer Yam

U.S. Food and Drug Administration

Center for Veterinary Medicine

Marcia Headrick
Linda Tollefson
David White

Participating State and Local Health Departments

Alabama Department of Public Health
LaDonna Cranidiotis
J. P. Lofgren
Sharon Massingale
Ethel Oldham
Joanna Roberson

Alaska Department of Health and Social Services
Mary Anctil
Tricia Franklin
Sam Obedi
Shellie Smith
Catherine Xavier

Arizona Department of Health Services
Graham Briggs
Mary Finnerty
Clare Kioski
Ken Komatsu
Stephanie Kreis
William Slanta
Victor Waddell

Arkansas Department of Health
Dennis Berry
Joanie Jones-Harp
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
James Beebe
Alicia Cronquist
Joyce Knutsen
Michael Rau

Connecticut Department of Public Health
Bob Howard
Sharon Hurd
Charles Welles

Delaware Health and Social Services
Leroy Hatcock
Gaile McLaughlin
Marjorie Postell
Debra Rutledge
Sue Shore

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
Onesia Bishop
Keri Goede
Vern Juchau
Joan Rogers

Idaho Department of Health and Welfare
Susan Dana
Colleen Greenwalt
Vivian Lockary

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

Indiana State Department of Health
Brent Barrett
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
Jennifer Everman
Karim George
Matt Nelson
Meloney Russell

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

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

Maine Department of Human Services
Geoff Beckett
Kathleen Gensheimer
Audrey Littlefield
James Martin
Jeff Randolph
Vicki Rea
Susan Schow
Lori Webber
Donna Wrigley

Maryland Department of Health and Mental Hygiene and University of Maryland School of Medicine, Department of Epidemiology and Preventive Medicine
Marisa Caipo
Karen Cuenco
Julie Kiehlbauch
Melanie Megginson
J. Glenn Morris, Jr.
Jonigene Ruark
Pat Ryan

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

Michigan Department of Community Health
Carrie Anglewicz
Frances Downes
James Rudrik
William Schneider
Dawn Sievert
Patricia Somsel

Minnesota Department of Health
John Besser
Billie Juni
Fe Leano
Kirk Smith
Sara Stenzel
Charlotte Taylor
Theresa Weber
Stephanie Wedel

Mississippi Department of Health
Jannifer Anderson
Kay Beggerly
Jane Campbell
Sheryl Hand
Cathie Hoover
Mills McNeill
Daphne Ware

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

Montana Department of Public Health and Human Services
Jim Murphy
Anne Weber
Susanne Zanto

Nebraska Health and Human Services System and University of Nebraska Medical Center, Department of Pathology and Microbiology
Jude Eberhardt
Paul Fey
Jodi Garrett
Peter Iwen
Tom Safranek

Nevada Department of Health and Human Services
Patricia Armour
Stephanie Ernaga
Jaime Frank
Paul Hug
Bradford Lee
Matt Mikoleit
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
John Brook
Sylvia Matiuck
Keith Pilot

New Mexico Department of Health
Bernadette Albanese
Joan Baumbach
Sonya Flores
Rey Griego
Debra Horensky
David Mills
Lisa Onsichuk
Debbie Sena Johnson
Erica Pierce
C. Mack Sewell
Karla Thornton
William Wiese

New York City Department of Health
Alice Agasan
Ludwin Chicaiza
Sharon Balter
Heather Hanson
Dennis Kinney
Vasudha Reddy

New York State Department of Health
Amy Davignon
Nellie Dumas
Yvette Khachadourian
Tammy Quinlan
Dale Morse
Tim Root
Shelley Zansky

North Carolina Department of Health and Human Services
Denise Griffin
Brad Jenkins

North Dakota Department of Health
Lisa Elijah
Julie Goplin
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
Jeff Mathewson
Mike McDermott

Oregon Department of Human Resources
Debbie Berquist
Cathy Ciaffoni
Paul Cieslak
Emilio DeBess
Julie Hatch
Mayland Heim
Steve Mauvais
Beletsachew Shiferaw
Larry Stauffer
Ivor Thomas
Janie Tierheimer
Robert Vega
Veronica Williams

Pennsylvania Department of Health
Wayne Chmielecki
Tait James
Nkuchia Mikanatha
James Rankin
Stanley Reynolds
Veronica Urdaneta
Kirsten Waller
Nancy Warren
Gisela Withers

Rhode Island Department of Health
Cheryl Campbell
Tara Cooper
Kerry Patterson
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
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Mike Smith
Yvette Thomas

Tennessee Department of Health
Jeanette Dill
Cynthia Graves
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Texas Department of State Health Services
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Leslie Bullion
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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
Valerie Cook
Eunice H. Froeliger
Christine LaBarre
Mary Spayne
Patsy Tassler

Virginia Division of Consolidated Laboratory Services and Virginia Department of Health
Ellen Basinger
Sherry Giese
Sally Henderson
Mary Mismas
Ann Munson
Denise Toney

Washington Department of Health
David Boyle
Jennifer Breezee
Romesh Gautom
Donna Green
Yolanda Houze
Jinxin Hu
Kathryn MacDonald

West Virginia Department of Health and Human Resources
Danae Bixler
Christi Clark
Maria del Rosario
Loretta Haddy
Andrea Labik
Doug McElfresh
Ron Ramirez
Connie Smith

Wisconsin Department of Health and Family Services
John Archer
Susan Ahrabi-Fard
Jeffrey Davis
Diep Hoang-Johnson
Ronald Laessig
Tim Monson
Dave Warshauer
Mark Wegner

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

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Information Available Online

All CDC NARMS Annual Reports and additional information about NARMS are posted on the CDC NARMS website: http://www.cdc.gov/narms

Information on CDC's National Surveillance Team of the Enteric Diseases Epidemiology Branch is available at http://www.cdc.gov/nationalsurveillance

Additional general information about the NARMS surveillance program is posted on the Food and Drug Administration's Center for Veterinary Medicine website: http://www.fda.gov/cvm/narms_pg.html

Information about animal isolates in NARMS is available on the U.S. Department of Agriculture—Agricultural Research Service website: http://www.ars.usda.gov/Main/docs.htm?docid=14491

General information about antimicrobial resistance is posted on the CDC website: http://www.cdc.gov/drugresistance

Information regarding CDC's Get Smart on the Farm program is available at http://www.cdc.gov/narms/get_smart.htm

Information regarding CDC's Get Smart program is available at http://www.cdc.gov/drugresistance/community

General information about CDC's Foodborne Diseases Active Surveillance Network (FoodNet) is available at http://www.cdc.gov/foodnet

General information about the National Molecular Subtyping Network for Foodborne Disease Surveillance (PulseNet) is available at http://www.cdc.gov/pulsenet

General information about the World Health Organization Global Salm-Surv is available at http://www.who.int/salmsurv/en

CDC *Salmonella* Annual Summaries are posted on the PHLIS website: http://www.cdc.gov/ncidod/dbmd/phlisdata/salmonella.htm

CDC *Shigella* Annual Summaries also posted on the PHLIS website: http://www.cdc.gov/ncidod/dbmd/phlisdata/shigella.htm

General information about the Foodborne and Diarrheal Diseases Branch at CDC is available at http://www.cdc.gov/enterics

What is New in the 2005 NARMS Report?

A New Look to NARMS

NARMS has a new look. Blue headline boxes differentiate between sections to facilitate navigating the annual report. Boxes in a blue double line border are at the beginning of each section, which consist of the major take home points of the NARMS 2005 Annual report.

NARMS gets interactive. The table of contents, list of tables, list of figures and all referenced tables and figures in the text are interactive, allowing quick access to tables and figures.

Antimicrobial Agents of Critical Importance

In May 2007, experts selected by the World Health Organization met in an expert consultation in Copenhagen to evaluate critically important antimicrobial agents for human medicine. The report from this meeting defines two criteria for antimicrobial agents important in human medicine: Criterion 1 is that the antimicrobial agent is the sole therapy or one of few alternatives to treat serious human disease. Criterion 2 is that the antimicrobial agent is used to treat diseases caused by organisms that may be transmitted via non-human sources or diseases caused by organisms that may acquire resistant genes from non-human sources. "Critically Important" antimicrobial agents are those that meet both criteria. "Highly Important" antimicrobial agents are those that meet one criteria. "Important" antimicrobial agents are those that meet neither criteria one nor two.[1] The antimicrobial agents in the NARMS annual report tables are ordered using these criteria (Table I).

Antimicrobial Resistance in Humans

A separate list of antimicrobial agents used for susceptibility testing is shown for *Campylobacter*, instead of an overall list showing antimicrobial agents for *Campylobacter, Salmonella, Shigella*, and *E. coli* O157 used in previous reports. The new *Campylobacter* table consists of 10 antimicrobial agents, of which two agents, florfenicol and telithromycin, were added in 2005. Minimum inhibitory concentrations (MICs) are interpreted using criteria established by the Clinical and Laboratory Standards Institute (CLSI) when available. For agents tested in NARMS for *Campylobacter*, CLSI breakpoints have only been published for erythromycin, ciprofloxacin, and tetracycline. If CLSI breakpoints are not available, we used breakpoints from the CDC-NARMS counterpart at the Food and Drug Administration (FDA) Center for Veterinary Medicine.

An explanation on "how to read a table," showing the distribution of MICs for antimicrobial agents tested, which we refer to as "squashtogram", has been provided to assist the reader with the different parts of each table (Figure 1.01).

Proportional figures are new additions that visually display data from squashtograms for an immediate comparative summary of resistance in specific pathogens and serotypes. These figures are a categorical visual aid for the interpretation of MIC values. For most antimicrobial agents tested, three categories (susceptible, intermediate, and resistant) are used to interpret MICs. The proportion representing each category is shown in a horizontal proportional bar chart (Figure 1.02).

[1] World Health Organization. Critically Important Antimicrobials for Human Medicine: Categorization for the Development of Risk Management Strategies to contain Antimicrobial Resistance due to Non-Human Antimicrobial Use. Report of the second WHO Expert Meeting Copenhagen, 29-31 May 2007.

Introduction

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

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

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

This annual report includes CDC's surveillance data for 2005 for clinical non-Typhi *Salmonella, Salmonella* Typhi, *Shigella*, and *E. coli* O157 isolates. Resistance trends and comparisons with previous years are included when appropriate. Antimicrobial subclasses defined by CLSI are used in data presentation and analysis. CLSI subclasses constitute major classifications of antimicrobial agents, e.g., aminoglycosides and cephalosporins.

This report also includes data from the *Escherichia coli* Resistance Study, which is part of NARMS surveillance on commensal bacteria. Appendix A summarizes the *Escherichia coli* Resistance Surveillance Pilot Study conducted in 2005. Appendix B provides some examples of how the NARMS MIC distributions of *Escherichia coli* compare with the distributions defined by the European Committee on Antimicrobial Susceptibility Testing (EUCAST).

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

Summary of NARMS 2005 Surveillance Data

Population

In 2005, all 50 states participated in NARMS, representing approximately 296 million persons (Table II). Surveillance for antimicrobial resistance included non-Typhi *Salmonella, Salmonella* Typhi, *Shigella*, and *Escherichia coli* O157. *Campylobacter* resistance to antimicrobial agents was monitored in 10 states that also participated in the Foodborne Diseases Active Surveillance Network (FoodNet), representing approximately 44.9 million persons (15.2% of the U.S. population).

Clinically Important Antimicrobial Resistance Patterns

In the United States, certain quinolones (e.g., the fluoroquinolone ciprofloxacin) and third-generation cephalosporins (e.g., ceftriaxone) are antimicrobial agents commonly used to treat severe *Campylobacter* and *Salmonella* infections, including *Salmonella* serotype Typhi, the organism that causes typhoid fever. Nalidixic acid is an elementary quinolone; resistance to nalidixic acid correlates with decreased susceptibility to ciprofloxacin and possible treatment failure. Ceftiofur is a third-generation cephalosporin used in food animals in the United States; resistance to ceftiofur correlates with decreased susceptibility to ceftriaxone. A substantial proportion of isolates tested by NARMS in 2005 demonstrated resistance to these clinically important antimicrobial agents, as follows:

- 21.7% (193/890) of *Campylobacter* isolates were resistant to the fluoroquinolone ciprofloxacin, compared with 12.9% (28/217) in 1997 (OR=2.2, 95% CI [1.4, 3.4]).
    - 23.5% (23/98) of *Campylobacter coli* isolates were resistant to ciprofloxacin.
    - 21.5% (170/791) of *Campylobacter jejuni* isolates were resistant to ciprofloxacin.
- 2.9% (59/2052) of non-Typhi *Salmonella* isolates were resistant to the quinolone nalidixic acid, compared with 0.4% (5/1324) in 1996 (OR=8.1, 95% CI [3.2, 20.5]).
    - *Salmonella* Enteritidis was the second most common serotype among nalidixic acid-resistant non-Typhi *Salmonella* isolates: 36.0% (18/50) of quinolone-resistant isolates were serotype Enteritidis.
    - Nalidixic acid resistance in *Salmonella* Enteritidis was 4.7% (18/383) in 2005, compared with 0.9% (3/351) in 1996 (OR 95% CI [1.6, 30.5]).
- 2.9% (60/2052) of non-Typhi *Salmonella* isolates were resistant to the third-generation cephalosporin ceftiofur, compared with 0.2% (2/1324) in 1996 (OR=24.4, 95% CI [5.9, 100.2]).
    - *Salmonella* Newport was the most common serotype among ceftiofur-resistant non-Typhi *Salmonella* isolates: 43.3% (26/60) of ceftiofur-resistant isolates were serotype Newport.
- 48.4% (154/318) of *Salmonella* Typhi isolates were resistant to the quinolone nalidixic acid, compared with 19.2% (32/167) in 1999 (OR=4.0, 95% CI [2.5, 6.3]).

Multidrug Resistance

Multidrug resistance is described in NARMS by the number of antimicrobial subclasses or specific coresistant phenotypes. Antimicrobial subclasses are used as defined by the Clinical and Laboratory Standards Institute (CLSI) (Table III). Multidrug resistance by the number of antimicrobial subclasses is defined as resistance to two or more CLSI subclasses. For non-Typhi *Salmonella*, common multidrug-resistant phenotypes in 2005 include resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline (ACSSuT) and resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline, amoxicillin-clavulanic acid, and ceftiofur, and decreased susceptibility to ceftriaxone (minimum inhibitory concentration ≥2 μg/mL) (MDR-AmpC).

- 14.8% (304/2052) of non-Typhi *Salmonella* isolates were resistant to two or more CLSI subclasses, and 7.6% (156/2052) were resistant to five or more CLSI subclasses.
    - 15.0% (31/207) of *Salmonella* Newport isolates were resistant to two or more CLSI subclasses, and 12.6% (26/207) were resistant to five or more CLSI subclasses.
    - 33.2% (145/437) of *Salmonella* Typhimurium isolates were resistant to two or more CLSI subclasses, and 23.6% (103/437) were resistant to five or more CLSI subclasses.

- 3.7% (14/383) of *Salmonella* Enteritidis isolates were resistant to two or more CLSI subclasses, and 0.5% (2/383) were resistant to five or more CLSI subclasses.

- 6.9% (141/2052) of non-Typhi *Salmonella* isolates had the ACSSuT resistance pattern, compared with 8.8% (116/1324) in 1996 (Table II).
  - 22.2% (97/437) of *Salmonella* Typhimurium isolates were ACSSuT, compared with 33.7% (103/306) in 1996(OR=0.6, 95% CI [0.4, 0.8]).
  - 12.6% (26/207) of *Salmonella* Newport isolates were ACSSuT, compared with 5.9% (3/51) in 1996.
- 2.0% (41/2052) of non-Typhi *Salmonella* isolates had the MDR-AmpC phenotype (Table III). These isolates consisted of five different serotypes. In 1996, MDR-AmpC was not detected in any serotype.
  - 12.6% (26/207) of *Salmonella* Newport isolates were MDR-AmpC, compared with none (0/51) in 1996 (95% CI [1.8, infinity]).
  - 1.8% (8/437) of *Salmonella* Typhimurium isolates were MDR-AmpC.

Table I: World Health Organization's categorization of antimicrobials of critical importance to human medicine[1]

Critical Importance	CLSI Subclass	Antimicrobial Agent	Categorization of Antimicrobials
I	Aminoglycosides	Amikacin	Critically important[2]
		Gentamicin	Critically important
		Streptomycin	Critically important
	Aminopenicillins	Ampicillin	Critically important
	β-Lactamase inhibitor combinations	Amoxicillin-Clavulanic acid	Critically important
	Cephalosporins (3rd generation)	Ceftriaxone[5]	Critically important
	Ketolides	Telithromycin	Critically important
	Macrolides	Azithromycin	Critically important
		Erythromycin	Critically important
	Quinolones	Ciprofloxacin	Critically important
		Nalidixic acid	Critically important
II	Aminoglycosides	Kanamycin	Highly important[3]
	Cephalosporin (1st generation)	Cephalothin	Highly important
	Cephamycins	Cefoxitin	Highly important
	Folate pathway inhibitors	Trimethoprim-Sulfamethoxazole	Highly important
	Phenicols	Chloramphenicol[6]	Highly important
	Sulfonamides¶	Sulfamethoxazole	Highly important
		Sulfisoxazole	Highly important
	Tetracyclines	Tetracycline	Highly important
III	Lincosamides	Clindamycin	Important[4]

[1]World Health Organization. Critically Important Antimicrobials for Human Medicine: Categorization for the Development of Risk Management Strategies to contain Antimicrobial Resistance due to Non-Human Antimicrobial Use. Report of the second WHO Expert Meeting Copenhagen, 29-31 May 2007.
[2]Both Criteria 1 and 2 met
[3]Either criteria 1 or 2 met but not both
[4]Neither criteria 1 or 2 met
Criteria 1 – the antimicrobial is the sole or one of few agents available for treatment of serious infections
Criteria 2 – Agent used to treat diseases caused by bacteria that may be transmitted from non-human sources to humans.
[5]Ceftiofur, a third-generation cephalosporin used in veterinary medicine is included in the panel of drugs.
[6] Florfenicol, a phenicol used in veterinary medicine has replaced chloramphenicol in 2005.

Table II: Population size and number of isolates received and tested, by site, NARMS, 2005

State/Site	Population Size*	Non-Typhi *Salmonella*		*Salmonella* Typhi		*Shigella*		*E. coli* O157		Campylobacter†	
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Alabama	4,539,611	46	(2.2%)	2	(0.6%)	13	(3.3%)	2	(1.0%)	N/A	
Alaska	669,411	5	(0.2%)	1	(0.3%)	1	(0.3%)	1	(0.5%)	N/A	
Arizona	5,952,083	37	(1.8%)	4	(1.3%)	17	(4.3%)	2	(1.0%)	N/A	
Arkansas	2,772,152	39	(1.9%)	0	(0.0%)	0	(0.0%)	6	(3.1%)	N/A	
California‡	32,143,253	143	(7.0%)	37	(11.6%)	2	(0.5%)	4	(2.1%)	71	(8.0%)
Colorado	4,673,724	30	(1.5%)	7	(2.2%)	2	(0.5%)	4	(2.1%)	110	(12.4%)
Connecticut	3,486,490	31	(1.5%)	8	(2.5%)	3	(0.8%)	2	(1.0%)	55	(6.2%)
Delaware	840,558	8	(0.4%)	3	(0.9%)	1	(0.3%)	2	(1.0%)	N/A	
District of Columbia	582,049	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	N/A	
Florida	17,736,027	52	(2.5%)	12	(3.8%)	0	(0.0%)	0	(0.0%)	N/A	
Georgia	9,107,719	108	(5.3%)	8	(2.5%)	26	(6.6%)	27	(13.9%)	163	(18.3%)
Hawaii	1,267,581	16	(0.8%)	11	(3.5%)	1	(0.3%)	1	(0.5%)	N/A	
Houston, Texas§	2,117,937	28	(1.4%)	6	(1.9%)	1	(0.3%)	0	(0.0%)	N/A	
Idaho	1,425,894	8	(0.4%)	0	(0.0%)	1	(0.3%)	1	(0.5%)	N/A	
Illinois	12,719,550	92	(4.5%)	23	(7.2%)	21	(5.3%)	6	(3.1%)	N/A	
Indiana	6,257,121	35	(1.7%)	3	(0.9%)	2	(0.5%)	3	(1.5%)	N/A	
Iowa	2,955,587	18	(0.9%)	2	(0.6%)	3	(0.8%)	3	(1.5%)	N/A	
Kansas	2,741,665	15	(0.7%)	0	(0.0%)	8	(2.0%)	2	(1.0%)	N/A	
Kentucky	4,171,016	24	(1.2%)	4	(1.3%)	14	(3.5%)	1	(0.5%)	N/A	
Los Angeles¶	3,847,059	68	(3.3%)	23	(7.2%)	5	(1.3%)	0	(0.0%)	N/A	
Louisiana	4,495,670	40	(1.9%)	0	(0.0%)	1	(0.3%)	0	(0.0%)	N/A	
Maine	1,312,222	9	(0.4%)	2	(0.6%)	1	(0.3%)	2	(1.0%)	N/A	
Maryland	5,573,163	30	(1.5%)	11	(3.5%)	11	(2.8%)	25	(12.9%)	64	(7.2%)
Massachusetts	6,429,137	57	(2.8%)	14	(4.4%)	10	(2.5%)	2	(1.0%)	N/A	
Michigan	10,107,940	42	(2.0%)	5	(1.6%)	7	(1.8%)	3	(1.5%)	N/A	
Minnesota	5,113,824	33	(1.6%)	6	(1.9%)	4	(1.0%)	5	(2.6%)	146	(16.4%)
Mississippi	2,900,456	38	(1.9%)	2	(0.6%)	2	(0.5%)	0	(0.0%)	N/A	
Missouri	5,787,885	59	(2.9%)	1	(0.3%)	44	(11.1%)	7	(3.6%)	N/A	
Montana	935,784	6	(0.3%)	0	(0.0%)	1	(0.3%)	1	(0.5%)	N/A	
Nebraska	1,754,042	13	(0.6%)	0	(0.0%)	9	(2.3%)	4	(2.1%)	N/A	
Nevada	2,408,948	14	(0.7%)	1	(0.3%)	4	(1.0%)	4	(2.1%)	N/A	
New Hampshire	1,303,112	8	(0.4%)	0	(0.0%)	1	(0.3%)	1	(0.5%)	N/A	
New Jersey	8,657,445	49	(2.4%)	20	(6.3%)	10	(2.5%)	12	(6.2%)	N/A	
New Mexico	1,916,331	12	(0.6%)	1	(0.3%)	8	(2.0%)	1	(0.5%)	40	(4.5%)
New York[4]	11,048,706	91	(4.4%)	8	(2.5%)	9	(2.3%)	6	(3.1%)	116	(13.0%)
New York City**	8,213,839	76	(3.7%)	30	(9.4%)	20	(5.1%)	5	(2.6%)	N/A	
North Carolina	8,679,089	90	(4.4%)	5	(1.6%)	6	(1.5%)	2	(1.0%)	N/A	
North Dakota	635,938	5	(0.2%)	0	(0.0%)	5	(1.3%)	1	(0.5%)	N/A	
Ohio	11,459,776	65	(3.2%)	1	(0.3%)	5	(1.3%)	7	(3.6%)	N/A	
Oklahoma	3,535,926	23	(1.1%)	1	(0.3%)	31	(7.8%)	3	(1.5%)	N/A	
Oregon	3,629,959	23	(1.1%)	4	(1.3%)	5	(1.3%)	5	(2.6%)	74	(8.3%)
Pennsylvania	12,367,276	89	(4.3%)	6	(1.9%)	6	(1.5%)	4	(2.1%)	N/A	
Rhode Island	1,066,721	7	(0.3%)	1	(0.3%)	1	(0.3%)	0	(0.0%)	N/A	
South Carolina	4,254,989	32	(1.6%)	0	(0.0%)	3	(0.8%)	1	(0.5%)	N/A	
South Dakota	780,046	8	(0.4%)	0	(0.0%)	3	(0.8%)	2	(1.0%)	N/A	
Tennessee	5,989,309	34	(1.7%)	2	(0.6%)	25	(6.3%)	2	(1.0%)	51	(5.7%)
Texas††	20,726,062	55	(2.7%)	18	(5.7%)	14	(3.5%)	0	(0.0%)	N/A	
Utah	2,505,013	16	(0.8%)	1	(0.3%)	2	(0.5%)	3	(1.5%)	N/A	
Vermont	619,736	4	(0.2%)	0	(0.0%)	0	(0.0%)	1	(0.5%)	N/A	
Virginia	7,557,588	65	(3.2%)	16	(5.0%)	4	(1.0%)	3	(1.5%)	N/A	
Washington	6,270,838	45	(2.2%)	4	(1.3%)	11	(2.8%)	8	(4.1%)	N/A	
West Virginia	1,805,626	54	(2.6%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	N/A	
Wisconsin	5,540,473	48	(2.3%)	4	(1.3%)	11	(2.8%)	5	(2.6%)	N/A	
Wyoming	506,541	9	(0.4%)	0	(0.0%)	1	(0.3%)	2	(1.0%)	N/A	
Total	**295,895,897**	**2052**	**(100.0%)**	**318**	**(100.0%)**	**396**	**(100.0%)**	**194**	**(100.0%)**	**890**	**(100.0%)**

* US Census Bureau, 2005
† *Campylobacter* isolates are submitted only from FoodNet sites; total population size of FoodNet sites was 44,531,182
‡ Excluding Los Angeles County
§ Houston City
¶ Los Angeles County
[4] Excluding New York City
** Five burroughs of New York City (Bronx, Brooklyn, Manhattan, Queens, Staten Island)
†† Excluding Houston, Texas

Table III: Summary of trend analysis of the proportion of specific resistance phenotypes among *Campylobacter*, non-Typhi *Salmonella*, and *Salmonella* Typhi isolates, 2005

Resistance Phenotype	Reference Year	Odds Ratio	[95% CI]*
Ciprofloxacin resistance in *Campylobacter*	1997	2.2	[1.4–3.4]
Nalidixic acid resistance in non-Typhi *Salmonella*	1996	8.1	[3.2–20.5]
Nalidixic acid resistance in *Salmonella* Enteritidis	1996	–†	[1.6–30.5]†
Ceftiofur resistance in non-Typhi *Salmonella*	1996	24.4	[5.9–100.2]
Nalidixic acid resistance in *Salmonella* Typhi	1999	4.0	[2.5–6.3]
ACSSuT resistance in *Salmonella* Typhimurium‡	1996	0.6	[0.4–0.8]
MDR-AmpC resistance in *Salmonella* Newport§	1996	–†	[1.8–infinity]†

* For logistic regression models that adjusted for site, odds ratios (ORs) (2005 vs. reference year) and 95% confidence intervals (CIs) were calculated using unconditional maximum likelihood estimation.
† Model included only year. In the analysis, the maximum likelihood estimate of the OR did not exist; only the 95% CIs, calculated using unconditional exact methods, are reported.
‡ Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline.
§ Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline, amoxicillin-clavulanic acid, and ceftiofur, and decreased susceptibility to ceftriaxone (minimum inhibitory concentration) ≥2 μg/mL.

Surveillance and Laboratory Testing Methods

Surveillance Sites and Isolate Submissions

In 2005, NARMS conducted nationwide surveillance among the population of approximately 296 million persons (2005 U.S. Census Bureau estimates). Public health laboratories systematically selected every 20th non-Typhi *Salmonella* (i.e., all *Salmonella* serotypes except serotype Typhi), *Shigella*, and *Escherichia coli* O157 isolate and every *Salmonella* Typhi isolate received at their laboratories and forwarded these isolates to CDC for antimicrobial susceptibility testing.

In 2005, a new scheme for *Campylobacter* isolate submission was initiated. Public health laboratories of the 10 state health departments that participated in CDC's Foodborne Diseases Active Surveillance Network (FoodNet) forwarded a representative sample of *Campylobacter* isolates to CDC for susceptibility testing. The FoodNet sites, representing approximately 45 million persons (2005 U.S. Census Bureau estimates), comprised California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee. There were three methods of selecting a representative sample of isolates for submission to CDC: 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 each week from participating FoodNet sites was submitted to NARMS. This submission scheme was described in the 2004 report[4].

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, Westlake, OH) to determine the minimum inhibitory concentration (MIC) for each of 15 antimicrobial agents: amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole (Table IV). Before 2004, sulfamethoxazole was used instead of sulfisoxazole to represent the sulfonamides. Interpretive criteria defined by the Clinical and Laboratory Standards Institute (CLSI) were used when available[1]. 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), E-Test (AB BIODISK, Solna, Sweden) was performed to determine amikacin MIC. The amikacin E-Test strip range of dilutions was 0.016-256 µg/mL. Since 2004, amikacin had a full range of dilutions (0.5-64 µg/mL) on the Sensititre panel (CMV1AGNF).

Table IV: Antimicrobial agents used for susceptibility testing for *Salmonella*, *Shigella*, and *Escherichia coli* O157 isolates, NARMS, 2005

CLSI Subclass	Antimicrobial Agent	Antimicrobial Agent Concentration Range (μg/mL)	Breakpoints		
			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
Aminopenicillins	Ampicillin	1–32	≤8	16	≥32
β-Lactamase inhibitor combinations	Amoxicillin-Clavulanic acid	1/0.5–32/16	≤8 / ≤4	16/8	≥32 / ≥16
Cephalosporin (1st generation)	Cephalothin‡	2–32	≤8	16	≥32
Cephalosporins (3rd generation)	Ceftiofur§	0.12–8	≤2	4	≥8
	Ceftriaxone	0.25–64	≤8	16–32	≥64
Cephamycins	Cefoxitin	0.5–32	≤8	16	≥32
Folate pathway inhibitors	Trimethoprim-Sulfamethoxazole	0.12/2.4–4/76	≤2 / ≤38		≥4 / ≥76
Phenicols	Chloramphenicol	2–32	≤8	16	≥32
Quinolones	Ciprofloxacin	0.015–4	≤1	2	≥4
	Nalidixic acid	0.5–32	≤16		≥32
Sulfonamides¶	Sulfamethoxazole	16–512	≤256		≥512
	Sulfisoxazole	16–256	≤256		≥512
Tetracyclines	Tetracycline	4–32	≤4	8	≥16

‡ Cephalothin was not tested in 2004 and 2005 but was tested in earlier years for *Salmonella*, *Shigella*, and *E. coli* O157.
§ No CLSI breakpoints; resistance breakpoint used in NARMS is 8 μg/mL.
¶ 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 1996–1998 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 1996–1998 that exhibited an MIC ≥2 µg/mL to ceftiofur or ceftriaxone. The retest results were first included in the 2003 and 2004 NARMS annual reports.

Serotype Confirmation/Categorization

To distinguish serotypes Paratyphi B and Paratyphi B var L(+) tartrate+ (formerly *Salmonella* Java), tartrate testing was performed at CDC on all *Salmonella* Paratyphi B isolates isolated from 1996 to 2005 for which the tartrate result was not reported or was reported to be negative. Jordan's tartrate test was used to determine tartrate fermentation, and Kauffman's tartrate test subsequently was performed on isolates negative for tartrate fermentation by Jordan's tartrate test. 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.

Salmonella serotype was accepted as reported with few exceptions. Because of increased submissions of *Salmonella* Typhimurium isolates lacking the second phase flagellar antigen (i.e., *Salmonella* I 4,[5],12:i:-), reports of such isolates tested in NARMS during 1996–2005 were reviewed, and isolates identified as serogroup B that exhibited first-phase flagellar antigen “I” but lacked a second phase are referred to in this report as *Salmonella* I 4,[5],12:i:- (monophasic Typhimurium). Serogroup B isolates for which the first-phase flagellar antigen was not reported were not included in this category because they could be one of several other serogroup B serotypes. Such isolates tested in NARMS in 2005 were similarly reviewed and reported as *Salmonella* I 4,[5],12:i:- when appropriate.

Testing of *Campylobacter*

Changes in testing methods in 2005

In 2005, there were two major changes in the methodology for *Campylobacter*. A scheme for selecting a representative sample of *Campylobacter* isolates for submission by FoodNet sites was initiated in 2005, which changed from a scheme that selected one *Campylobacter* isolate each week for submission during 1997 to 2004. In 2005, *Campylobacter* isolates were susceptibility tested using Sensititre; isolates were tested by E-test from 1997 to 2004. In addition, florfenicol replaced chloramphenicol and telithromycin was added to the NARMS panel of agents tested in 2005.

Identification/Speciation and Antimicrobial Susceptibility Testing

In 2005, isolates were confirmed as *Campylobacter* by dark-field microscopy, catalase, and oxidase test. Identification of *C. jejuni* was performed using the hippurate hydrolysis test. Hippurate-positive isolates were identified as *C. jejuni*. Hippurate-negative isolates were identified by polymerase chain reaction (PCR) as *C. jejuni* using a hippuricase gene-based PCR assay[2], or as *C. coli* using a *C. coli*-specific *ceuE* PCR[3]. Isolates determined to be neither *C. jejuni* nor *C. coli* were identified by alternative PCR methods[4]. The same methodology was used during 1997–2003.

In 2004, putative *Campylobacter* isolates were identified as *Campylobacter jejuni* or *Campylobacter coli* by PCR using species-specific BAX® primers according to the manufacturer's instructions (DuPont Qualicon, Wilmington, DE). Isolates not identified as *C. jejuni* or *C. coli* were further characterized in conjunction with the CDC *Campylobacter* Reference Laboratory.

In 2005, the broth microdilution methodology (Sensititre®, Trek Diagnostics, Westlake, OH) was used to determine the MICs for nine antimicrobial agents: azithromycin, ciprofloxacin, clindamycin, erythromycin, florfenicol, gentamicin, nalidixic acid, telithromycin, and tetracycline (Table V). Florfenicol replaced chloramphenicol in the NARMS panel to represent the phenicol antimicrobial subclass. Similar to the 2004 report, CLSI interpretive criteria for erythromycin, ciprofloxacin, and tetracycline (published in 2006) and revised NARMS criteria for azithromycin were used for all years in this report[5,6]. In annual reports published before 2004, these CLSI interpretive criteria were not available, and NARMS used resistance breakpoints for azithromycin and erythromycin that were lower than the new and revised breakpoints. In addition, revised NARMS interpretive criteria, adopted from the FDA arm of NARMS, have been used for clindamycin, gentamicin, and nalidixic acid since 2004. From 1997 to 2004, E-test was used for susceptibility testing of *Campylobacter* isolates[4].

Table V: Antimicrobial agents used for susceptibility testing of *Campylobacter* isolates, NARMS, 1997-2005

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

*E-test 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 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, Westlake, OH). Totals reported here reflect the retest results.

Data Analysis

For all pathogens, MICs were categorized as resistant, intermediately susceptible (if applicable), or susceptible. Analysis was restricted to one isolate (per genus under surveillance) per patient. Where established, CLSI interpretive criteria were used; ceftiofur resistance was defined as MIC ≥8 µg/mL (Table IV). The 95% confidence intervals (CI) for the percentage of resistant isolates are included in the MIC distribution tables. The 95% CI was calculated using the Clopper-Pearson exact method[7]. Multidrug resistance by CLSI antimicrobial subclass was defined as resistance to two or more subclasses.

When describing results for several years, multidrug resistance for *Salmonella* and *E. coli* O157 isolates was limited to the nine CLSI subclasses tested in all years from 1996 through 2005 represented by 13 agents: amoxicillin-clavulanic acid, ampicillin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole. For *Salmonella* serotype Typhi and *Shigella,* results for several years included the nine CLSI subclasses tested in all years from 1999 through 2005 represented by 14 agents (13 antimicrobial agents mentioned above and amikacin). Similarly, when describing multidrug resistance for several years for *Campylobacter* isolates, multidrug resistance was limited to the five CLSI subclasses tested in all years from 1997 through 2004, represented by ciprofloxacin, chloramphenicol/florfenicol, clindamycin, erythromycin, nalidixic acid, and tetracycline.

Logistic regression was performed to compare the change in antimicrobial resistance among *Salmonella* and *Campylobacter* isolates tested in NARMS during 2005 with that of previous years for the following:

1. Non-Typhi *Salmonella*: resistance to nalidixic acid, resistance to ceftiofur, resistance to one or more CLSI subclasses.
2. *Salmonella* Typhimurium: resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole, and tetracycline (ACSSuT).
3. *Salmonella* Enteritidis: resistance to nalidixic acid.
4. *Salmonella* Newport: resistance to at least ACSSuT, amoxicillin-clavulanic acid, and ceftiofur, with decreased susceptibility to ceftriaxone (MDR-AmpC).
5. *Salmonella* Typhi: resistance to nalidixic acid.
6. *Campylobacter* species: resistance to ciprofloxacin.
7. *Campylobacter jejuni*: resistance to ciprofloxacin.

The final regression models for non-Typhi *Salmonella,* and final models for serotypes Typhimurium and Typhi, adjusted for site using the nine Public Health Service geographic regions described in the Public Health Laboratory Information System (PHLIS [http://www.cdc.gov/ncidod/dbmd/phlisdata/]) based on the patient's state of residence. The PHLIS regions are East North Central, East South Central, Mid-Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central. For all regression models that adjusted for site, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using unconditional maximum likelihood estimation. In the final regression models for serotypes Enteritidis and Newport, which included only year and used unconditional exact methods, the maximum likelihood estimate of the OR did not exist; only the 95% CIs are reported. For *Campylobacter*, the final regression models adjusted for site using patient's state of residence. 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 also was used[8]. Finally, residual analysis was performed to examine the influence of individual observations. Odds ratios that did not include 1.0 in the 95% CI were reported as significant.

Results for 2005

1. Non-Typhi *Salmonella*

In non-Typhi *Salmonella*, an increase in resistance to two clinically important subclasses, quinolones (represented by nalidixic acid) and third-generation cephalosporins (represented by ceftiofur), was observed from 1996 to 2005. Nalidixic acid resistance increased from 0.4% to 2.4% and ceftiofur resistance increased from 0.2% to 2.9%.

In 2005, CDC received 2090 non-Typhi *Salmonella* isolates, of which 2052 (98.2%) were viable and tested for antimicrobial susceptibility (Table II).

Fluoroquinolones (e.g., ciprofloxacin) and third-generation cephalosporins (e.g., ceftriaxone) are commonly used to treat severe *Salmonella* infections. Nalidixic acid is an elementary quinolone; resistance to nalidixic acid correlates with decreased susceptibility to ciprofloxacin and possible treatment failure. Ceftiofur is a third-generation cephalosporin used in food animals in the United States; resistance to ceftiofur correlates with decreased susceptibility to ceftriaxone. In 2005, the prevalence of resistance among non-Typhi *Salmonella* isolates was 2.4% for quinolones (represented by nalidixic acid) and 2.9% for third-generation cephalosporins (represented by ceftiofur) (Table 1.01).

The antimicrobial agents with the highest prevalence of resistance were tetracycline (13.7%), followed by sulfisoxazole (12.5%), ampicillin (11.3%), and streptomycin (11.0%).

The prevalence of nalidixic acid resistance increased from 0.4% (5/1324) in 1996 to 2.4% (50/2052) in 2005 (Table 1.02), a statistically significant increase (OR=8.1, 95% CI [3.2, 20.5]). The prevalence of ceftiofur resistance increased from 0.2% (2/1324) in 1996 to 2.9% (60/2052) in 2005, a statistically significant increase (OR=24.4, 95% CI [5.9, 100.2]). The proportion of resistance to most of the agents tested in 2005 was lower than in 2004, including ampicillin, amoxicillin-clavulanic acid, ceftiofur, cefoxitin, chloramphenicol, tetracycline, and streptomycin.

Of the 2052 non-Typhi *Salmonella* isolated in 2005, 80.6% (1654) showed no resistance to the drugs tested, a slight increase from the 79.6% in 2004 (Table 1.03). In 2005, 398 (19.4%) were resistant to one or more CLSI subclass, 304 (14.8%) to two or more subclasses, 247 (12.0%) to three or more subclasses, 186 (9.1%) to four or more subclasses, and 156 (7.6%) to five or more subclasses. There was a statistically significant decline in resistance to one or more subclass from 33.8% in 1996 to 19.4% in 2005 (OR=0.6, 95% CI [0.5, 0.7]) (Table 1.04).

In 2005, resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline (ACSSuT) was among the most common multidrug-resistant phenotype (6.9%) among non-Typhi *Salmonella* isolates, but was lower than in 2004 (7.1%), and 1996 (8.8%). Another common multidrug-resistant phenotype among non-Typhi *Salmonella* isolates was to at least ACSSuT, amoxicillin-clavulanic acid,, and ceftiofur, and decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL); this pattern is called MDR-AmpC and 2.0% of isolates had this pattern. The prevalence of MDR-AmpC increased from 0% (0/1324) in 1996 to 2.0% (41/2052) in 2005. Seven (0.3%) isolates were resistant to nalidixic acid and ceftiofur (Table 1.03); this pattern was first detected in 1997.

In 2005, serotypes were identified for a higher proportion of isolates in NARMS (98.9%) than in the Public Health Laboratory Information System (PHLIS) (92.1%) (Table 1.04). The 20 most common serotypes accounted for 82.5% of isolates in NARMS and 77.2% in PHLIS. The same five most common serotypes were reported in NARMS and PHILIS, which accounted for 59.9% of isolates in NARMS and 56.5% in PHLIS. In NARMS; 1.1% of isolates were not completely serotyped in 2005, which was a decline compared with 4.2% in 2004.

Figure 1.01: How to read a squashtogram

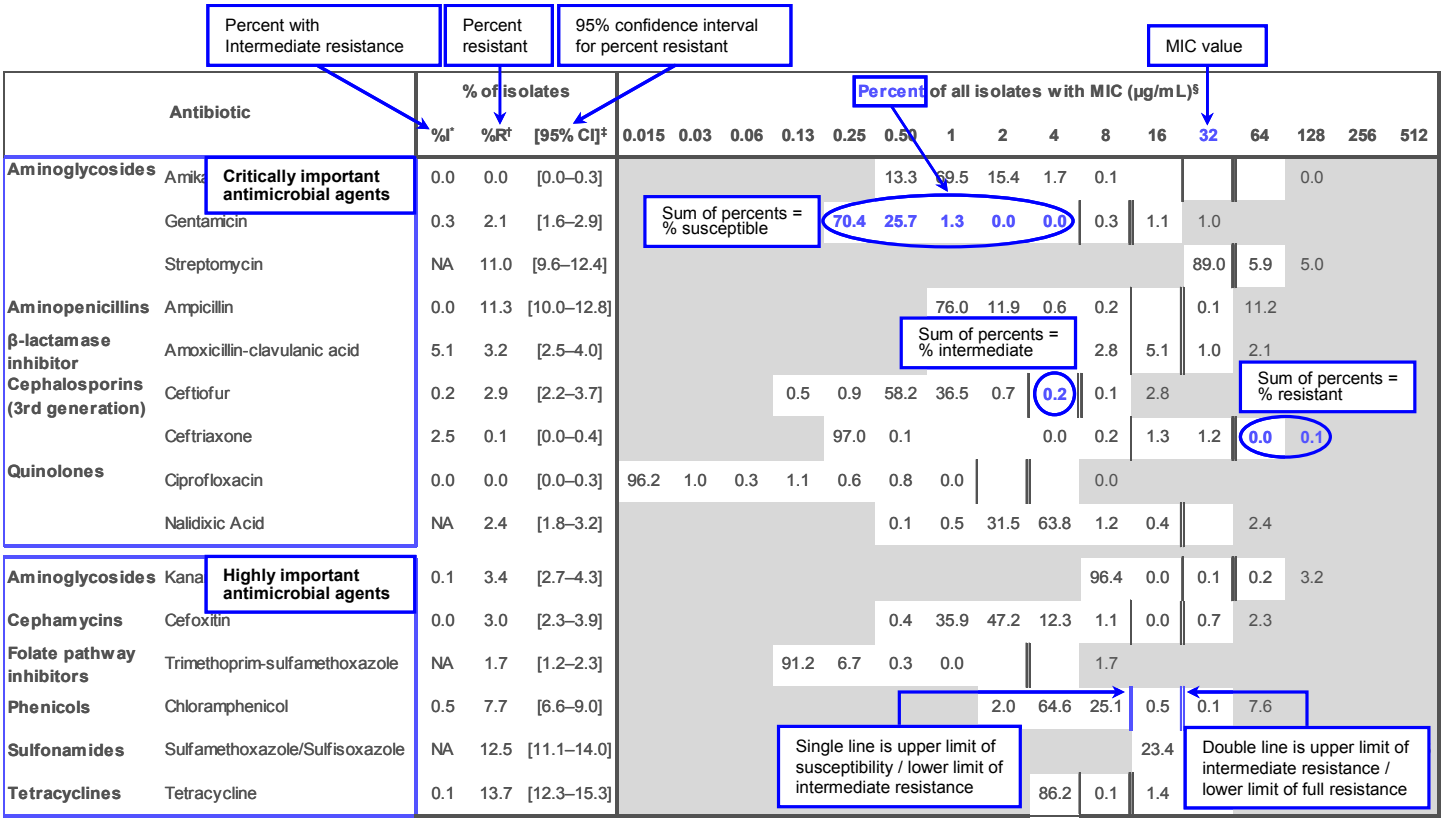


Figure 1.02: Proportional chart, a categorical graph of a squashtogram

Antibiotic		% 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	0.1	[0.0–0.3]						13.7	69.1	15.3	1.6	0.1				0.1		
	Gentamicin	0.3	2.1	[1.6–2.9]					70.5	25.6	1.3	0.0	0.0	0.3	1.1	1.0				
	Streptomycin	NA	11.0	[9.6–12.4]												89.0	5.9	5.0		
Aminopenicillins	Ampicillin	0.0	11.3	[10.0–12.7]							75.6	12.3	0.6	0.2		0.1	11.2			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	5.0	3.2	[2.4–4.0]							84.9	3.3	0.8	2.8	5.0	1.0	2.1			
Cephalosporins (3rd generation)	Ceftiofur	0.2	2.9	[2.2–3.7]				0.5	0.9	58.0	36.8	0.7	0.2	0.1	2.8					
	Ceftriaxone	2.5	0.1	[0.0–0.4]					97.0	0.1			0.0	0.2	1.3	1.2	0.0	0.1		
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.3]	95.8	1.0	0.3	1.1	0.6	1.2	0.0			0.0						
	Nalidixic Acid	NA	2.9	[2.2–3.7]						0.1	0.5	31.4	63.5	1.2	0.4		2.9			
Aminoglycosides	Kanamycin	0.1	3.4	[2.7–4.3]										96.4	0.0	0.1	0.2	3.2		
Cephamycins	Cefoxitin	0.0	3.0	[2.3–3.8]						0.4	35.7	47.0	12.7	1.1	0.0	0.7	2.3			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	1.7	[1.2–2.4]				91.2	6.7	0.3	0.0			1.7						
Phenicols	Chloramphenicol	0.5	7.8	[6.6–9.0]								2.0	64.2	25.4	0.5	0.1	7.6			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	12.5	[11.1–14.0]											23.7	48.5	14.6	0.7	0.1	12.5
Tetracyclines	Tetracycline	0.1	13.7	[12.3–15.3]									86.2	0.1	1.4	4.4	8.0			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists
[†]Percent of isolates that were resistant
[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
[§]The 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.

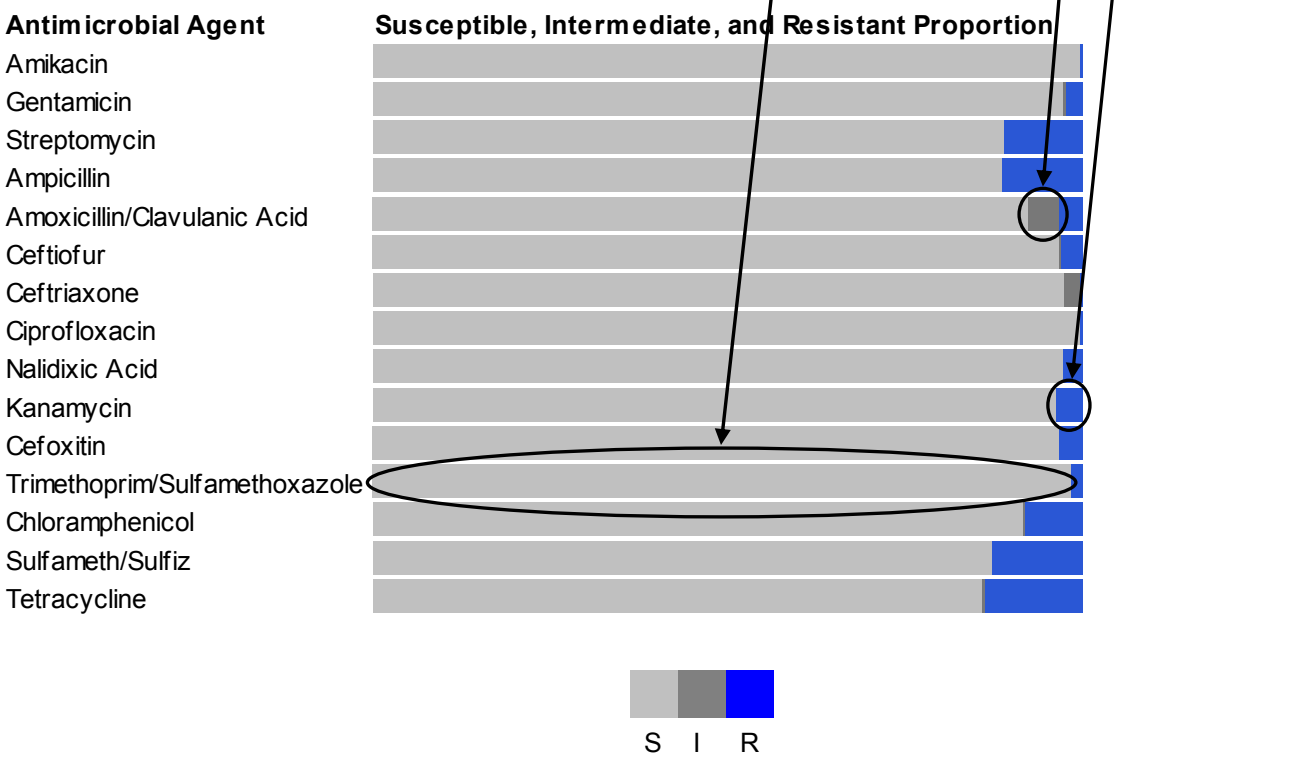


Table 1.01: Minimum inhibitory concentrations (MICs) and resistance of non-Typhi *Salmonella* isolates to antimicrobial agents, 2005 (N=2052)

Antibiotic		% 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	[0.0–0.3]						13.3	69.5	15.4	1.7	0.1				0.0		
	Gentamicin	0.3	2.1	[1.6–2.9]					70.4	25.7	1.3	0.0	0.0	0.3	1.1	1.0				
	Streptomycin	NA	11.0	[9.6–12.4]												89.0	5.9	5.0		
Aminopenicillins	Ampicillin	0.0	11.3	[10.0–12.8]							76.0	11.9	0.6	0.2		0.1	11.2			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	5.1	3.2	[2.5–4.0]							85.2	2.9	0.8	2.8	5.1	1.0	2.1			
Cephalosporins (3rd generation)	Ceftiofur	0.2	2.9	[2.2–3.7]				0.5	0.9	58.2	36.5	0.7	0.2	0.1	2.8					
	Ceftriaxone	2.5	0.1	[0.0–0.4]					97.0	0.1			0.0	0.2	1.3	1.2	0.0	0.1		
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.3]	96.2	1.0	0.3	1.1	0.6	0.8	0.0			0.0						
	Nalidixic Acid	NA	2.4	[1.8–3.2]						0.1	0.5	31.5	63.8	1.2	0.4		2.4			
Aminoglycosides	Kanamycin	0.1	3.4	[2.7–4.3]										96.4	0.0	0.1	0.2	3.2		
Cephamycins	Cefoxitin	0.0	3.0	[2.3–3.9]						0.4	35.9	47.2	12.3	1.1	0.0	0.7	2.3			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	1.7	[1.2–2.3]				91.2	6.7	0.3	0.0			1.7						
Phenicols	Chloramphenicol	0.5	7.7	[6.6–9.0]								2.0	64.6	25.1	0.5	0.1	7.6			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	12.5	[11.1–14.0]											23.4	48.7	14.6	0.7	0.1	12.5
Tetracyclines	Tetracycline	0.1	13.7	[12.3–15.3]									86.2	0.1	1.4	4.4	8.0			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

[§]The 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 1.03: Antimicrobial resistance pattern for non-Typhi *Salmonella*, 2005

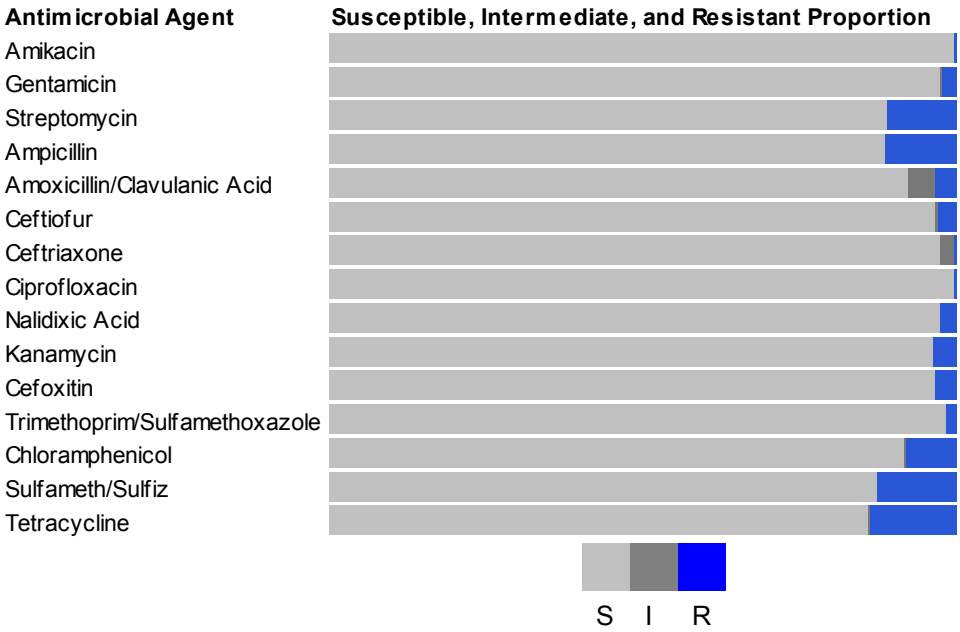


Table 1.02: Percentage and number of non-Typhi *Salmonella* isolates resistant to antimicrobial agents, 1996–2005

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates		1324	1301	1460	1495	1377	1419	2008	1864	1793	2052
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 1
	Gentamicin (MIC ≥ 16)	4.8% 63	2.9% 38	2.8% 41	2.1% 32	2.7% 37	1.9% 27	1.3% 27	1.4% 26	1.3% 24	2.1% 44
	Streptomycin (MIC ≥ 64)	20.6% 273	21.4% 278	18.6% 272	16.7% 250	16.3% 224	17.0% 241	13.2% 265	15.0% 279	11.8% 212	11.0% 225
Aminopenicillins	Ampicillin (MIC ≥ 32)	20.7% 274	18.3% 238	16.5% 241	15.5% 232	15.9% 219	17.4% 247	12.9% 259	13.6% 254	12.0% 216	11.3% 232
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	1.1% 15	1.0% 13	1.7% 25	2.3% 34	3.9% 54	4.7% 66	5.3% 106	4.6% 86	3.7% 67	3.2% 65
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.2% 2	0.5% 6	0.8% 12	2.0% 30	3.2% 44	4.1% 58	4.3% 87	4.5% 83	3.4% 61	2.9% 60
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.1% 1	0.0% 0	0.3% 5	0.0% 0	0.0% 0	0.2% 4	0.4% 8	0.6% 10	0.1% 3
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.1% 1	0.1% 1	0.4% 5	0.2% 3	0.0% 1	0.2% 3	0.2% 4	0.0% 1
	Nalidixic Acid (MIC ≥ 32)	0.4% 5	0.9% 12	1.4% 20	0.9% 14	2.5% 34	2.6% 37	1.8% 36	2.3% 42	2.6% 47	2.4% 50
Aminoglycosides	Kanamycin (MIC ≥ 64)	5.0% 66	5.1% 67	5.7% 83	4.3% 65	5.6% 77	4.8% 68	3.8% 76	3.4% 64	2.8% 50	3.4% 70
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	2.9% 39	2.2% 29	2.3% 33	3.5% 53	4.0% 55	4.0% 57	5.0% 101	5.4% 100	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	3.2% 44	3.4% 48	4.3% 86	4.2% 79	3.5% 62	3.0% 62
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	3.9% 51	1.8% 24	2.3% 34	2.0% 30	2.1% 29	2.0% 28	1.4% 28	1.9% 36	1.8% 32	1.7% 34
Phenicols	Chloramphenicol (MIC ≥ 32)	10.6% 140	10.1% 131	9.9% 145	9.2% 137	10.1% 139	11.6% 164	8.6% 172	10.0% 187	7.6% 136	7.7% 159
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	20.3% 269	22.8% 297	19.4% 283	18.0% 269	17.1% 235	17.7% 251	12.8% 258	15.0% 280	13.2% 237	12.5% 256
Tetracyclines	Tetracycline (MIC ≥ 16)	24.2% 320	21.7% 282	20.2% 295	19.3% 289	18.6% 256	19.7% 280	14.9% 299	16.3% 303	13.5% 242	13.7% 282

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

Table 1.03: Resistance patterns of non-Typhi *Salmonella* isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	1324	1301	1460	1495	1377	1419	2008	1864	1793	2052
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	66.2% 876	68.4% 890	72.9% 1064	74.2% 1109	74.4% 1024	72.3% 1026	79.0% 1586	77.7% 1449	79.6% 1427	80.6% 1654
Resistance ≥1CLSI subclass*	33.8% 448	31.6% 411	27.1% 396	25.8% 386	25.6% 353	27.7% 393	21.0% 422	22.3% 415	20.4% 366	19.4% 398
Resistance ≥2 CLSI subclasses*	27.0% 358	24.1% 314	22.6% 330	20.4% 305	20.2% 278	22.1% 314	15.8% 318	17.7% 330	15.0% 269	14.8% 304
Resistance ≥3 CLSI subclasses*	18.1% 240	17.7% 230	16.7% 244	15.1% 225	15.6% 215	16.8% 239	12.2% 244	14.3% 266	11.7% 210	12.0% 247
Resistance ≥4 CLSI subclasses*	13.7% 181	13.7% 178	13.1% 191	12.2% 183	12.9% 178	14.2% 202	9.9% 199	11.6% 216	9.4% 168	9.1% 186
Resistance ≥5 CLSI subclasses*	10.0% 132	9.9% 129	10.1% 147	8.6% 129	9.9% 137	10.5% 149	8.3% 167	9.9% 185	8.1% 146	7.6% 156
At least ACSSuT†	8.8% 116	9.5% 124	8.9% 130	8.4% 125	8.9% 122	10.0% 142	7.8% 156	9.3% 173	7.1% 128	6.9% 141
At least ACSuTm‡	0.8% 10	0.4% 5	0.9% 13	0.9% 14	1.0% 14	0.5% 7	1.0% 21	1.2% 23	0.6% 10	0.9% 18
At least ACSSuTAuCf§	0.0% 0	0.3% 4	0.3% 5	1.5% 23	2.6% 36	2.5% 36	3.3% 67	3.2% 60	2.3% 42	2.0% 41
At least MDR-AmpC¶	0.0% 0	0.3% 4	0.3% 5	1.5% 23	2.6% 36	2.5% 36	3.3% 67	3.2% 60	2.3% 42	2.0% 41
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.2% 2	0.1% 1	0.1% 1	0.3% 4	0.3% 4	0.2% 5	0.2% 4	0.4% 7	0.3% 7

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

Table 1.04: Twenty most common non-Typhi *Salmonella* serotypes in NARMS and the Public Health Laboratory Information System, 2005

NARMS		Isolates	
Rank	Serotype	N	(%)
1	Typhimurium	437	(21.3%)
2	Enteritidis	383	(18.7%)
3	Newport	207	(10.1%)
4	Heidelberg	125	(6.1%)
5	Javiana	75	(3.7%)
6	Montevideo	48	(2.3%)
7	Braenderup	47	(2.3%)
8	Muenchen	44	(2.1%)
9	Saintpaul	41	(2.0%)
10	Paratyphi B var. L(+) tartrate+	38	(1.9%)
11	Mississippi	37	(1.8%)
12	I 4,[5],12:i:- (monophasic Typhimurium)	33	(1.6%)
13	Oranienburg	33	(1.6%)
14	Infantis	30	(1.5%)
15	Thompson	26	(1.3%)
16	Agona	22	(1.1%)
17	Poona	19	(0.9%)
18	Stanley	17	(0.8%)
19	Mbandaka	17	(0.8%)
20	Berta	13	(0.6%)
	Subtotal	**1692**	**(82.5%)**
	All Other serotypes	336	(16.4%)
	Unknown serotype	1	(0.0%)
	Partially serotyped	21	(1.0%)
	Rough/Nonmotile isolates	2	(0.1%)
	Subtotal	**360**	**(17.5%)**
	Grand Total	**2052**	**(100.0%)**

PHLIS		Isolates	
Rank	Serotype	N	(%)
1	Typhimurium	6982	(19.5%)
2	Enteritidis	6730	(18.8%)
3	Newport	3295	(9.2%)
4	Heidelberg	1903	(5.3%)
5	Javiana	1324	(3.7%)
6	I 4,[5],12:i:- (monophasic Typhimurium)	822	(2.3%)
7	Montevideo	809	(2.3%)
8	Muenchen	733	(2.0%)
9	Saintpaul	683	(1.9%)
10	Braenderup	603	(1.7%)
11	Oranienburg	590	(1.6%)
12	Mississippi	565	(1.6%)
13	Infantis	505	(1.4%)
14	Paratyphi B var. L(+) tartrate+	460	(1.3%)
15	Thompson	428	(1.2%)
16	Agona	367	(1.0%)
17	Hartford	239	(0.7%)
18	Stanley	224	(0.7%)
19	Berta	209	(0.6%)
20	Hadar	205	(0.6%)
	Subtotal	**27676**	**(77.2%)**
	All Other serotypes	5324	(14.9%)
	Unknown serotype	1113	(3.1%)
	Partially serotyped	1684	(4.7%)
	Rough/Nonmotile isolates	39	(0.1%)
	Subtotal	**8160**	**(22.8%)**
	Grand Total	**35836**	**(100.0%)**

A. *Salmonella* Typhimurium

In 2005, Typhimurium was the most common non-Typhi *Salmonella* serotype in NARMS. ACSSuT in *Salmonella* Typhimurium decreased from 33.7% in 1996 to 22.2% in 2005.

In 2005, Typhimurium was the most common non-Typhi *Salmonella* serotype in NARMS, accounting for 21.3% (437/2052) of non-Typhi *Salmonella* isolates (Table 1.05). Of the 437 *Salmonella* Typhimurium isolates tested, resistance was highest to sulfisoxazole (31.8%), tetracycline (30.2%), ampicillin (28.8%), streptomycin (27.9%), and chloramphenicol (24.3%). The prevalence of resistance among clinically important antimicrobial subclasses was 0.9% for quinolones (represented by nalidixic acid) and 2.5% for third-generation cephalosporins (represented by ceftiofur).

Resistance to many of the other antimicrobial agents decreased since 1996 (Table 1.06). Resistance to tetracycline decreased from 49.3% in 1996 to 30.2% in 2005; ampicillin, from 50.0% to 28.8%; streptomycin, from 51.6% to 27.9%; chloramphenicol, from 39.9% to 24.3%; and gentamicin, from 4.2% to 1.8%.

Of the 437 *Salmonella* Typhimurium isolates tested during 2005, 65.2% (285) had no detected resistance, a slight increase from the 60.7% of isolates in 2004 (Table 1.07). In 2005, 33.2% (145/437) were resistant to two or more CLSI subclasses, compared with 37.2% in 2004. Similarly, in 2005, 23.6% (103/437) were resistant to at least five subclasses, compared with 24.3% in 2004.

In 2005, the most common multidrug-resistant phenotype among *Salmonella* Typhimurium was ACSSuT (22.2% of isolates). For *Salmonella* Typhimurium, ACSSuT commonly is associated with definitive phage type 104. Since 1996, the prevalence of ACSSuT among *Salmonella* Typhimurium decreased from 33.7% to 22.2%. In the logistic regression model, this decrease is statistically significant (OR=0.6, 95% CI [0.4, 0.8]).

One (0.2%) serotype Typhimurium isolate was resistant to both quinolones and third-generation cephalosporins in 2005. Since 1996, seven *Salmonella* Typhimurium isolates have shown this multidrug resistance pattern.

Table 1.05: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* Typhimurium isolates to antimicrobial agents, 2005 (N=437)

Antibiotic		% 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	[0.0–0.8]						3.9	75.3	17.6	3.2							
	Gentamicin	0.2	1.8	[0.8–3.6]					66.1	29.7	2.1			0.2	1.1	0.7				
	Streptomycin	NA	27.9	[23.8–32.4]												72.1	18.3	9.6		
Aminopenicillins	Ampicillin	0.0	28.8	[24.6–33.3]							63.4	7.6	0.2				28.8			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	19.0	3.2	[1.8–5.3]							68.9	2.1	0.5	6.4	19.0	1.1	2.1			
Cephalosporins (3rd generation)	Ceftiofur	0.2	2.5	[1.3–4.5]				0.2	0.7	60.2	35.2	0.9	0.2		2.5					
	Ceftriaxone	2.1	0.0	[0.0–0.8]					97.5					0.5	1.1	0.9				
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.8]	97.3	1.4		0.7	0.2	0.2	0.2									
	Nalidixic Acid	NA	0.9	[0.2–2.3]						0.2	0.5	37.3	59.7	0.9	0.5		0.9			
Aminoglycosides	Kanamycin	0.0	5.7	[3.7–8.3]										94.1	0.2		0.5	5.3		
Cephamycins	Cefoxitin	0.0	2.5	[1.3–4.5]							34.3	54.5	7.3	1.4		0.5	2.1			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	2.7	[1.4–4.7]				78.5	18.1	0.7				2.7						
Phenicols	Chloramphenicol	0.2	24.3	[20.3–28.6]								1.4	55.6	18.5	0.2	0.5	23.8			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	31.8	[27.5–36.4]											20.1	43.5	4.3	0.2		31.8
Tetracyclines	Tetracycline	0.2	30.2	[25.9–34.7]									69.6	0.2	5.5	14.6	10.1			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists
[†]Percent of isolates that were resistant
[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
§The 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 1.04: Antimicrobial resistance pattern for *Salmonella* Typhimurium, 2005

Table 1.06: Percentage and number of *Salmonella* Typhimurium isolates resistant to antimicrobial agents, 1996–2005

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates		306	328	379	362	304	325	393	406	382	437
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	4.2% 13	4.6% 15	3.7% 14	2.2% 8	2.6% 8	1.5% 5	2.3% 9	2.0% 8	2.1% 8	1.8% 8
	Streptomycin (MIC ≥ 64)	51.6% 158	55.2% 181	47.5% 180	43.1% 156	39.5% 120	40.0% 130	31.8% 125	35.2% 143	31.7% 121	27.9% 122
Aminopenicillins	Ampicillin (MIC ≥ 32)	50.0% 153	50.3% 165	45.4% 172	41.2% 149	42.1% 128	42.5% 138	33.6% 132	36.0% 146	31.9% 122	28.8% 126
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.6% 8	3.4% 11	4.5% 17	2.8% 10	6.3% 19	6.2% 20	7.6% 30	5.4% 22	4.7% 18	3.2% 14
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	1.5% 5	1.8% 7	1.9% 7	3.6% 11	3.1% 10	4.3% 17	4.9% 20	4.5% 17	2.5% 11
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.2% 1	0.8% 3	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	0.3% 1	0.9% 3	0.5% 2	0.0% 0	1.3% 4	0.6% 2	1.3% 5	1.2% 5	0.5% 2	0.9% 4
Aminoglycosides	Kanamycin (MIC ≥ 64)	14.4% 44	15.5% 51	15.8% 60	13.0% 47	13.2% 40	8.3% 27	7.6% 30	7.1% 29	5.8% 22	5.7% 25
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	2.0% 6	4.3% 14	4.0% 15	4.4% 16	4.3% 13	3.1% 10	5.6% 22	6.2% 25	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	3.6% 11	3.1% 10	4.3% 17	4.4% 18	4.7% 18	2.5% 11
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	4.6% 14	3.0% 10	4.5% 17	2.8% 10	3.6% 11	2.5% 8	2.3% 9	3.4% 14	2.6% 10	2.7% 12
Phenicols	Chloramphenicol (MIC ≥ 32)	39.9% 122	36.0% 118	33.8% 128	28.7% 104	30.9% 94	31.7% 103	23.2% 91	27.8% 113	24.1% 92	24.3% 106
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	53.3% 163	56.7% 186	49.9% 189	45.6% 165	45.4% 138	43.1% 140	32.1% 126	38.4% 156	35.9% 137	31.8% 139
Tetracyclines	Tetracycline (MIC ≥ 16)	49.3% 151	52.4% 172	46.2% 175	41.7% 151	43.4% 132	43.4% 141	31.8% 125	37.9% 154	30.1% 115	30.2% 132

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

Table 1.07: Resistance patterns of *Salmonella* Typhimurium isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	306	328	379	362	304	325	393	406	382	437
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	37.9% 116	39.0% 128	46.7% 177	50.6% 183	49.3% 150	49.2% 160	60.3% 237	54.9% 223	60.7% 232	65.2% 285
Resistance ≥1CLSI subclass*	62.1% 190	61.0% 200	53.3% 202	49.4% 179	50.7% 154	50.8% 165	39.7% 156	45.1% 183	39.3% 150	34.8% 152
Resistance ≥2 CLSI subclasses*	56.2% 172	56.7% 186	51.2% 194	46.1% 167	47.0% 143	48.0% 156	36.1% 142	41.4% 168	37.2% 142	33.2% 145
Resistance ≥3 CLSI subclasses*	51.0% 156	52.4% 172	47.5% 180	43.1% 156	43.4% 132	41.8% 136	32.3% 127	36.9% 150	31.4% 120	30.0% 131
Resistance ≥4 CLSI subclasses*	45.4% 139	47.9% 157	43.0% 163	38.4% 139	39.8% 121	38.2% 124	28.5% 112	32.0% 130	28.0% 107	27.2% 119
Resistance ≥5 CLSI subclasses*	35.6% 109	36.0% 118	34.3% 130	27.9% 101	30.6% 93	29.8% 97	23.4% 92	27.8% 113	24.3% 93	23.6% 103
At least ACSSuT†	33.7% 103	35.1% 115	32.2% 122	27.6% 100	28.0% 85	29.5% 96	21.4% 84	26.1% 106	23.3% 89	22.2% 97
At least ACSuTm‡	2.0% 6	0.6% 2	2.6% 10	2.2% 8	1.6% 5	0.9% 3	2.0% 8	3.2% 13	1.6% 6	2.1% 9
At least ACSSuTAuCf§	0.0% 0	1.2% 4	1.1% 4	0.6% 2	2.0% 6	1.2% 4	1.8% 7	2.2% 9	2.6% 10	1.8% 8
At least MDR-AmpC¶	0.0% 0	1.2% 4	1.1% 4	0.6% 2	2.0% 6	1.2% 4	1.8% 7	2.2% 9	2.6% 10	1.8% 8
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.3% 1	0.5% 2	0.0% 0	0.3% 1	0.2% 1

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

B. *Salmonella* Enteritidis

In 2005, Enteritidis was the second most common non-Typhi *Salmonella* serotype in NARMS. Most *Salmonella* Enteritidis isolates had no detected resistance. However, nalidixic acid resistance increased from 0.9% in 1996 to 4.7% in 2005.

In 2005, Enteritidis was the second most common non-Typhi *Salmonella* serotype identified in NARMS, accounting for 18.6% (383/2052) of non-Typhi *Salmonella* isolates (Table 1.04). Among *Salmonella* Enteritidis isolates tested in 2005, resistance was rare. The most dramatic increase occurred with nalidixic acid. There is a statistically significant increase in nalidixic acid resistance from 0.9% in 1996 to 4.7% in 2005 (95% CI [1.6, 30.5]) (Table 1.09). *Salmonella* Enteritidis was the second most prevalent (30.5%) non-Typhi *Salmonella* serotype that had resistance to nalidixic acid (Table 1.20).

Most (91.9%) of the *Salmonella* Enteritidis isolates tested in 2005 had no detected resistance (Table 1.10). Multidrug resistance was rare.

Table 1.08: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* Enteritidis isolates to antimicrobial agents, 2005 (N=383)

Antibiotic		% 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	[0.0–1.0]						30.5	61.1	8.4								
	Gentamicin	0.0	0.8	[0.2–2.3]					86.2	13.1					0.5	0.3				
	Streptomycin	NA	1.0	[0.3–2.7]												99.0	0.3	0.8		
Aminopenicillins	Ampicillin	0.0	2.9	[1.4–5.1]							72.1	24.3	0.5	0.3		0.3	2.6			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	1.0	0.8	[0.2–2.3]							93.5	3.1	0.5	1.0	1.0	0.5	0.3			
Cephalosporins (3rd generation)	Ceftiofur	0.3	0.5	[0.1–1.9]				0.3	0.8	36.3	61.6	0.3	0.3	0.3	0.3					
	Ceftriaxone	0.3	0.0	[0.0–1.0]					99.5	0.3						0.3				
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.0]	94.5	0.5	1.0	3.1	0.8											
	Nalidixic Acid	NA	4.7	[2.8–7.3]								14.1	78.6	2.6			4.7			
Aminoglycosides	Kanamycin	0.3	0.3	[0.0–1.4]										99.5		0.3		0.3		
Cephamycins	Cefoxitin	0.0	1.0	[0.3–2.7]						0.5	34.2	59.0	4.7	0.5		0.5	0.5			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	0.5	[0.1–1.9]				97.7	1.6	0.3				0.5						
Phenicols	Chloramphenicol	0.3	0.5	[0.1–1.9]								1.0	77.3	20.9	0.3		0.5			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	1.6	[0.6–3.4]											22.2	63.4	12.0	0.5	0.3	1.6
Tetracyclines	Tetracycline	0.0	2.3	[1.1–4.4]									97.7				2.3			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

§The 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 1.05: Antimicrobial resistance pattern for *Salmonella* Enteritidis, 2005

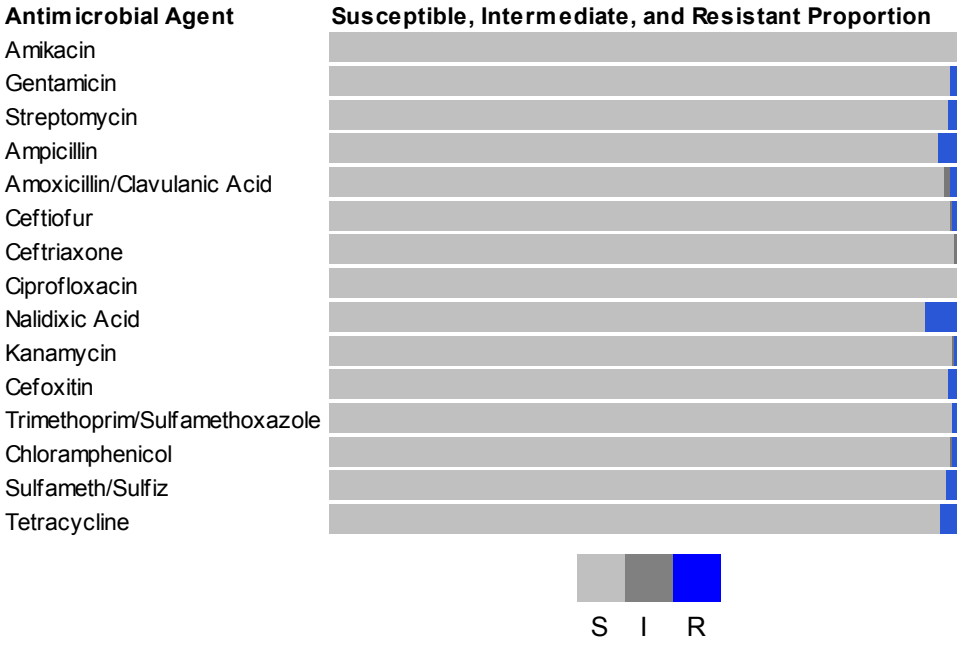


Table 1.09: Percentage and number of *Salmonella* Enteritidis isolates resistant to antimicrobial agents, 1996–2005

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates		351	301	244	269	319	277	337	257	271	383
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	4.8% 17	0.3% 1	0.4% 1	0.0% 0	0.3% 1	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.8% 3
	Streptomycin (MIC ≥ 64)	2.0% 7	4.3% 13	1.6% 4	2.2% 6	0.0% 0	1.4% 4	1.8% 6	1.2% 3	2.2% 6	1.0% 4
Aminopenicillins	Ampicillin (MIC ≥ 32)	20.5% 72	11.3% 34	6.1% 15	10.8% 29	7.5% 24	8.7% 24	7.1% 24	2.3% 6	4.1% 11	2.9% 11
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	0.6% 2	0.0% 0	0.0% 0	0.4% 1	0.0% 0	1.4% 4	0.6% 2	0.0% 0	0.0% 0	0.8% 3
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.3% 1	0.0% 0	0.4% 1	0.0% 0	2.2% 6	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	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	0.9% 3	1.7% 5	2.0% 5	2.2% 6	2.2% 7	4.3% 12	3.9% 13	4.7% 12	6.6% 18	4.7% 18
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.7% 2	0.4% 1	0.4% 1	0.3% 1	0.7% 2	0.3% 1	0.0% 0	0.7% 2	0.3% 1
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	4.0% 14	1.3% 4	0.0% 0	1.9% 5	0.9% 3	1.1% 3	0.6% 2	1.2% 3	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.0% 0	1.0% 4
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	6.6% 23	1.3% 4	0.8% 2	0.7% 2	0.0% 0	0.7% 2	0.6% 2	0.8% 2	0.0% 0	0.5% 2
Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.7% 2	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.6% 2	0.4% 1	0.4% 1	0.5% 2
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	8.5% 30	9.0% 27	2.0% 5	3.0% 8	0.9% 3	2.2% 6	1.8% 6	1.2% 3	1.8% 5	1.6% 6
Tetracyclines	Tetracycline (MIC ≥ 16)	16.8% 59	9.6% 29	6.6% 16	8.2% 22	1.9% 6	1.8% 5	4.5% 15	1.6% 4	3.3% 9	2.3% 9

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

Table 1.10: Resistance patterns of *Salmonella* Enteritidis isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	351	301	244	269	319	277	337	257	271	383
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	73.5% 258	77.4% 233	87.7% 214	83.6% 225	89.0% 284	86.6% 240	87.2% 294	91.8% 236	87.1% 236	91.9% 352
Resistance ≥1CLSI subclass*	26.5% 93	22.6% 68	12.3% 30	16.4% 44	11.0% 35	13.4% 37	12.8% 43	8.2% 21	12.9% 35	8.1% 31
Resistance ≥2 CLSI subclasses*	19.1% 67	9.6% 29	6.6% 16	8.6% 23	1.9% 6	4.7% 13	4.2% 14	2.3% 6	3.0% 8	3.7% 14
Resistance ≥3 CLSI subclasses*	8.0% 28	3.0% 9	0.8% 2	1.1% 3	0.3% 1	2.9% 8	2.4% 8	0.8% 2	1.1% 3	2.1% 8
Resistance ≥4 CLSI subclasses*	4.6% 16	1.3% 4	0.0% 0	0.7% 2	0.0% 0	1.8% 5	1.5% 5	0.4% 1	0.7% 2	0.8% 3
Resistance ≥5 CLSI subclasses*	1.7% 6	0.7% 2	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.3% 1	0.4% 1	0.7% 2	0.5% 2
At least ACSSuT†	0.0% 0	0.3% 1	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.3% 1	0.4% 1	0.4% 1	0.5% 2
At least ACSuTm‡	0.0% 0	0.3% 1	0.0% 0	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.0% 0
At least ACSSuTAuCf§	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	0.3% 1
At least MDR-AmpC¶	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	0.3% 1
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.3% 1

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

C. *Salmonella* Newport

In 2005, Newport was the third most common non-Typhi *Salmonella* serotype in NARMS. MDR-AmpC in *Salmonella* Newport increased from 1996 to 2005, which was similar to the trend in ceftiofur resistance. MDR-AmpC was first noted in 1998, increased to 18.2% in 1999, peaked at 25.0% in 2001, and declined to 12.6% in 2005.

In 2005, Newport was the third most commonly isolated non-Typhi *Salmonella* serotype in NARMS, accounting for 10.0% (207/2052) of non-Typhi *Salmonella* isolates (Table 1.04). The highest proportions of the *Salmonella* Newport isolates tested were resistant to sulfisoxazole (15.5%), tetracycline (14.5%), ampicillin (14.0%), streptomycin (14.0%), chloramphenicol (13.5%) amoxicillin-clavulanic acid (12.6%), ceftiofur (12.6%), and cefoxitin (12.6%). The prevalence of resistance among clinically important antimicrobial subclasses was 0.0% for quinolones (represented by nalidixic acid) and 12.6% for third-generation cephalosporins (represented by ceftiofur).

Ceftiofur resistance was first noted in one isolate (1.3%) in 1998; it increased to 18.2% in 1999, peaked at 27.4% in 2001, and declined to 12.6% in 2005 (Table 1.12). *Salmonella* Newport was the most prevalent (43.3%) non-Typhi *Salmonella* serotype that had resistance to ceftiofur (Table 1.20).

In contrast to other common serotypes, the percentage of *Salmonella* Newport isolates with no detected resistance declined from 86.3% in 1996 and 73.5% in 2003 (Table 1.13). However, the percentage of *Salmonella* Newport isolates with no detected resistance was higher in 2005 (84.1%) than in 2004 (82.2%). In addition, resistance to at least five subclasses of antimicrobial agents increased from 5.9% in 1996 to 12.6% in 2005; it peaked in 2001, similar to the trend in ceftiofur resistance.

In 2005, MDR-AmpC was among the most common multidrug-resistant phenotype in serotype Newport (12.6% of isolates). MDR-AmpC increased since 1996, which was similar to the trend in ceftiofur resistance (Table 1.13); it was first noted in 1998, increased to 18.2% in 1999, peaked at 25.0% in 2001, and declined to 12.6% in 2005. In the logistic regression model, the increase from 1996 to 2005 was statistically significant (95% CI [1.8, infinity]).

Table 1.11: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* Newport isolates to antimicrobial agents, 2005 (N=207)

Antibiotic		% 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	[0.0–1.8]						8.2	75.4	13.0	3.4							
	Gentamicin	1.0	1.0	[0.1–3.4]					75.8	21.7	0.5			1.0	1.0					
	Streptomycin	NA	14.0	[9.6–19.5]												86.0	1.0	13.0		
Aminopenicillins	Ampicillin	0.0	14.0	[9.6–19.5]							82.1	3.4	0.5				14.0			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	0.0	12.6	[8.4–17.9]							85.0	0.5	0.5	1.4		4.3	8.2			
Cephalosporins (3rd generation)	Ceftiofur	0.0	12.6	[8.4–17.9]				0.5		58.9	27.5	0.5			12.6					
	Ceftriaxone	11.1	1.4	[0.3–4.2]					87.4						4.3	6.8	0.5	1.0		
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.8]	100.0															
	Nalidixic Acid	NA	0.0	[0.0–1.8]							1.4	33.8	64.7							
Aminoglycosides	Kanamycin	0.0	1.9	[0.5–4.9]										98.1				1.9		
Cephamycins	Cefoxitin	0.0	12.6	[8.4–17.9]						0.5	41.1	42.5	2.4	1.0		1.0	11.6			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	1.9	[0.5–4.9]				94.7	3.4					1.9						
Phenicols	Chloramphenicol	0.0	13.5	[9.2–19.0]								5.3	75.4	5.8			13.5			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	15.5	[10.8–21.1]											4.8	44.0	33.8	1.9		15.5
Tetracyclines	Tetracycline	0.0	14.5	[10.0–20.0]									85.5			3.4	11.1			

*Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

†Percent of isolates that were resistant

‡95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

§The 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 1.06: Antimicrobial resistance pattern for *Salmonella* Newport, 2005

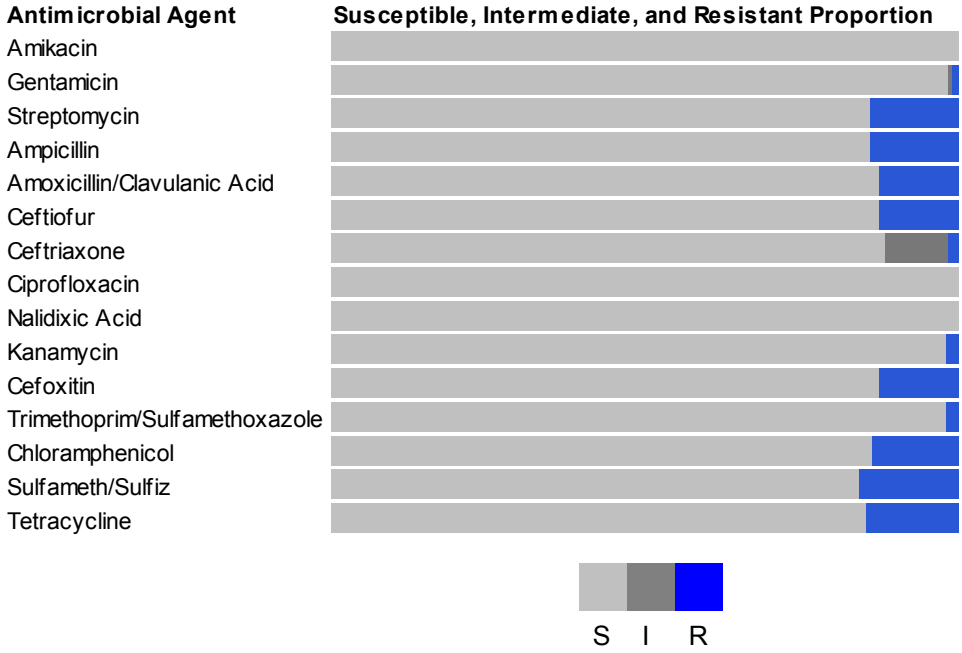


Table 1.12: Percentage and number of *Salmonella* Newport isolates resistant to antimicrobial agents, 1996–2005

Year Total Isolates		1996 51	1997 46	1998 77	1999 99	2000 121	2001 124	2002 241	2003 223	2004 191	2005 207
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	5.9% 3	4.3% 2	0.0% 0	0.0% 0	2.5% 3	3.2% 4	3.3% 8	3.1% 7	0.5% 1	1.0% 2
	Streptomycin (MIC ≥ 64)	7.8% 4	4.3% 2	2.6% 2	19.2% 19	24.0% 29	31.5% 39	25.3% 61	24.2% 54	15.7% 30	14.0% 29
Aminopenicillins	Ampicillin (MIC ≥ 32)	5.9% 3	6.5% 3	2.6% 2	18.2% 18	23.1% 28	29.8% 37	24.9% 60	22.9% 51	15.7% 30	14.0% 29
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.0% 1	0.0% 0	2.6% 2	18.2% 18	22.3% 27	26.6% 33	22.8% 55	21.5% 48	15.2% 29	12.6% 26
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	1.3% 1	18.2% 18	22.3% 27	27.4% 34	22.8% 55	22.0% 49	15.2% 29	12.6% 26
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	3.0% 3	0.0% 0	0.0% 0	0.8% 2	1.8% 4	2.6% 5	1.4% 3
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.8% 1	0.0% 0	0.8% 2	0.4% 1	0.5% 1	0.0% 0
Aminoglycosides	Kanamycin (MIC ≥ 64)	2.0% 1	0.0% 0	1.3% 1	1.0% 1	5.0% 6	7.3% 9	10.0% 24	4.5% 10	2.6% 5	1.9% 4
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	3.9% 2	4.3% 2	2.6% 2	18.2% 18	22.3% 27	26.6% 33	22.8% 55	22.4% 50	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	22.3% 27	25.8% 32	22.4% 54	21.5% 48	15.2% 29	12.6% 26
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	3.9% 2	4.3% 2	1.3% 1	2.0% 2	4.1% 5	1.6% 2	4.1% 10	0.9% 2	2.1% 4	1.9% 4
Phenicols	Chloramphenicol (MIC ≥ 32)	5.9% 3	4.3% 2	2.6% 2	18.2% 18	23.1% 28	28.2% 35	25.3% 61	22.4% 50	15.2% 29	13.5% 28
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	11.8% 6	4.3% 2	3.9% 3	22.2% 22	23.1% 28	32.3% 40	25.7% 62	24.7% 55	16.8% 32	15.5% 32
Tetracyclines	Tetracycline (MIC ≥ 16)	7.8% 4	4.3% 2	2.6% 2	19.2% 19	23.1% 28	30.6% 38	25.7% 62	24.2% 54	16.8% 32	14.5% 30

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

Table 1.13: Resistance patterns of *Salmonella* Newport isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	51	46	77	99	121	124	241	223	191	207
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	86.3% 44	93.5% 43	94.8% 73	75.8% 75	75.2% 91	65.3% 81	72.2% 174	73.5% 164	82.2% 157	84.1% 174
Resistance ≥1CLSI subclass*	13.7% 7	6.5% 3	5.2% 4	24.2% 24	24.8% 30	34.7% 43	27.8% 67	26.5% 59	17.8% 34	15.9% 33
Resistance ≥2 CLSI subclasses*	7.8% 4	4.3% 2	2.6% 2	18.2% 18	23.1% 28	32.3% 40	25.7% 62	25.1% 56	17.3% 33	15.0% 31
Resistance ≥3 CLSI subclasses*	5.9% 3	4.3% 2	2.6% 2	18.2% 18	23.1% 28	31.5% 39	25.3% 61	23.3% 52	16.8% 32	14.5% 30
Resistance ≥4 CLSI subclasses*	5.9% 3	4.3% 2	2.6% 2	18.2% 18	23.1% 28	31.5% 39	25.3% 61	22.9% 51	15.7% 30	14.0% 29
Resistance ≥5 CLSI subclasses*	5.9% 3	4.3% 2	2.6% 2	18.2% 18	23.1% 28	27.4% 34	23.7% 57	22.4% 50	14.7% 28	12.6% 26
At least ACSSuT†	5.9% 3	4.3% 2	1.3% 1	18.2% 18	23.1% 28	25.8% 32	23.7% 57	22.0% 49	14.7% 28	12.6% 26
At least ACSuTm‡	3.9% 2	4.3% 2	1.3% 1	2.0% 2	4.1% 5	0.8% 1	3.7% 9	0.9% 2	1.0% 2	1.9% 4
At least ACSSuTAuCf§	0.0% 0	0.0% 0	1.3% 1	18.2% 18	22.3% 27	25.0% 31	22.8% 55	21.1% 47	14.7% 28	12.6% 26
At least MDR-AmpC¶	0.0% 0	0.0% 0	1.3% 1	18.2% 18	22.3% 27	25.0% 31	22.8% 55	21.1% 47	14.7% 28	12.6% 26
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	1.3% 1	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.0% 0	0.5% 1	0.0% 0

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

D. *Salmonella* Heidelberg

In 2005, Heidelberg was the fourth most commonly isolated non-Typhi *Salmonella* serotype in NARMS, accounting for 6.1% (125/2052) of non-Typhi *Salmonella* isolates (Table 1.04). The highest proportions of the *Salmonella* Heidelberg isolates tested were resistant to ampicillin (20.0%), tetracycline (18.4%), streptomycin (13.6%), kanamycin (12.8%) amoxicillin-clavulanic acid, ceftiofur, and cefoxitin (8.8%) and sulfisoxazole (8.0%). The prevalence of resistance among clinically important antimicrobial subclasses was 1.7% for quinolones (represented by nalidixic acid) and 18.3% for third-generation cephalosporins (represented by ceftiofur) (Table 1.20).

Ceftiofur resistance was first noted in one isolate (1.3%) in 1996; it increased to 9.7% in 2004 and decreased to 8.8% in 2005 (Table 1.15). *Salmonella* Heidelberg was the second most common serotype (18.3%), tied with Typhimurium, among ceftiofur-resistant non-Typhi *Salmonella* (Table 1.20).

In contrast to other common serotypes, the percentage of *Salmonella* Heidelberg isolates with no detected resistance increased from 54.1% in 1996 and 62.4% in 2005 (Table 1.16). In addition, resistance to at least five subclasses of antimicrobial agents decreased from 3.2% in 2004 to 2.4% in 2005.

In 2005, one *Salmonella* Heidelberg isolate was found to have the combination of quinolone and third-generation cephalosporin resistance (Table 1.16).

Table 1.14: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* Heidelberg isolates to antimicrobial agents, 2005 (N=125)

Antibiotic		% 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	[0.0–2.9]						26.4	63.2	8.8	0.8	0.8						
	Gentamicin	0.8	6.4	[2.8–12.2]					73.6	16.0	2.4	0.8		0.8	3.2	3.2				
	Streptomycin	NA	13.6	[8.1–20.9]												86.4	7.2	6.4		
Aminopenicillins	Ampicillin	0.0	20.0	[13.4–28.1]							62.4	16.8	0.8				20.0			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	4.8	8.8	[4.5–15.2]							77.6	1.6	0.8	6.4	4.8	2.4	6.4			
Cephalosporins (3rd generation)	Ceftiofur	0.0	8.8	[4.5–15.2]					1.6	73.6	15.2	0.8			8.8					
	Ceftriaxone	7.2	0.0	[0.0–2.9]					91.2					1.6	6.4	0.8				
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–2.9]	99.2					0.8										
	Nalidixic Acid	NA	0.8	[0.0–4.4]								20.8	77.6	0.8			0.8			
Aminoglycosides	Kanamycin	0.0	12.8	[7.5–20.0]										87.2				12.8		
Cephamycins	Cefoxitin	0.0	8.8	[4.5–15.2]							59.2	26.4	4.0	1.6		4.8	4.0			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	0.8	[0.0–4.4]				96.0	3.2					0.8						
Phenicols	Chloramphenicol	0.8	0.8	[0.0–4.4]								0.8	61.6	36.0	0.8		0.8			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	0.0	[3.9–14.2]											50.4	37.6	4.0		8.0	
Tetracyclines	Tetracycline	0.0	18.4	[12.0–26.3]									81.6			1.6	16.8			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

§The 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 1.07: Antimicrobial resistance pattern for *Salmonella* Heidelberg, 2005

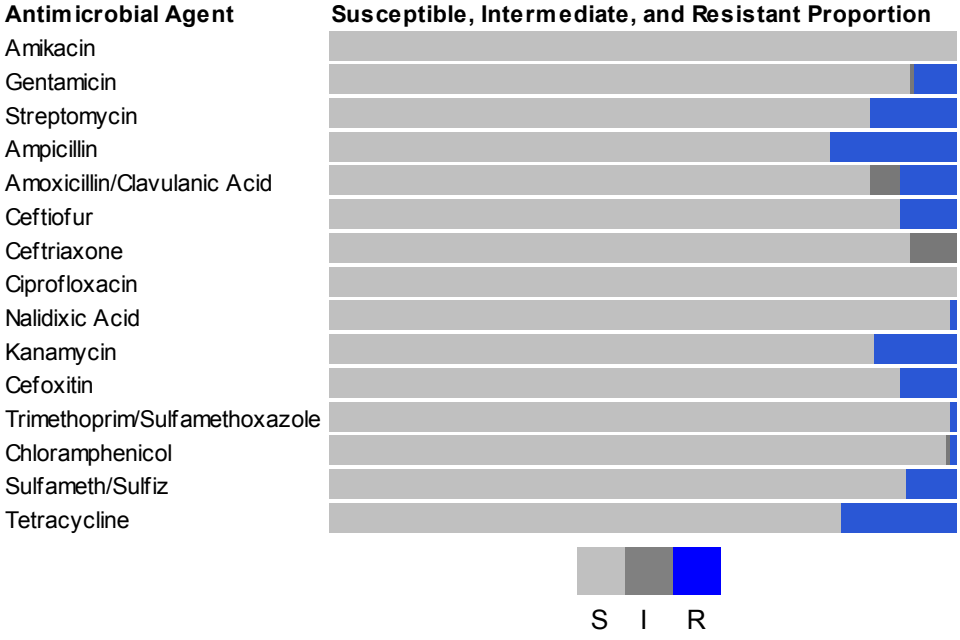


Table 1.15: Percentage and number of *Salmonella* Heidelberg isolates resistant to antimicrobial agents, 1996–2005

Table 1.15: Percentage and number of *Salmonella* Heidelberg isolates resistant to antimicrobial agents, 1996–2005

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates		74	75	101	88	79	102	105	96	93	125
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	23.0% 17	17.3% 13	16.8% 17	14.8% 13	8.9% 7	7.8% 8	3.8% 4	5.2% 5	4.3% 4	6.4% 8
	Streptomycin (MIC ≥ 64)	40.5% 30	24.0% 18	30.7% 31	23.9% 21	22.8% 18	25.5% 26	17.1% 18	12.5% 12	15.1% 14	13.6% 17
Aminopenicillins	Ampicillin (MIC ≥ 32)	14.9% 11	13.3% 10	16.8% 17	6.8% 6	10.1% 8	9.8% 10	12.4% 13	10.4% 10	25.8% 24	20.0% 25
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.7% 2	1.3% 1	1.0% 1	1.1% 1	3.8% 3	2.9% 3	9.5% 10	5.2% 5	10.8% 10	8.8% 11
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	1.4% 1	0.0% 0	0.0% 0	0.0% 0	3.8% 3	2.9% 3	7.6% 8	5.2% 5	9.7% 9	8.8% 11
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
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	1.0% 1	1.1% 1	1.3% 1	0.0% 0	0.0% 0	1.0% 1	0.0% 0	0.8% 1
Aminoglycosides	Kanamycin (MIC ≥ 64)	14.9% 11	8.0% 6	12.9% 13	9.1% 8	15.2% 12	19.6% 20	10.5% 11	8.3% 8	8.6% 8	12.8% 16
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	6.8% 5	2.7% 2	5.9% 6	3.4% 3	5.1% 4	3.9% 4	10.5% 11	7.3% 7	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	2.5% 2	2.9% 3	8.6% 9	5.2% 5	8.6% 8	8.8% 11
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	0.0% 0	0.0% 0	2.0% 2	1.1% 1	1.3% 1	2.0% 2	1.0% 1	2.1% 2	0.0% 0	0.8% 1
Phenicols	Chloramphenicol (MIC ≥ 32)	1.4% 1	0.0% 0	1.0% 1	1.1% 1	1.3% 1	1.0% 1	1.0% 1	0.0% 0	1.1% 1	0.8% 1
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	17.6% 13	21.3% 16	21.8% 22	18.2% 16	11.4% 9	8.8% 9	6.7% 7	7.3% 7	7.5% 7	8.0% 10
Tetracyclines	Tetracycline (MIC ≥ 16)	20.3% 15	12.0% 9	19.8% 20	18.2% 16	21.5% 17	24.5% 25	19.0% 20	16.7% 16	19.4% 18	18.4% 23

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

Table 1.16: Resistance patterns of *Salmonella* Heidelberg isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	74	75	101	88	79	102	105	96	93	125
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	54.1% 40	66.7% 50	56.4% 57	68.2% 60	63.3% 50	64.7% 66	67.6% 71	68.8% 66	55.9% 52	62.4% 78
Resistance ≥1CLSI subclass*	45.9% 34	33.3% 25	43.6% 44	31.8% 28	36.7% 29	35.3% 36	32.4% 34	31.3% 30	44.1% 41	37.6% 47
Resistance ≥2 CLSI subclasses*	33.8% 25	26.7% 20	33.7% 34	26.1% 23	26.6% 21	29.4% 30	25.7% 27	17.7% 17	23.7% 22	24.8% 31
Resistance ≥3 CLSI subclasses*	12.2% 9	12.0% 9	13.9% 14	10.2% 9	7.6% 6	7.8% 8	11.4% 12	10.4% 10	14.0% 13	15.2% 19
Resistance ≥4 CLSI subclasses*	4.1% 3	1.3% 1	4.0% 4	4.5% 4	3.8% 3	2.0% 2	1.9% 2	2.1% 2	4.3% 4	4.8% 6
Resistance ≥5 CLSI subclasses*	2.7% 2	1.3% 1	1.0% 1	0.0% 0	3.8% 3	2.0% 2	1.9% 2	0.0% 0	3.2% 3	2.4% 3
At least ACSSuT†	1.4% 1	0.0% 0	0.0% 0	0.0% 0	1.3% 1	1.0% 1	1.0% 1	0.0% 0	1.1% 1	0.0% 0
At least ACSuTm‡	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 1	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.3% 1	1.0% 1	1.0% 1	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC¶	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.3% 1	1.0% 1	1.0% 1	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.8% 1

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

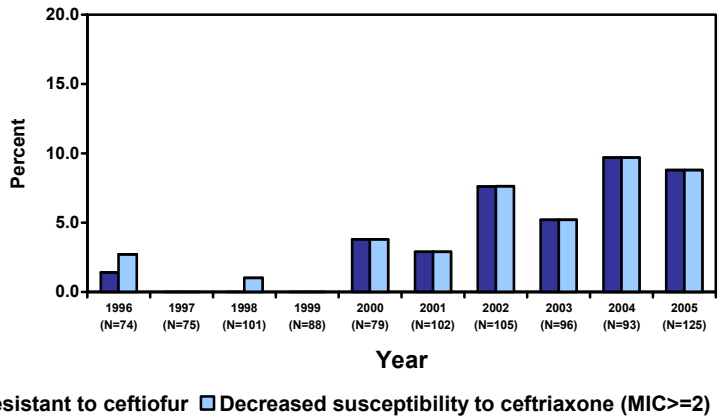
Resistance to Third-Generation Cephalosporins in *Salmonella enterica* Serotype Heidelberg, NARMS, 1996-2005

Salmonella Heidelberg is one of the leading non-Typhi *Salmonella* serotypes. In 2005, it ranked 5th among human non-Typhi *Salmonella* isolates tested by the National Antimicrobial Resistance Monitoring (NARMS) and among culture-confirmed infections reported to National *Salmonella* Surveillance System at CDC (http://www.cdc.gov/ncidod/dbmd/phlisdata/default.htm). It is one of the most common serotypes among non-Typhi *Salmonella* isolates reported from retail poultry (http://www.fda.gov/cvm/2005NARMSAnnualRpt.htm) and food animals (http://www.ars.usda.gov/Main/docs.htm?docid=16598). Ceftriaxone, a third-generation cephalosporin used to treat invasive *Salmonella* infections in children, is closely related to ceftiofur, a third-generation cephalosporin used in food animals in the United States. Ceftiofur resistance has been associated with decreased susceptibility to ceftriaxone (Medalla et al., ICEID 2006). Molecular biological analyses of extended-spectrum cephalosporin-resistant strains of *Salmonella* have revealed that resistance is primarily associated with plasmids (designated types A, B, C, and D) that carry the bla_{CMY-2} gene. These data suggest that the bla_{CMY-2} gene has been disseminated among *Salmonella* strains primarily through plasmid transfer (Carattoli et al., Antimicrob Agents Chemother 2002, 46:1269-72; Giles et al., Antimicrob Agents Chemother 2004, 48:2845-52).

Although ceftriaxone resistance is rare among non-Typhi *Salmonella* submitted to NARMS, an increase in ceftiofur resistance since 1996 has been seen. This increase was mainly driven by an increase in the so-called "MDR-AmpC" phentoype in serotype Newport (Gupta et al., J Infect Dis 2003, 188:1707-16). MDR-AmpC is defined as resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftiofur, and decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL). From 1996 to 2005, MDR-AmpC was noted in 12 serotypes in addition to Newport. Here we describe the trend in ceftiofur resistance in *Salmonella* Heidelberg in NARMS from 1996-2005. Isolate submission and testing are described in the methods section of this report.

From 1996-2005, 938 (5.8%) of 16,093 non-Typhi *Salmonella* isolates were serotype Heidelberg. Of 938 Heidelberg isolates, 40 (4.3%) were ceftiofur-resistant. Ceftiofur resistance increased from 1.4% in 1996 to 8.8% in 2005 [Figure 1]. Decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL) showed the same trend [Figure 1]. In contrast to an increase in MDR-AmpC observed with the emergence of extended-spectrum cephalosporin resistance among serotype Newport, only 3 of the ceftiofur-resistant Heidelberg isolates were MDR-AmpC. NARMS is characterizing the genetic elements involved in the dissemination of the bla_{CMY} genes that confer extended-spectrum cephalosporin resistance in *Salmonella* Heidelberg.

Figure 1: Percentage of *Salmonella* Heidelberg with ceftiofur resistance and decreased susceptibility to ceftriaxone, by year, 1996-2005



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

In 2005, I 4,[5],12:i:- was the twelfth most common non-Typhi *Salmonella* serotype in NARMS. Most *Salmonella* I 4,[5],12:i:- isolates had no detected resistance. Multidrug resistance was not common in this serotype.

In 2005, I 4,[5],12:i:- was the twelfth most commonly isolated non-Typhi *Salmonella* serotype in NARMS, accounting for 1.6% (33/2052) of non-Typhi *Salmonella* isolates (Table 1.04). The highest proportions of the *Salmonella* I 4,[5],12:i:- isolates tested were resistant to ampicillin (6.1%), tetracycline, streptomycin, amoxicillin-clavulanic acid, ceftiofur, and cefoxitin (3.0%). The prevalence of resistance among clinically important antimicrobial subclasses was 0.0% for quinolones (represented by nalidixic acid) and 1.7% for third-generation cephalosporins (represented by ceftiofur) (Table 1.20).

Ceftiofur resistance was first noted in one isolate (7.1%) in 2001; it decreased to 2.8% in 2004 and rose again to 3.0% in 2005 (Table 1.18).

Most *Salmonella* I 4,[5],12:i:- isolates had no detected resistance. In contrast to other common serotypes, the percentage of *Salmonella* I 4,[5],12:i:- isolates with no detected resistance increased from 80.6% in 2004 to 87.9% in 2005 (Table 1.19). In addition, resistance to at least three subclasses of antimicrobial agents decreased from 11.1% in 2004 to 3.0% in 2005.

Multidrug-resistance was not common in *Salmonella* I 4,[5],12:i:- (Table 1.19). Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline (ACSSuT) and resistance to at least ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole (ACSuTm) were first reported in 2001.

Table 1.17: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* I 4,[5],12:i:- isolates to antimicrobial agents, 2005 (N=33)

Antibiotic		% 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	[0.0–10.6]						9.1	75.8	15.2								
	Gentamicin	0.0	0.0	[0.0–10.6]					72.7	27.3										
	Streptomycin	NA	3.0	[0.1–15.8]												97.0	3.0			
Aminopenicillins	Ampicillin	0.0	6.1	[0.7–20.2]							78.8	15.2					6.1			
β-lactamase inhibitor Cephalosporins (3rd generation)	Amoxicillin-clavulanic acid	0.0	3.0	[0.1–15.8]							81.8	9.1	3.0	3.0			3.0			
	Ceftiofur	0.0	3.0	[0.1–15.8]						78.8	18.2				3.0					
	Ceftriaxone	3.0	0.0	[0.0–10.6]					97.0						3.0					
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–10.6]	100.0															
	Nalidixic Acid	NA	0.0	[0.0–10.6]								60.6	36.4	3.0						
Aminoglycosides	Kanamycin	0.0	0.0	[0.0–10.6]										100.0						
Cephamycins	Cefoxitin	0.0	3.0	[0.1–15.8]							42.4	51.5	3.0				3.0			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	0.0	[0.0–10.6]				93.9	6.1											
Phenicols	Chloramphenicol	0.0	0.0	[0.0–10.6]									81.8	18.2						
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	0.0	[0.0–10.6]											15.2	66.7	18.2			
Tetracyclines	Tetracycline	0.0	3.0	[0.1–15.8]									97.0			3.0				

*Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

†Percent of isolates that were resistant

‡95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

§The 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 1.08: Antimicrobial resistance pattern for *Salmonella* I 4,[5],12:i:-, 2005

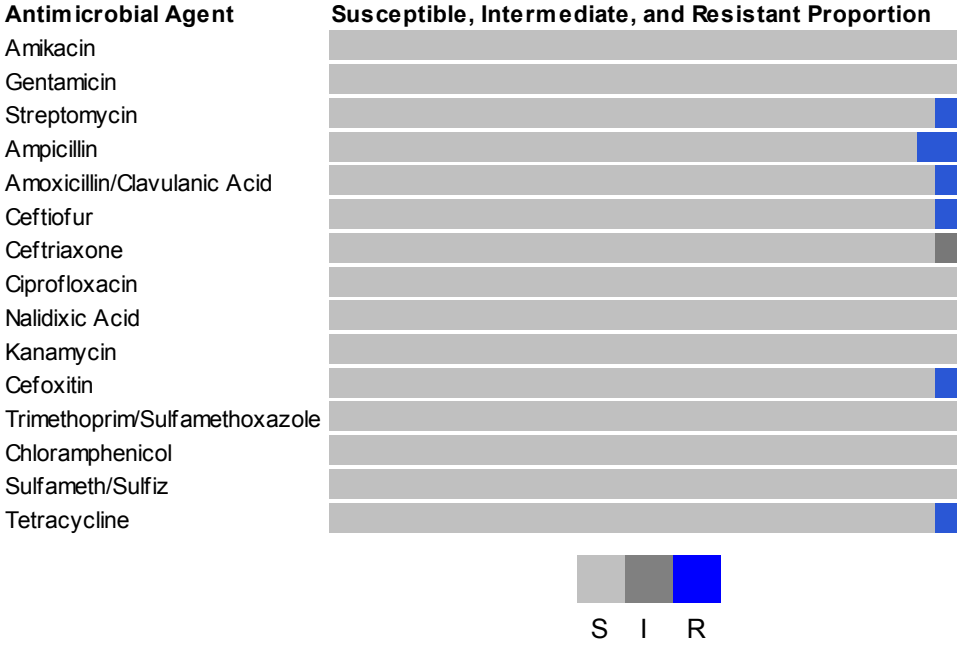


Table 1.18: Percentage and number of *Salmonella* I 4,[5],12:i:- isolates resistant to antimicrobial agents, 1996–2005

Year Total Isolates		1996 3	1997 3	1998 0	1999 8	2000 13	2001 14	2002 35	2003 37	2004 36	2005 33
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	0.0% 0	5.4% 2	5.6% 2	0.0% 0
	Streptomycin (MIC ≥ 64)	0.0% 0	66.7% 2	0.0% 0	0.0% 0	7.7% 1	14.3% 2	2.9% 1	8.1% 3	5.6% 2	3.0% 1
Aminopenicillins	Ampicillin (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.7% 1	7.1% 1	8.6% 3	8.1% 3	5.6% 2	6.1% 2
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	2.9% 1	5.4% 2	2.8% 1	3.0% 1
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	5.4% 2	2.8% 1	3.0% 1
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.8% 1	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.7% 1	2.8% 1	0.0% 0
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	5.4% 2	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.0% 0	2.9% 1	5.4% 2	2.8% 1	3.0% 1
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0
Phenicols	Chloramphenicol (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	0.0% 0	100.0% 3	0.0% 0	12.5% 1	0.0% 0	14.3% 2	2.9% 1	5.4% 2	11.1% 4	0.0% 0
Tetracyclines	Tetracycline (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.7% 1	7.1% 1	5.7% 2	0.0% 0	11.1% 4	3.0% 1

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

Table 1.19: Resistance patterns of *Salmonella* I 4,[5],12:i:- isolates, 1996–2005

Year	1996	1997	1999	2000	2001	2002	2003	2004	2005
Total Isolates	3	3	8	13	14	35	37	36	33
	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	100.0% 3	0.0% 0	87.5% 7	92.3% 12	78.6% 11	91.4% 32	78.4% 29	80.6% 29	87.9% 29
Resistance ≥1CLSI subclass*	0.0% 0	100.0% 3	12.5% 1	7.7% 1	21.4% 3	8.6% 3	21.6% 8	19.4% 7	12.1% 4
Resistance ≥2 CLSI subclasses*	0.0% 0	66.7% 2	0.0% 0	7.7% 1	14.3% 2	8.6% 3	10.8% 4	13.9% 5	3.0% 1
Resistance ≥3 CLSI subclasses*	0.0% 0	0.0% 0	0.0% 0	7.7% 1	7.1% 1	5.7% 2	5.4% 2	11.1% 4	3.0% 1
Resistance ≥4 CLSI subclasses*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0
Resistance ≥5 CLSI subclasses*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0
At least ACSSuT†	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	2.8% 1	0.0% 0
At least ACSuTm‡	0.0% 0	0.0% 0	0.0% 0	0.0% 0	7.1% 1	2.9% 1	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC¶	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

F. Specific Phenotypes

The multidrug-resistant phenotypes ACSSuT and MDR-AmpC, and resistance to nalidixic acid and ceftiofur, were detected in several other serotypes in 2005 (Table 1.20).

In 2005, 141 (6.9%) non-Typhi *Salmonella* isolates were resistant to at least ACSSuT. Of these isolates, 68.8% were serotype Typhimurium; 18.4% were Newport; and 2.8% were serotype Java [Paratyphi B var. L(+) tartrate+]; 2.1% were serotype Agona; 1.4% were serotype Enteritidis, and 0.7% were serotype Mbandaka (Table 1.20). Forty-one (1.9%) non-Typhi *Salmonella* isolates were at least MDR-AmpC, of which 63.4% were serotype Newport, 19.5% Typhimurium; 7.3%, Agona; 2.4%, Enteritidis and 2.4%, Mbandaka. Fifty (2.4%) non-Typhi *Salmonella* isolates were nalidixic acid resistant, 36.0% of which were Enteritidis; 8.0%, Typhimurium; 4.0% Javiana, and 2.0%, Agona, Infantis, Heidelberg Muenchen, and Thompson. Sixty (2.9%) non-Typhi *Salmonella* isolates were ceftiofur resistant, of which 43.3% were serotype Newport; 18.3% were Typhimurium; 18.3% were Heidelberg; and 5.0% were Agona, 3.3% were Enteritidis, and 1.7% were Mbandaka, and “monophasic Typhimurium.”

Table 1.20: Number and percentage of ACSSuT-, MDR-AmpC-, nalidixic acid-, and ceftiofur-resistant isolates among the 20 most common non-Typhi *Salmonella* serotypes isolated in NARMS, 2005

			ACSSuT*		MDRAmpC†		Nalidixic Acid		Ceftiofur	
Rank	**Serotype**	**N**	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**
1	Typhimurium	437	**97**	**(68.8%)**	**8**	**(19.5%)**	**4**	**(8.0%)**	**11**	**(18.3%)**
2	Enteritidis	383	**2**	**(1.4%)**	**1**	**(2.4%)**	**18**	**(36.0%)**	**2**	**(3.3%)**
3	Newport	207	**26**	**(18.4%)**	**26**	**(63.4%)**	0	(0.0%)	**26**	**(43.3%)**
4	Heidelberg	125	0	(0.0%)	0	(0.0%)	**1**	**(2.0%)**	**11**	**(18.3%)**
5	Javiana	75	0	(0.0%)	0	(0.0%)	**2**	**(4.0%)**	0	(0.0%)
6	Montevideo	48	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
7	Braenderup	47	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
8	Muenchen	44	0	(0.0%)	0	(0.0%)	**1**	**(2.0%)**	0	(0.0%)
9	Saintpaul	41	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
10	Paratyphi B var. L(+) tartrate+	38	**4**	**(2.8%)**	0	(0.0%)	0	(0.0%)	0	(0.0%)
11	Mississippi	37	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
12	I 4,[5],12:i:- (monophasic Typhimurium)	33	0	(0.0%)	0	(0.0%)	0	(0.0%)	**1**	**(1.7%)**
13	Oranienburg	33	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
14	Infantis	30	0	(0.0%)	0	(0.0%)	**1**	**(2.0%)**	0	(0.0%)
15	Thompson	26	0	(0.0%)	0	(0.0%)	**1**	**(2.0%)**	0	(0.0%)
16	Agona	22	**3**	**(2.1%)**	**3**	**(7.3%)**	**1**	**(2.0%)**	**3**	**(5.0%)**
17	Poona	19	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
18	Stanley	17	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
19	Mbandaka	17	**1**	**(0.7%)**	**1**	**(2.4%)**	0	(0.0%)	**1**	**(1.7%)**
20	Berta	13	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	Subtotal	**1692**	**133**	**(94.3%)**	**39**	**(95.1%)**	**29**	**(58.0%)**	**55**	**(91.7%)**
	All Other Serotypes	360	8	(5.7%)	2	(4.9%)	21	(42.0%)	5	(8.3%)
	Total	**2052**	**141**	**(100.0%)**	**41**	**(100.0%)**	**50**	**(100.0%)**	**60**	**(100.0%)**

*ACSSuT: ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, tetracycline
† MDR-AmpC: ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2µg/mL)

2. *Salmonella* Typhi

Among *Salmonella* Typhi isolates, resistance to nalidixic acid increased from 19.2% in 1996 to 48.4% in 2005. Resistance increased from 2004 to 2005 to most of the antimicrobial agents tested. The percentage of isolates with no detected resistance decreased from 56.6% in 2004 to 48.1% in 2005.

During 2005, CDC received 418 *Salmonella* Typhi isolates, of which 382 (91.3%) were viable and tested for antimicrobial susceptibility; of these isolates, 64 (1.4%) were not included in the analysis because they were duplicate submissions from the same patient, leaving 318 isolates for analysis (Tables II and 2.01). Antimicrobial agents with the highest prevalence of resistance were nalidixic acid (48.4%), trimethoprim-sulfamethoxazole (14.2%), sulfisoxazole (14.2%), and chloramphenicol, streptomycin and ampicillin (13.2%).

Resistance increased from 2004 to 2005 to most of the antimicrobial agents tested (Table 2.02). Nalidixic acid resistance increased from 19.2% in 1999 to 48.4% in 2005; a statistically significant increase (OR=4.0, 95% CI [2.5, 6.3]).

The percentage of isolates with no detected resistance decreased from 56.6% in 2004 to 48.1% in 2005. In 1999, 12.6% of *Salmonella* Typhi isolates were resistant to at least ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole (ACSuTm), which increased to 15.6% in 2003 but declined to 12.9% in 2005 (Table 2.03).

Table 2.01: Minimum inhibitory concentrations (MICs) and resistance of *Salmonella* Typhi isolates to antimicrobial agents, 2005 (N=318)

Antibiotic		% 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	[0.0–1.2]						34.9	57.9	6.3	0.9							
	Gentamicin	0.0	0.0	[0.0–1.2]					94.0	6.0										
	Streptomycin	NA	13.2	[9.7–17.4]												86.8		13.2		
Aminopenicillins	Ampicillin	0.0	13.2	[9.7–17.4]							69.2	17.6					13.2			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	0.6	0.0	[0.0–1.2]							86.8		4.1	8.5	0.6					
Cephalosporins (3rd generation)	Ceftiofur	0.0	0.0	[0.0–1.2]				2.2	11.0	77.7	9.1									
	Ceftriaxone	0.0	0.0	[0.0–1.2]					100.0											
Quinolones	Ciprofloxacin	0.0	0.3	[0.0–1.7]	48.4	1.3	2.2	15.7	29.6	2.5				0.3						
	Nalidixic Acid	NA	48.4	[42.8–54.1]							1.3	43.1	5.3	1.9		0.6	47.8			
Aminoglycosides	Kanamycin	0.0	0.0	[0.0–1.2]										100.0						
Cephamycins	Cefoxitin	0.0	0.0	[0.0–1.2]						4.7	38.1	11.6	33.3	12.3						
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	14.5	[10.8–18.8]				76.4	9.1					14.5						
Phenicols	Chloramphenicol	0.0	13.2	[9.7–17.4]								5.3	73.0	8.5			13.2			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	14.2	[10.5–18.5]											50.3	22.3	11.3	1.9		14.2
Tetracyclines	Tetracycline	0.0	10.1	[7.0–13.9]									89.9				10.1			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

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

Figure 2.01: Antimicrobial resistance pattern for *Salmonella* Typhi, 2005

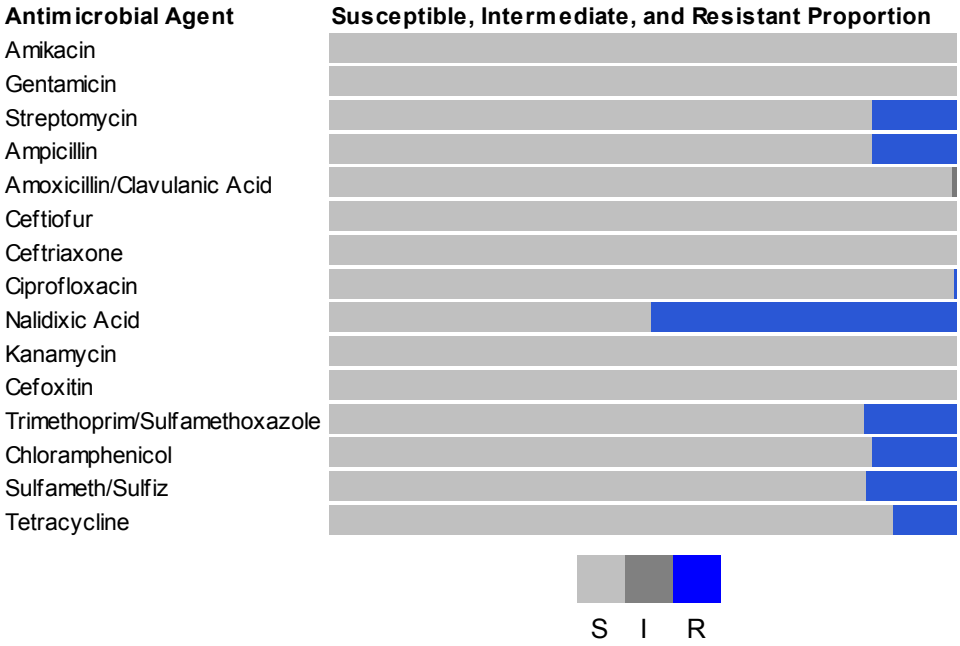


Table 2.02: Percentage and number of *Salmonella* Typhi isolates resistant to antimicrobial agents, 1999–2005

Year Total Isolates		1999 167	2000 177	2001 197	2002 195	2003 334	2004 304	2005 318
Subclass	Antibiotic (Resistance breakpoint)							
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
	Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Streptomycin (MIC ≥ 64)	13.8% 23	9.0% 16	20.3% 40	7.2% 14	14.4% 48	11.8% 36	13.2% 42
Aminopenicillins	Ampicillin (MIC ≥ 32)	13.2% 22	9.0% 16	20.3% 40	5.6% 11	16.2% 54	11.8% 36	13.2% 42
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.6% 2	0.0% 0	0.0% 0
	Ceftriaxone (MIC ≥ 64)	0.6% 1	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.3% 1
	Nalidixic Acid (MIC ≥ 32)	19.2% 32	22.0% 39	29.9% 59	23.6% 46	37.7% 126	41.8% 127	48.4% 154
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	0.5% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	2.4% 4	1.1% 2	0.5% 1	1.5% 3	0.6% 2	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	0.6% 1	0.5% 1	0.0% 0	0.9% 3	0.0% 0	0.0% 0
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	13.2% 22	9.0% 16	20.8% 41	6.7% 13	16.8% 56	13.2% 40	14.5% 46
Phenicols	Chloramphenicol (MIC ≥ 32)	12.6% 21	10.7% 19	20.8% 41	6.2% 12	16.5% 55	13.2% 40	13.2% 42
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	16.8% 28	11.3% 20	20.8% 41	6.2% 12	17.1% 57	11.8% 36	14.2% 45
Tetracyclines	Tetracycline (MIC ≥ 16)	9.6% 16	9.6% 17	20.8% 41	6.7% 13	15.6% 52	8.9% 27	10.1% 32

*Sulfamethoxazole, which was tested during 1999-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 2.03: Resistance patterns of *Salmonella* Typhi isolates, 1999–2005

Year Total Isolates	1999 167	2000 177	2001 197	2002 195	2003 334	2004 304	2005 318
	% n	% n	% n	% n	% n	% n	% n
No resistance detected	71.3% 119	72.9% 129	59.4% 117	74.4% 145	56.6% 189	56.6% 172	48.1% 153
Resistance ≥1CLSI subclass*	28.7% 48	27.1% 48	40.6% 80	25.6% 50	43.4% 145	43.4% 132	51.9% 165
Resistance ≥2 CLSI subclasses*	15.0% 25	10.7% 19	22.8% 45	7.2% 14	18.0% 60	13.2% 40	14.5% 46
Resistance ≥3 CLSI subclasses*	13.2% 22	9.6% 17	22.8% 45	6.7% 13	17.7% 59	12.8% 39	13.8% 44
Resistance ≥4 CLSI subclasses*	13.2% 22	9.0% 16	21.8% 43	6.7% 13	16.8% 56	12.5% 38	12.9% 41
Resistance ≥5 CLSI subclasses*	12.6% 21	9.0% 16	18.8% 37	5.6% 11	15.9% 53	11.8% 36	11.9% 38
At least ACSSuT†	9.6% 16	7.9% 14	16.8% 33	5.6% 11	12.6% 42	7.9% 24	9.1% 29
At least ACSuTm‡	12.6% 21	9.0% 16	17.8% 35	5.6% 11	15.6% 52	11.8% 36	12.9% 41
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC¶	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	0.0% 0	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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

3. *Shigella*

There were differences in resistance to antimicrobial agents between *Shigella sonnei* and *Shigella flexneri.* In 2005, *Shigella sonnei* isolates showed a higher prevalence of resistance to streptomycin and trimethoprim-sulfamethoxazole*, while S. flexneri* showed a higher prevalence of resistance to tetracycline and chloramphenicol. The percentage of isolates with no detected resistance was low in *S. sonnei* (4.4%) and *S. flexneri* (5.8%).

During 2005, CDC received 436 *Shigella* isolates, of which 398 (91.3%) were viable and tested for antimicrobial susceptibility; two (0.5%) isolates were determined to be duplicate submissions from the same patient and were removed from analysis, leaving 396 (90.8%) isolates for analysis (Table II). Of the 396 isolates tested, 340 (85.9%) were *S. sonnei*; 52 (13.1%), *S. flexneri*; three (0.8%), *S. boydii*; and one (0.3%), *S. dysenteriae* (Table 3.01). Resistance was highest to ampicillin (70.7%), streptomycin (68.7%), trimethoprim-sulfamethoxazole (58.6%), sulfisoxazole (57.6%), and tetracycline (38.4%) (Table 3.02).

In 2005, there were differences in resistance to antimicrobial agents between *Shigella sonnei* and *Shigella flexneri* (Tables 3.03 and 3.04). *Shigella sonnei* isolates showed a higher prevalence of resistance to streptomycin and trimethoprim-sulfamethoxazole than *Shigella flexneri*: 70.3% streptomycin resistance in *S. sonnei*, compared with 57.7% in *S. flexneri*; 61.2% trimethoprim-sulfamethoxazole resistance in *S.sonnei*, compared with 44.2% in *S. flexneri.* However, *S. flexneri* showed a higher prevalence of resistance to tetracycline and chloramphenicol than *S. sonnei*: 94.2% tetracycline resistance in *S. flexneri*, compared with 29.4% in *S. sonnei*; 65.4% chloramphenicol resistance in *S. flexneri*, compared with 2.4% in *S. sonnei*.

The percentage of *S. sonnei* isolates resistant to trimethoprim-sulfamethoxazole increased from 53.1% in 2004 to 61.2% in 2005 (Tables 3.05 and 3.06), a rate similar to that during 1999–2000 (53.1–54.9%). Ampicillin resistance

among *S. sonnei* isolates remained high (70.3%). Tetracycline resistance also decreased from 36.1% in 2004 to 29.4% in 2005. Two *S. sonnei* isolates were resistant to ceftriaxone in 2005 and one in 2004; these are the first three ceftriaxone-resistant *Shigella* isolates detected since NARMS began testing *Shigella* in 1999.

Resistance of *S. flexneri* isolates to trimethoprim-sulfamethoxazole also increased from 28.8% in 2002 to 44.2% in 2005 (Tables 3.05 and 3.07). Nalidixic acid resistance was 1.6% in 2004, compared with 3.8% in 2005. Resistance to streptomycin and tetracycline was higher in 2004 (72.1% and 95.1%, respectively) than in 2005 (57.7% and 94.2%, respectively).

Among all *Shigella* spp. isolates tested in all years from 1999 to 2005, more than 90% of isolates, which ranged from 90.9% to 95.6%, were resistant to at least one CLSI subclass. However, resistance to at least five CLSI subclasses declined from 1999 to 2005: 40.5% were resistant to at least five subclasses in 1999, compared with 15.7% in 2005 (Table 3.08).

In all years from 1999 to 2005, resistance to at least ampicilin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline (ACSSuT) and resistance to at least ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole (ACSuTm) were higher in *S. flexneri* compared with *S. sonnei* (Tables 3.09 and 3.10). The percentage of isolates with no detected resistance among *S. sonnei* and S*. flexneri* remained low in all years from 1999 to 2005; it was 4.4% in *S. sonnei* and 5.8% in *S. flexneri* in 2005.

For both *S. sonnei* and *S. flexneri*, resistance to clinically important antimicrobial classes and specific combinations changed from 1999 to 2005 (Tables 3.09 and 3.10). One *Shigella* (*S. sonnei*) isolate was resistant to nalidixic acid and ceftiofur. This was the second *S. sonnei* isolate with this phenotype reported in NARMS. The first reported *Shigella* isolate with this phenotype in NARMS was a *S. flexneri* isolated in 2003. Combined resistance to ampicillin and trimethoprim-sulfamethoxazole was present in more than 40% of isolates from 1999 through 2001, declined to 30.2% in 2002, but increased to 39.4% in 2004 and 40.6% in 2005. Resistance to both agents is clinically relevant, particularly for children for whom treatment with fluoroquinolones is not recommended.

Table 3.01: Frequency of *Shigella* species isolated in NARMS, 2005

Species	2005	
	N	(%)
Shigella sonnei	340	(85.9%)
Shigella flexneri	52	(13.1%)
Shigella boydii	3	(0.8%)
Shigella dysenteriae	1	(0.3%)
Other	0	(0.0%)
Total	**396**	**(100.0%)**

Table 3.02: Minimum inhibitory concentrations (MICs) and resistance of *Shigella* isolates to antimicrobial agents, 2005 (N=396)

Antibiotic		% 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	0.3	0.0	[0.0–0.9]						0.3	5.3	51.5	39.6	3.0		0.3				
	Gentamicin	0.0	1.0	[0.3–2.6]					2.3	32.1	61.1	3.3	0.3			1.0				
	Streptomycin	NA	68.7	[63.9–73.2]												31.3	37.4	31.3		
Aminopenicillins	Ampicillin	0.8	70.7	[66.0–75.1]							4.5	18.9	4.5	0.5	0.8	1.3	69.4			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	16.9	1.0	[0.3–2.6]							1.8	5.3	22.0	53.0	16.9	1.0				
Cephalosporins (3rd generation)	Ceftiofur	0.0	0.5	[0.1–1.8]				15.2	76.3	6.6	1.5				0.5					
	Ceftriaxone	0.0	0.5	[0.1–1.8]					99.0	0.5								0.5		
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–0.9]	98.2		0.5	1.0	0.3											
	Nalidixic Acid	NA	1.5	[0.6–3.3]						0.8	72.2	24.0	1.5			0.5	1.0			
Aminoglycosides	Kanamycin	0.0	0.8	[0.2–2.2]										98.2	1.0			0.8		
Cephamycins	Cefoxitin	0.8	0.3	[0.0–1.4]							17.9	68.9	11.9	0.3	0.8		0.3			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	58.6	[53.6–63.5]				24.2	5.1	2.0	4.0	6.1	4.3	54.3						
Phenicols	Chloramphenicol	10.6	10.9	[8.0–14.3]								10.9	56.8	10.9	10.6	1.5	9.3			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	57.6	[52.5–62.5]											39.1	2.8	0.5			57.6
Tetracyclines	Tetracycline	0.3	38.4	[33.6–43.4]									61.4	0.3	2.5	11.9	24.0			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

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

Figure 3.01: Antimicrobial resistance pattern for *Shigella*, 2005

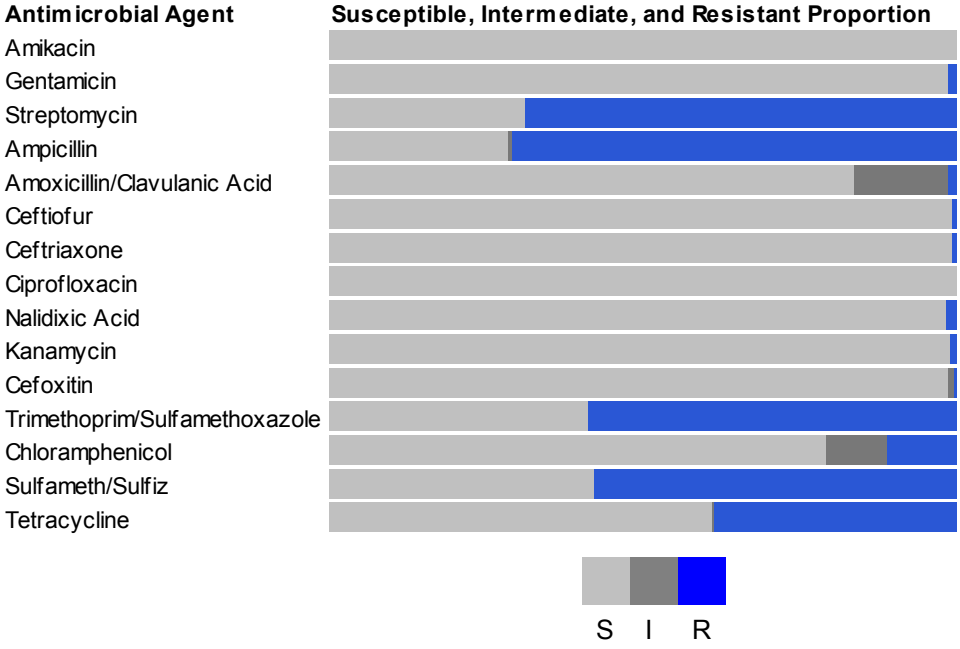


Table 3.03: Minimum inhibitory concentrations (MICs) and resistance of *Shigella sonnei* isolates to antimicrobial agents, 2005 (N=340)

Antibiotic		% 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	[0.0–1.1]						0.3	5.9	56.8	36.2	0.9						
	Gentamicin	0.0	1.2	[0.3–3.0]					2.1	34.4	60.3	2.1				1.2				
	Streptomycin	NA	70.3	[65.1–75.1]												29.7	40.3	30.0		
Aminopenicillins	Ampicillin	0.9	70.6	[65.4–75.4]							1.8	20.9	5.3	0.6	0.9	1.5	69.1			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	9.7	1.2	[0.3–3.0]							0.9	3.5	24.1	60.6	9.7	1.2				
Cephalosporins (3rd generation)	Ceftiofur	0.0	0.6	[0.1–2.1]				11.5	80.0	6.5	1.5				0.6					
	Ceftriaxone	0.0	0.6	[0.1–2.1]					98.8	0.6								0.6		
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.1]	98.5		0.3	1.2												
	Nalidixic Acid	NA	1.2	[0.3–3.0]						0.9	74.7	21.8	1.5			0.3	0.9			
Aminoglycosides	Kanamycin	0.0	0.0	[0.0–1.1]										98.8	1.2					
Cephamycins	Cefoxitin	0.9	0.3	[0.0–1.6]							19.7	71.5	7.6		0.9		0.3			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	61.2	[55.8–66.4]				22.1	4.1	0.9	4.7	7.1	5.0	56.2						
Phenicols	Chloramphenicol	12.4	2.4	[1.0–4.6]								7.1	65.6	12.6	12.4	0.9	1.5			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	57.9	[52.5–63.2]											38.2	3.2	0.6			57.9
Tetracyclines	Tetracycline	0.3	29.4	[24.6–34.6]									70.3	0.3	2.4	12.6	14.4			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

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

Figure 3.02: Antimicrobial resistance pattern for *Shigella sonnei*, 2005

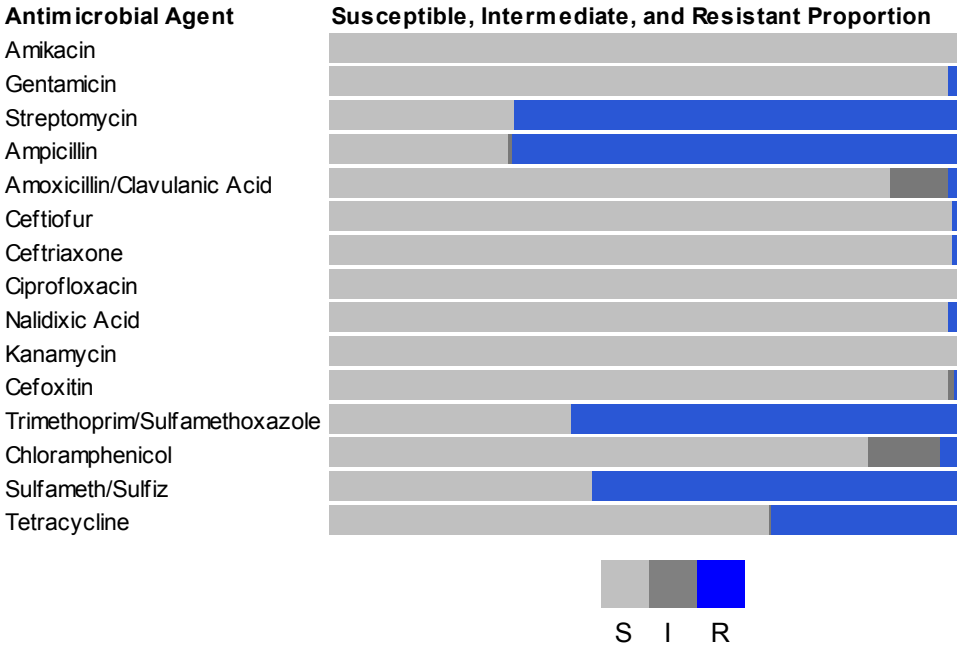


Table 3:04: Minimum inhibitory concentrations and resistance of *Shigella flexneri* isolates to antimicrobial agents, 2005 (N=52)

Antibiotic		% 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	1.9	0.0	[0.0–6.8]							1.9	19.2	59.6	17.3		1.9				
	Gentamicin	0.0	0.0	[0.0–6.8]					3.8	19.2	63.5	11.5	1.9							
	Streptomycin	NA	57.7	[43.2–71.3]												42.3	19.2	38.5		
Aminopenicillins	Ampicillin	0.0	75.0	[61.1–86.0]							21.2	3.8					75.0			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	65.4	0.0	[0.0–6.8]							5.8	17.3	3.8	7.7	65.4					
Cephalosporins (3rd generation)	Ceftiofur	0.0	0.0	[0.0–6.8]				36.5	55.8	5.8	1.9									
	Ceftriaxone	0.0	0.0	[0.0–6.8]					100.0											
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–6.8]	96.2		1.9		1.9											
	Nalidixic Acid	NA	3.8	[0.5–13.2]							55.8	38.5	1.9			1.9	1.9			
Aminoglycosides	Kanamycin	0.0	3.8	[0.5–13.2]										96.2				3.8		
Cephamycins	Cefoxitin	0.0	0.0	[0.0–6.8]							5.8	53.8	38.5	1.9						
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	44.2	[30.5–58.7]				38.5	9.6	7.7				44.2						
Phenicols	Chloramphenicol	0.0	65.4	[50.9–78.0]								30.8	3.8			5.8	59.6			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	55.8	[41.3–69.5]											44.2					55.8
Tetracyclines	Tetracycline	0.0	94.2	[84.1–98.8]									5.8		1.9	7.7	84.6			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

[†]Percent of isolates that were resistant

[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

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

Figure 3.03: Antimicrobial resistance pattern for *Shigella flexneri*, 2005

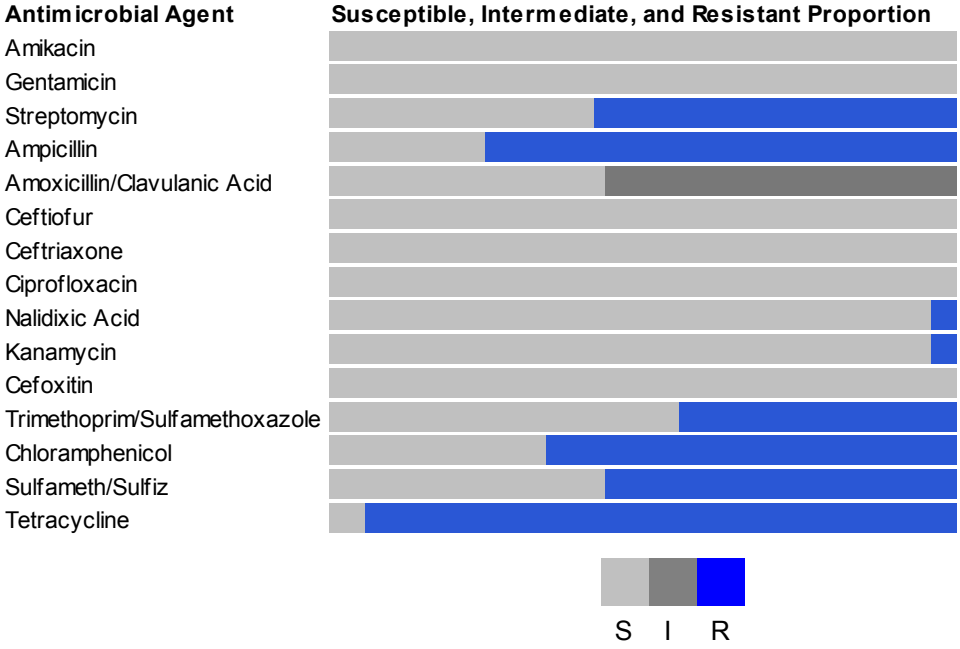


Table 3.05: Percentage and number of *Shigella* isolates resistant to antimicrobial agents, 1999–2005

Year Total Isolates		1999 375	2000 450	2001 344	2002 620	2003 495	2004 315	2005 396
Subclass	Antibiotic (Resistance breakpoint)							
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
	Gentamicin (MIC ≥ 16)	0.3% 1	0.2% 1	0.0% 0	0.2% 1	0.0% 0	0.0% 0	1.0% 4
	Streptomycin (MIC ≥ 64)	55.7% 209	57.1% 257	53.2% 183	54.4% 337	57.0% 282	61.0% 192	68.7% 272
Aminopenicillins	Ampicillin (MIC ≥ 32)	77.6% 291	79.1% 356	79.7% 274	76.6% 475	79.4% 393	77.8% 245	70.7% 280
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	1.1% 4	2.2% 10	4.4% 15	2.6% 16	1.4% 7	1.6% 5	1.0% 4
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.3% 1	0.5% 2
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	1.6% 6	0.9% 4	1.7% 6	1.6% 10	1.0% 5	1.6% 5	1.5% 6
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.5% 2	1.3% 6	0.6% 2	0.8% 5	0.4% 2	0.0% 0	0.8% 3
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	3.2% 12	8.0% 36	9.0% 31	6.6% 41	9.3% 46	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	0.2% 1	1.2% 4	0.3% 2	0.0% 0	0.3% 1	0.3% 1
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	51.5% 193	52.9% 238	46.8% 161	37.3% 231	38.6% 191	51.4% 162	58.6% 232
Phenicols	Chloramphenicol (MIC ≥ 32)	17.3% 65	14.0% 63	21.5% 74	7.6% 47	8.5% 42	14.9% 47	10.9% 43
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	56.0% 210	55.8% 251	56.4% 194	31.8% 197	33.9% 168	52.4% 165	57.6% 228
Tetracyclines	Tetracycline (MIC ≥ 16)	57.3% 215	44.9% 202	59.3% 204	30.6% 190	29.1% 144	49.2% 155	38.4% 152

*Sulfamethoxazole, which was tested during 1999-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 3.06: Percentage and number of *Shigella sonnei* isolates resistant to antimicrobial agents, 1999–2005

Year Total Isolates		1999 275	2000 366	2001 239	2002 536	2003 434	2004 241	2005 340
Subclass	Antibiotic (Resistance breakpoint)							
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
	Gentamicin (MIC ≥ 16)	0.4% 1	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.2% 4
	Streptomycin (MIC ≥ 64)	52.0% 143	56.0% 205	54.0% 129	55.4% 297	56.5% 245	58.1% 140	70.3% 239
Aminopenicillins	Ampicillin (MIC ≥ 32)	79.6% 219	80.6% 295	82.8% 198	77.6% 416	79.7% 346	79.3% 191	70.6% 240
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	0.4% 1	1.9% 7	4.6% 11	2.2% 12	1.4% 6	1.7% 4	1.2% 4
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.6% 2
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
	Nalidixic Acid (MIC ≥ 32)	1.5% 4	1.1% 4	0.8% 2	1.5% 8	0.5% 2	1.7% 4	1.2% 4
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.7% 2	1.6% 6	0.4% 1	0.4% 2	0.0% 0	0.0% 0	0.0% 0
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	2.9% 8	8.7% 32	12.6% 30	7.3% 39	10.1% 44	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	0.3% 1	1.7% 4	0.4% 2	0.0% 0	0.4% 1	0.3% 1
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	53.1% 146	54.9% 201	50.6% 121	37.9% 203	38.5% 167	53.1% 128	61.2% 208
Phenicols	Chloramphenicol (MIC ≥ 32)	1.8% 5	2.7% 10	1.3% 3	0.2% 1	1.2% 5	2.5% 6	2.4% 8
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	54.5% 150	56.0% 205	54.4% 130	29.9% 160	31.3% 136	49.0% 118	57.9% 197
Tetracyclines	Tetracycline (MIC ≥ 16)	46.2% 127	34.4% 126	44.8% 107	23.5% 126	22.1% 96	36.1% 87	29.4% 100

*Sulfamethoxazole, which was tested during 1999-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 3.07: Percentage and number of *Shigella flexneri* isolates resistant to antimicrobial agents, 1999–2005

Year Total Isolates		1999 87	2000 75	2001 91	2002 73	2003 51	2004 61	2005 52
Subclass	Antibiotic (Resistance breakpoint)							
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
	Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	1.4% 1	0.0% 0	0.0% 0	0.0% 0
	Streptomycin (MIC ≥ 64)	63.2% 55	61.3% 46	47.3% 43	43.8% 32	60.8% 31	72.1% 44	57.7% 30
Aminopenicillins	Ampicillin (MIC ≥ 32)	77.0% 67	77.3% 58	72.5% 66	75.3% 55	84.3% 43	82.0% 50	75.0% 39
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	3.4% 3	4.0% 3	4.4% 4	5.5% 4	2.0% 1	1.6% 1	0.0% 0
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	1.4% 1	2.0% 1	0.0% 0	0.0% 0
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	1.1% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic Acid (MIC ≥ 32)	1.1% 1	0.0% 0	3.3% 3	2.7% 2	5.9% 3	1.6% 1	3.8% 2
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	1.1% 1	4.1% 3	3.9% 2	0.0% 0	3.8% 2
Cephalosporin (1st generation)	Cephalothin (MIC ≥ 32)	4.6% 4	2.7% 2	1.1% 1	2.7% 2	3.9% 2	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	48.3% 42	42.7% 32	34.1% 31	28.8% 21	39.2% 20	45.9% 28	44.2% 23
Phenicols	Chloramphenicol (MIC ≥ 32)	64.4% 56	69.3% 52	74.7% 68	63.0% 46	68.6% 35	60.7% 37	65.4% 34
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	58.6% 51	53.3% 40	57.1% 52	41.1% 30	52.9% 27	65.6% 40	55.8% 29
Tetracyclines	Tetracycline (MIC ≥ 16)	92.0% 80	92.0% 69	94.5% 86	78.1% 57	82.4% 42	95.1% 58	94.2% 49

*Sulfamethoxazole, which was tested during 1999-2003 to represent sulfonamides, was replaced by sulfisoxazole in 2004.

Table 3.08: Resistance patterns of *Shigella* isolates, 1999–2005

Year Total Isolates	1999 375	2000 450	2001 344	2002 620	2003 495	2004 315	2005 396
	% n	% n	% n	% n	% n	% n	% n
No resistance detected	9.1% 34	7.3% 33	4.9% 17	8.2% 51	8.5% 42	4.4% 14	4.5% 18
Resistance ≥1CLSI subclass*	90.9% 341	92.7% 417	95.1% 327	91.8% 569	91.5% 453	95.6% 301	95.5% 378
Resistance ≥2 CLSI subclasses*	63.7% 239	64.7% 291	69.8% 240	55.3% 343	57.8% 286	66.7% 210	73.7% 292
Resistance ≥3 CLSI subclasses*	61.1% 229	62.0% 279	61.3% 211	41.8% 259	41.4% 205	62.2% 196	62.9% 249
Resistance ≥4 CLSI subclasses*	54.1% 203	56.7% 255	54.1% 186	31.0% 192	32.5% 161	52.1% 164	55.6% 220
Resistance ≥5 CLSI subclasses*	40.5% 152	26.2% 118	36.0% 124	20.5% 127	22.4% 111	27.6% 87	15.7% 62
At least ACSSuT†	8.5% 32	5.6% 25	6.4% 22	1.8% 11	3.2% 16	6.0% 19	4.0% 16
At least ACSuTm‡	9.9% 37	6.9% 31	7.0% 24	2.7% 17	3.6% 18	6.7% 21	6.3% 25
At least ASuTm§	44.3% 166	44.4% 200	37.5% 129	29.8% 185	33.7% 167	37.8% 119	39.9% 158
At least ANSuTm¶	0.3% 1	0.0% 0	0.6% 2	0.3% 2	0.8% 4	0.6% 2	0.5% 2
At least ACSSuTAuCf**	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC††	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.3% 1	0.3% 1

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

§ASuTm: resistance to ampicillin, trimethoprim-sulfamethoxazole

¶ANSuTm: resistance to ASuTm + naladixic acid

**ACSSuTAuCf: resistance to ACSSuT + amoxicillin-clavulanic acid, ceftiofur

††MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

Table 3.09: Resistance patterns of *Shigella sonnei* isolates, 1999–2005

Year Total Isolates	1999 275	2000 366	2001 239	2002 536	2003 434	2004 241	2005 340
	% n	% n	% n	% n	% n	% n	% n
No resistance detected	10.5% 29	7.7% 28	5.4% 13	7.1% 38	8.5% 37	5.0% 12	4.4% 15
Resistance ≥1CLSI subclass*	89.5% 246	92.3% 338	94.6% 226	92.9% 498	91.5% 397	95.0% 229	95.6% 325
Resistance ≥2 CLSI subclasses*	56.0% 154	60.7% 222	60.7% 145	52.1% 279	54.1% 235	59.8% 144	72.6% 247
Resistance ≥3 CLSI subclasses*	54.5% 150	57.7% 211	53.1% 127	36.6% 196	36.2% 157	54.4% 131	60.0% 204
Resistance ≥4 CLSI subclasses*	50.5% 139	54.1% 198	49.0% 117	26.7% 143	28.6% 124	46.5% 112	53.5% 182
Resistance ≥5 CLSI subclasses*	38.5% 106	23.5% 86	36.0% 86	19.4% 104	20.0% 87	24.9% 60	11.5% 39
At least ACSSuT†	0.4% 1	0.8% 3	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.3% 1
At least ACSuTm‡	1.8% 5	1.9% 7	0.8% 2	0.2% 1	0.9% 4	1.7% 4	2.4% 8
At least ASuTm§	45.1% 124	46.2% 169	41.0% 98	30.2% 162	33.6% 146	39.4% 95	40.6% 138
At least ANSuTm¶	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.2% 1	0.8% 2	0.3% 1
At least ACSSuTAuCf**	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC††	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.4% 1	0.3% 1

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

§ASuTm: resistance to ampicillin, trimethoprim-sulfamethoxazole

¶ANSuTm: resistance to ASuTm + naladixic acid

**ACSSuTAuCf: resistance to ACSSuT + amoxicillin-clavulanic acid, ceftiofur

††MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

Table 3.10: Resistance patterns of *Shigella flexneri* isolates, 1999–2005

Year Total Isolates	1999 87	2000 75	2001 91	2002 73	2003 51	2004 61	2005 52
	% n	% n	% n	% n	% n	% n	% n
No resistance detected	4.6% 4	4.0% 3	3.3% 3	15.1% 11	7.8% 4	0.0% 0	5.8% 3
Resistance ≥1CLSI subclass*	95.4% 83	96.0% 72	96.7% 88	84.9% 62	92.2% 47	100.0% 61	94.2% 49
Resistance ≥2 CLSI subclasses*	83.9% 73	82.7% 62	90.1% 82	76.7% 56	86.3% 44	93.4% 57	80.8% 42
Resistance ≥3 CLSI subclasses*	80.5% 70	81.3% 61	80.2% 73	75.3% 55	82.4% 42	91.8% 56	80.8% 42
Resistance ≥4 CLSI subclasses*	67.8% 59	69.3% 52	65.9% 60	58.9% 43	64.7% 33	75.4% 46	69.2% 36
Resistance ≥5 CLSI subclasses*	49.4% 43	40.0% 30	31.9% 29	28.8% 21	45.1% 23	41.0% 25	44.2% 23
At least ACSSuT†	33.3% 29	29.3% 22	22.0% 20	15.1% 11	29.4% 15	27.9% 17	28.8% 15
At least ACSuTm‡	34.5% 30	32.0% 24	23.1% 21	21.9% 16	27.5% 14	24.6% 15	32.7% 17
At least ASuTm§	44.8% 39	38.7% 29	25.3% 23	27.4% 20	37.3% 19	36.1% 22	38.5% 20
At least ANSuTm¶	1.1% 1	0.0% 0	1.1% 1	1.4% 1	5.9% 3	0.0% 0	1.9% 1
At least ACSSuTAuCf**	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC††	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	2.0% 1	0.0% 0	0.0% 0

*CLSI: Clinical and Laboratory Standards Institute

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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

§ASuTm: resistance to ampicillin, trimethoprim-sulfamethoxazole

¶ANSuTm: resistance to ASuTm + naladixic acid

**ACSSuTAuCf: resistance to ACSSuT + amoxicillin-clavulanic acid, ceftiofur

††MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

4. *Escherichia coli* O157

In *E. coli O157*, resistance to antimicrobial agents was not common. From 1996 to 2005, there was no temporal trend in the percentage of isolates with no detected resistance, which ranged from 86.6% to 95.3%. Multidrug resistance was rare.

In 2005, CDC received a total of 214 *Escherichia coli* O157 isolates, of which 194 (90.7%) were viable and tested for antimicrobial susceptibility (Table II). Resistance to antimicrobial agents was not common. Antimicrobial agents with the highest prevalence of resistance were tetracycline (8.8%), sulfisoxazole (6.7%), ampicillin (4.1%), and streptomycin (2.1%). Ampicillin resistance decreased from 3.2% in 2003 to 1.2% in 2004 but increased again in 2005 to 4.1% (Table 4.01). Cefoxitin resistance decreased to 0.0% in 2005, down from 0.6% in 2004. No isolates in 2005 were resistant to ceftiofur, whereas two isolates were resistant in 2003 (Table 4.02).

Isolates resistant to at least one CLSI subclass increased from 4.7% in 2004 to 12.4% in 2005 (Table 4.03). Resistance to at least two CLSI subclasses increased from 1.2% in 2004 to 5.2% in 2005. No isolates were resistant to at least five subclasses in 2005. From 1996 to 2005, there was no temporal trend in the percentage of isolates with no detected resistance, which ranged from 86.6% to 95.3%. Multidrug resistance was rare.

Antimicrobial treatment of *E. coli* O157 infections is not recommended. However, third-generation cephalosporin resistance surveillance might prove useful in understanding resistance mechanisms and the exchange of mobile resistance elements among enteric pathogens in bovine production settings.

Table 4.01: Minimum inhibitory concentrations (MICs) and resistance of *Escherichia coli* O157 isolates to antimicrobial agents, 2005 (N=194)

Antibiotic		% 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	[0.0–1.9]						5.2	73.2	19.1	2.6							
	Gentamicin	0.0	0.5	[0.0–2.8]					54.6	42.8	2.1					0.5				
	Streptomycin	NA	2.1	[0.6–5.2]												97.9	1.0	1.0		
Aminopenicillins	Ampicillin	0.0	4.1	[1.8–8.0]							4.6	72.7	17.0	1.5			4.1			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	0.5	0.0	[0.0–1.9]							0.5	9.3	86.1	3.6	0.5					
Cephalosporins (3rd generation)	Ceftiofur	0.0	0.0	[0.0–1.9]				3.1	30.9	63.4	2.6									
	Ceftriaxone	0.0	0.0	[0.0–1.9]					100.0											
Quinolones	Ciprofloxacin	0.0	0.0	[0.0–1.9]	97.9	0.5		0.5	1.0											
	Nalidixic Acid	NA	1.5	[0.3–4.5]						0.5	2.6	77.3	18.0				1.5			
Aminoglycosides	Kanamycin	0.0	0.5	[0.0–2.8]										99.5				0.5		
Cephamycins	Cefoxitin	1.0	0.0	[0.0–1.9]							2.1	7.7	75.3	13.9	1.0					
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	0.5	[0.0–2.8]				95.9	3.6					0.5						
Phenicols	Chloramphenicol	0.5	1.0	[0.1–3.7]								4.6	31.4	62.4	0.5		1.0			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	6.7	[3.6–11.2]											87.1	5.7	0.5			6.7
Tetracyclines	Tetracycline	1.0	8.8	[5.2–13.7]									90.2	1.0	1.0	0.5	7.2			

*Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists

†Percent of isolates that were resistant

‡95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method

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

Figure 4.01: Antimicrobial resistance pattern for *Escherichia coli* O157, 2005

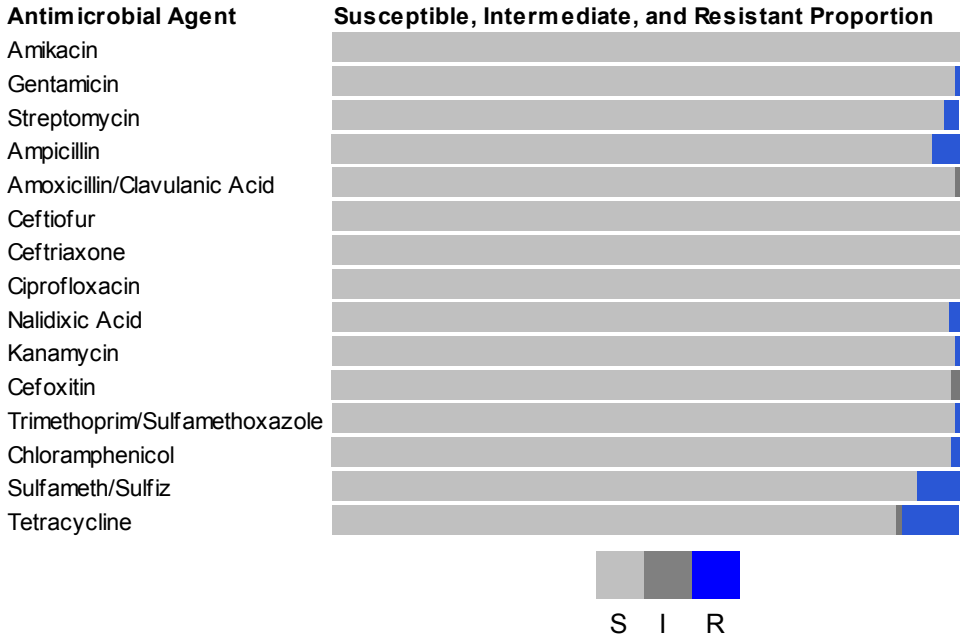


Table 4.02: Percentage and number of *Escherichia coli* O157 isolates resistant to antimicrobial agents, 1996–2005

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates		201	161	318	292	407	277	399	157	169	194
Subclass	Antibiotic (Resistance breakpoint)										
Aminoglycosides	Amikacin (MIC ≥ 64)	Not Tested	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 2	0.4% 1	0.0% 0	0.0% 0	0.6% 1	0.5% 1
	Streptomycin (MIC ≥ 64)	2.0% 4	2.5% 4	1.9% 6	2.7% 8	5.2% 21	1.8% 5	2.3% 9	1.9% 3	1.8% 3	2.1% 4
Aminopenicillins	Ampicillin (MIC ≥ 32)	1.5% 3	0.0% 0	2.5% 8	1.4% 4	2.7% 11	2.2% 6	1.5% 6	3.2% 5	1.2% 2	4.1% 8
Beta-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.3% 1	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.0% 0	0.0% 0
Cephalosporins (3rd Gen.)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 4	1.1% 3	0.0% 0	1.3% 2	0.0% 0	0.0% 0
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	Nalidixic acid (MIC ≥ 32)	0.0% 0	0.0% 0	0.0% 0	0.7% 2	0.5% 2	1.1% 3	1.0% 4	0.6% 1	1.8% 3	1.5% 3
Aminoglycosides	Kanamycin (MIC ≥ 64)	0.0% 0	0.0% 0	0.3% 1	0.7% 2	1.0% 4	0.0% 0	0.5% 2	0.0% 0	0.0% 0	0.5% 1
Cephalosporin (1st Gen.)	Cephalothin (MIC ≥ 32)	1.5% 3	2.5% 4	0.0% 0	0.7% 2	1.2% 5	1.4% 4	1.5% 6	2.5% 4	Not Tested	Not Tested
Cephamycins	Cefoxitin (MIC ≥ 32)	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 4	0.7% 2	0.0% 0	1.3% 2	0.6% 1	0.0% 0
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	0.0% 0	0.0% 0	0.6% 2	1.4% 4	0.7% 3	0.7% 2	0.5% 2	0.6% 1	0.0% 0	0.5% 1
Phenicols	Chloramphenicol (MIC ≥ 32)	0.5% 1	0.0% 0	0.3% 1	0.0% 0	3.7% 15	1.4% 4	1.3% 5	1.3% 2	0.6% 1	1.0% 2
Sulfonamides	Sulfamethoxazole/Sulfisoxazole* (MIC ≥ 512)	11.9% 24	9.9% 16	5.7% 18	8.2% 24	5.9% 24	5.1% 14	3.5% 14	3.8% 6	1.8% 3	6.7% 13
Tetracyclines	Tetracycline (MIC ≥ 16)	5.0% 10	3.1% 5	4.4% 14	3.4% 10	7.1% 29	5.4% 15	3.0% 12	5.7% 9	1.8% 3	8.8% 17

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

Table 4.03: Resistance patterns of *Escherichia coli* O157 isolates, 1996–2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Isolates	201	161	318	292	407	277	399	157	169	194
	% n	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	86.6% 174	88.8% 143	92.8% 295	89.7% 262	90.4% 368	91.3% 253	94.0% 375	90.4% 142	95.3% 161	87.6% 170
Resistance ≥1CLSI subclass*	13.4% 27	11.2% 18	7.2% 23	10.3% 30	9.6% 39	8.7% 24	6.0% 24	9.6% 15	4.7% 8	12.4% 24
Resistance ≥2 CLSI subclasses*	5.0% 10	3.7% 6	5.3% 17	3.4% 10	6.6% 27	5.4% 15	3.8% 15	5.1% 8	1.2% 2	5.2% 10
Resistance ≥3 CLSI subclasses*	1.5% 3	0.6% 1	1.9% 6	3.1% 9	4.7% 19	2.2% 6	2.0% 8	3.2% 5	0.6% 1	1.0% 2
Resistance ≥4 CLSI subclasses*	0.5% 1	0.0% 0	0.9% 3	1.0% 3	3.7% 15	1.8% 5	1.0% 4	1.3% 2	0.6% 1	0.5% 1
Resistance ≥5 CLSI subclasses*	0.5% 1	0.0% 0	0.0% 0	0.7% 2	1.5% 6	0.7% 2	0.3% 1	0.6% 1	0.0% 0	0.0% 0
At least ACSSuT†	0.5% 1	0.0% 0	0.0% 0	0.0% 0	1.2% 5	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ACSuTm‡	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.2% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least ACSSuTAuCf§	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 4	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
At least MDR-AmpC¶	0.0% 0	0.0% 0	0.0% 0	0.0% 0	1.0% 4	0.4% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0	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

‡ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

¶MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

5. *Campylobacter*

Among all *Campylobacter* isolates tested, ciprofloxacin resistance increased from 12.9% in 1997 to 21.7 in 2005. Resistance to erythromycin remained low during 1997 to 2005. An increase in ciprofloxacin resistance in *C. jejuni* similar to the trend in all *Campylobacter* isolates was observed. The percentage of resistance to most agents tested, including ciprofloxacin and erythromycin, was higher in *C. coli* compared with *C. jejuni*.

In 2005, CDC received 998 *Campylobacter* isolates, of which 890 (89.2%) were viable and tested for antimicrobial susceptibility. A total of 791 (92.6%) were *C. jejuni* and 98 (11.5%) were *C. coli* (Table 5.01).

Of the *Campylobacter* isolates tested in 2005 (Table II), resistance was highest to tetracycline (40.6%), nalidixic acid (22.4%), and ciprofloxacin (21.7%) (Table 5.02). Of the isolates tested, 0.6% were resistant to florfenicol, which replaced chloramphenicol to represent the phenicol antimicrobial subclass.

The percentage of *Campylobacter* isolates resistant to ciprofloxacin increased from 12.9% in 1997 to 21.7% in 2005, which is a statistically significant increase (OR=2.2, 95% CI [1.4, 3.4]). Resistance to erythromycin remained low at 2.1% or less during 1997 to 2005. It increased from 0.3% in 2004 to 1.8% in 2005 (Table 5.03).

In 2005, 51.6% of *Campylobacter* isolates were resistant to one or more CLSI subclass, compared with 53.9% in 2004 (Table 5.04). In 2005, 13.6% of *Campylobacter* isolates were resistant to two or more subclasses, compared with 14.1% in 2004.

In 2005, the antimicrobial agent with the highest prevalence of resistance among the 791 *C. jejuni* isolates was tetracycline (41.8), followed by nalidixic acid (21.9%) and ciprofloxacin (21.5%) (Table 5.05). Of note, 0.5% and 1.6% of *C. jejuni* isolates were resistant to gentamicin and erythromycin, respectively.

The percentage of *C. jejuni* isolates resistant to ciprofloxacin increased from 12.4% in 1997 to 21.5% in 2005 (Table 5.06); this increase was statistically significant (OR=2.2, 95% CI [1.4, 3.5]). Erythromycin resistance was low at 1.9% or less during 1997 to 2005.

The percentage of resistance to most agents tested, including ciprofloxacin and erythromycin, was higher in *C. coli* compared with *C. jejuni*. In 2005, the highest levels of resistance among the 98 *C. coli* isolates were to tetracycline (30.6%), nalidixic acid (26.5%), and ciprofloxacin (23.5%) (Table 5.07). The percentage of *C. coli* isolates resistant to ciprofloxacin was 33.3% in 1997, not detected in 1998, but ranged from 12.0% to 47.1% from 1999 to 2005; it was 23.5% in 2005 (Table 5.08). Resistance to erythromycin was not detected in 1997, 12.5% in 1998, ranged from 4.0% to 10.0% during 1999 to 2003, decreased to 0.0% in 2004, and increased to 3.1% in 2005.

Table 5.01: Frequency of *Campylobacter* species isolated in NARMS, 2005

Species	2005	
	N	(%)
Campylobacter jejuni	791	(88.9%)
Campylobacter coli	98	(11.0%)
Other	1	(0.1%)
Total	**890**	**(100.0%)**

Table 5.02: Minimum inhibition concentrations (MICs) and resistance of *Campylobacter* isolates to antimicrobial agents, 2005 (N=890)

Antibiotic		% 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	Gentamicin	0.0	0.6	[0.2–1.4]				6.4	34.7	52.6	5.2	0.6		0.1	0.1		0.4			
Ketolide	Telithromycin	0.7	0.8	[0.3–1.7]	0.1	0.2	0.4	1.2	11.2	39.6	28.3	13.8	3.6	0.7	0.8					
Macrolides	Azithromycin	0.1	1.9	[1.1–3.0]	4.4	24.8	43.5	19.3	4.9	0.1	0.9		0.1	0.3		0.1		1.5		
	Erythromycin	0.0	1.8	[1.0–2.9]			0.6	8.1	34.0	32.8	17.9	3.5	1.2	0.1			0.2	1.6		
Quinolones	Ciprofloxacin	0.0	21.7	[19.0–24.5]	0.6	3.1	34.7	30.0	7.2	2.4	0.3		1.9	9.6	5.5	2.6	1.9	0.2		
	Nalidixic Acid	0.7	22.4	[19.7–25.2]									52.6	20.0	4.4	0.7	3.3	19.1		
Phenicols	Florfenicol[¶]	N/A	0.5	[0.2–1.3]					0.2	19.4	61.5	13.4	4.9	0.3	0.2					
Tetracyclines	Tetracycline	0.8	40.6	[37.3–43.9]			6.5	24.7	16.0	6.5	3.8	0.7	0.4	0.8	0.7	4.2	12.7	23.0		
Lincosamides	Clindamycin	0.4	1.5	[0.8–2.5]		4.9	27.2	36.3	21.0	5.4	2.7	0.6	0.4	0.3	0.3	0.8				

[*]Percent of isolates with intermediate susceptibility
[†]Percent of isolates that were resistant
[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
[§]The unshaded areas indicate the range of dilutions tested for each antimicrobial agent. 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 tested concentrations. 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.
¶CLSI guidelines do not currently define a resistance-breakpoint for florfenicol.

Figure 5.01: Antimicrobial resistance pattern for *Campylobacter*, 2005

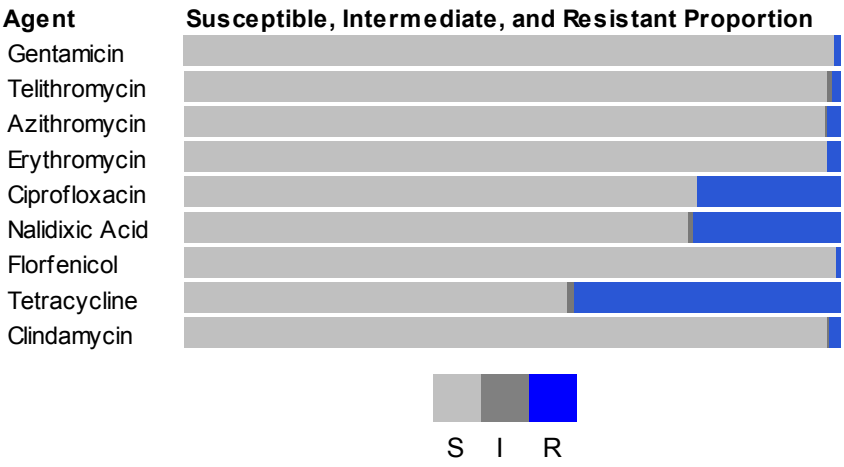


Table 5.03: Percentage and number of *Campylobacter* isolates resistant to antimicrobial agents, 1997–2005

Year Total Isolates		1997 217	1998 310	1999 317	2000 324	2001 384	2002 354	2003 328	2004 347	2005 890
Subclass	Antibiotic (Resistance breakpoint)									
Aminoglycosides	Gentamicin (MIC ≥ 8)	Not Tested	0.3% 1	0.0% 0	0.3% 1	0.0% 0	0.0% 0	0.3% 1	0.3% 1	0.7% 6
Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 9
Macrolides	Azithromycin (MIC ≥ 8)	Not Tested	0.6% 2	2.2% 7	1.9% 6	2.1% 8	2.0% 7	0.9% 3	0.6% 2	1.9% 17
	Erythromycin (MIC ≥ 32)	1.8% 4	1.0% 3	1.9% 6	1.2% 4	2.1% 8	1.4% 5	0.9% 3	0.3% 1	1.8% 16
Quinolones	Ciprofloxacin (MIC ≥ 4)	12.9% 28	13.9% 43	18.3% 58	14.8% 48	19.5% 75	20.1% 71	17.7% 58	19.0% 66	21.7% 193
	Nalidixic acid (MIC ≥ 64)	14.3% 31	16.8% 52	21.1% 67	16.7% 54	20.3% 78	20.6% 73	18.9% 62	19.6% 68	22.4% 199
Phenicols	Chloramphenicol (MIC ≥ 32)	5.1% 11	2.9% 9	0.6% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.4% 5	Not Tested
	Florfenicol* Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.6% 5
Tetracyclines	Tetracycline (MIC ≥ 16)	47.9% 104	45.5% 141	43.8% 139	38.3% 124	40.9% 157	41.2% 146	38.4% 126	46.1% 160	40.6% 361
Lincosamides	Clindamycin (MIC ≥ 8)	1.8% 4	1.3% 4	1.3% 4	0.9% 3	2.1% 8	2.0% 7	0.6% 2	2.0% 7	1.5% 13

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

Table 5.04: Resistance patterns of *Campylobacter* isolates, 2005

Year Total Isolates	1997 217	1998 310	1999 317	2000 324	2001 384	2002 354	2003 328	2004 347	2005 890
	% n	% n	% n	% n	% n	% n	% n	% n	% n
No resistance detected	47.0% 102	45.2% 140	47.3% 150	52.2% 169	49.2% 189	48.3% 171	50.9% 167	46.1% 160	48.4% 431
Resistance ≥1CLSI subclass*	53.0% 115	54.8% 170	52.7% 167	47.8% 155	50.8% 195	51.7% 183	49.1% 161	53.9% 187	51.6% 459
Resistance ≥2 CLSI subclasses*	15.7% 34	9.7% 30	13.6% 43	8.0% 26	13.3% 51	12.7% 45	8.5% 28	14.1% 49	13.6% 121
Resistance ≥3 CLSI subclasses*	1.8% 4	2.6% 8	1.6% 5	0.9% 3	1.6% 6	1.1% 4	0.9% 3	1.2% 4	1.5% 13
Resistance ≥4 CLSI subclasses*	0.5% 1	0.3% 1	0.9% 3	0.3% 1	0.3% 1	0.0% 0	0.3% 1	0.3% 1	0.3% 3
Resistance ≥5 CLSI subclasses*	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0

*CLSI: Clinical and Laboratory Standards Institute

Table 5.05: Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter jejuni* isolates to antimicrobial agents, 2005, (N=791)

Antibiotic		% 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	Gentamicin	0.0	0.5	[0.1–1.3]				7.1	37.3	51.3	3.3	0.5		0.1			0.4			
Ketolide	Telithromycin	0.4	0.5	[0.1–1.3]		0.3	0.4	1.3	11.2	41.1	30.0	12.9	1.8	0.4	0.5					
Macrolides	Azithromycin	0.1	1.8	[1.0–3.0]	4.8	26.4	46.6	16.9	2.3		1.0		0.1	0.4		0.1		1.3		
	Erythromycin	0.0	1.6	[0.9–2.8]			0.5	8.7	36.9	33.6	16.2	2.0	0.3	0.1			0.3	1.4		
Quinolones	Ciprofloxacin	0.0	21.5	[18.7–24.5]	0.6	3.4	35.9	30.2	5.8	2.3	0.3		1.8	9.5	5.4	2.7	2.0	0.1		
	Nalidixic Acid	0.8	21.9	[19.0–24.9]									55.0	18.8	3.5	0.8	2.9	19.0		
Phenicols	Florfenicol¶	N/A	0.5	[0.1–1.3]					0.3	20.7	62.3	12.0	4.2	0.25	0.25					
Tetracyclines	Tetracycline	0.9	41.8	[38.4–45.4]			7.1	25.0	14.8	5.6	3.7	0.6	0.5	0.9	0.8	4.6	13.5	23.0		
Lincosamides	Clindamycin	0.5	1.1	[0.5–2.1]		5.2	29.6	38.4	19.6	3.8	1.5	0.3	0.5		0.3	0.9				

*Percent of isolates with intermediate susceptibility
†Percent of isolates that were resistant
‡95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
§The unshaded areas indicate the range of dilutions tested for each antimicrobial agent. 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 tested concentrations. 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.
¶CLSI guidelines do not currently define a resistance-breakpoint for florfenicol.

Figure 5.02: Antimicrobial resistance pattern for *Campylobacter jejuni*, 2005

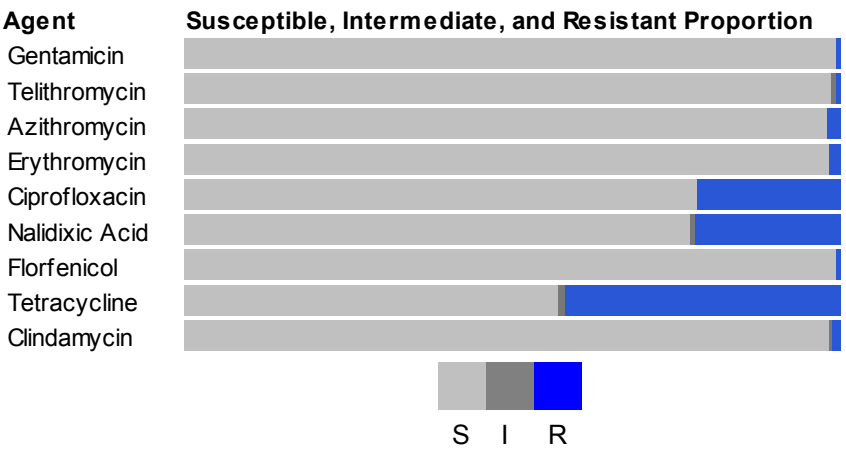


Table 5.06: Percentage and number of *Campylobacter jejuni* isolates resistant to antimicrobial agents, 1997–2005

Year Total Isolates		1997 209	1998 297	1999 293	2000 306	2001 365	2002 329	2003 303	2004 320	2005 791
Subclass	Antibiotic (Resistance breakpoint)									
Aminoglycosides	Gentamicin (MIC ≥ 8)	Not Tested	0.3% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.3% 1	0.5% 4
Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.0% 0
Macrolides	Azithromycin (MIC ≥ 8)	Not Tested	0.3% 1	1.7% 5	1.6% 5	1.9% 7	1.8% 6	0.3% 1	0.6% 2	1.8% 14
	Erythromycin (MIC ≥ 32)	1.4% 3	0.7% 2	1.4% 4	1.0% 3	1.9% 7	1.2% 4	0.3% 1	0.3% 1	1.6% 13
Quinolones	Ciprofloxacin (MIC ≥ 4)	12.4% 26	13.8% 41	17.7% 52	14.7% 45	18.4% 67	20.7% 68	17.2% 52	18.1% 58	21.5% 170
	Nalidixic acid (MIC ≥ 64)	13.4% 28	15.5% 46	20.1% 59	16.0% 49	18.9% 69	21.3% 70	17.8% 54	18.4% 59	21.9% 173
Phenicols	Chloramphenicol (MIC ≥ 32)	3.8% 8	1.0% 3	0.7% 2	0.0% 0	0.3% 1	0.3% 1	0.0% 0	1.6% 5	Not Tested
	Florfenicol* Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	0.5% 4
Tetracyclines	Tetracycline (MIC ≥ 16)	47.8% 100	46.1% 137	45.4% 133	39.2% 120	40.3% 147	41.3% 136	38.3% 116	46.9% 150	41.8% 331
Lincosamides	Clindamycin (MIC ≥ 8)	1.0% 2	1.0% 3	0.7% 2	0.7% 2	1.9% 7	1.8% 6	0.0% 0	2.2% 7	1.1% 9

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

Table 5.07: Minimum inhibitory concentrations (MICs) and resistance of *Campylobacter coli* isolates to antimicrobial agents, 2005 (N=98)

Antibiotic		% 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	Gentamicin	0.0	1.1	[0.0–5.8]				1.1	12.8	63.8	20.2	1.1			1.1					
Ketolide	Telithromycin	3.2	3.2	[0.7–9.0]	1.1				11.7	26.6	14.9	21.3	18.1	3.2	3.2					
Macrolides	Azithromycin	0.0	3.1	[0.6–8.7]	1.0	11.2	18.4	38.8	26.5	1.0								3.1		
	Erythromycin	0.0	3.1	[0.6–8.7]			1.0	3.1	11.2	25.5	31.6	15.3	9.2					3.1		
Quinolones	Ciprofloxacin	0.0	23.5	[15.5–33.1]		1.0	25.5	27.6	18.4	3.1	1.0		3.1	10.2	6.1	2.0	1.0	1.0		
	Nalidixic Acid	0.0	26.5	[18.1–36.4]									32.7	29.6	11.2		6.1	20.4		
Phenicols	Florfenicol[¶]	N/A	1.0	[0.0–5.6]						9.2	54.1	24.5	11.2	1.0						
Tetracyclines	Tetracycline	0.0	30.6	[21.7–40.7]			2.0	21.4	25.5	14.3	5.1	1.0				1.0	6.1	23.5		
Lincosamides	Clindamycin	0.0	4.1	[1.1–10.1]		3.1	8.2	19.4	31.6	18.4	12.2	3.1		3.1	1.0					

[*]Percent of isolates with intermediate susceptibility
[†]Percent of isolates that were resistant
[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
[§]The unshaded areas indicate the range of dilutions tested for each antimicrobial agent. 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 tested concentrations. 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.
¶CLSI guidelines do not currently define a resistance-breakpoint for florfenicol.

Figure 5.03: Antimicrobial resistance pattern for *Campylobacter coli*, 2005

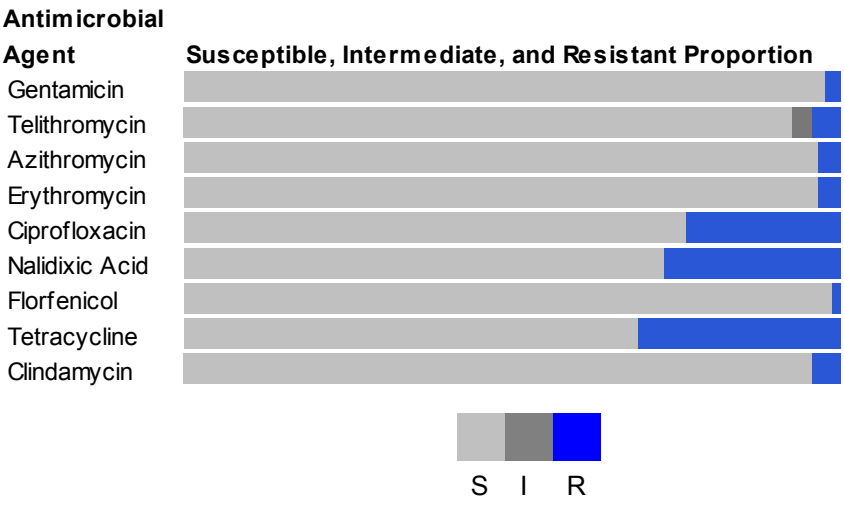


Table 5.08: Percentage and number of *Campylobacter coli* isolates resistant to antimicrobial agents, 1997–2005

Year Total Isolates		1997 6	1998 8	1999 20	2000 12	2001 17	2002 25	2003 22	2004 26	2005 98
Subclass	Antibiotic (Resistance breakpoint)									
Aminoglycosides	Gentamicin (MIC ≥ 8)	Not Tested	0.0% 0	0.0% 0	8.3% 1	0.0% 0	0.0% 0	4.5% 1	0.0% 0	2.0% 2
Ketolides	Telithromycin (MIC ≥ 16)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	4.1% 4
Macrolides	Azithromycin (MIC ≥ 8)	Not Tested	12.5% 1	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3
	Erythromycin (MIC ≥ 32)	0.0% 0	12.5% 1	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	3.1% 3
Quinolones	Ciprofloxacin (MIC ≥ 4)	33.3% 2	0.0% 0	30.0% 6	25.0% 3	47.1% 8	12.0% 3	22.7% 5	30.8% 8	23.5% 23
	Nalidixic acid (MIC ≥ 64)	50.0% 3	50.0% 4	30.0% 6	25.0% 3	47.1% 8	12.0% 3	22.7% 5	34.6% 9	26.5% 26
Phenicols	Chloramphenicol (MIC ≥ 32)	50.0% 3	37.5% 3	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	Not Tested
	Florfenicol* Susceptible breakpoint: (MIC ≤ 4)	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	1.0% 1
Tetracyclines	Tetracycline (MIC ≥ 16)	66.7% 4	50.0% 4	30.0% 6	25.0% 3	58.8% 10	40.0% 10	45.5% 10	38.5% 10	30.6% 30
Lincosamides	Clindamycin (MIC ≥ 8)	16.7% 1	12.5% 1	10.0% 2	8.3% 1	5.9% 1	4.0% 1	9.1% 2	0.0% 0	4.1% 4

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

Limitations to NARMS Campylobacter *Surveillance*

Three limitations are evident in NARMS *Campylobacter* surveillance; the use of sentinel clinical laboratories in some states, the sampling scheme implemented during 1997 to 2004, and the limited geographic area under surveillance.

In four states that participated in NARMS *Campylobacter* surveillance (California, Colorado, Connecticut, and Oregon), *Campylobacter* isolates were submitted to NARMS from one sentinel clinical laboratory. In Georgia, Maryland, Minnesota, New Mexico, New York, and Tennessee, the *Campylobacter* isolates submitted were selected from all *Campylobacter* isolates from most clinical laboratories within a specific geographic area (metro Atlanta area in Georgia; statewide in Maryland, Minnesota, New Mexico, and Tennessee; and the metro Albany and Rochester areas in New York). In California, Colorado, Connecticut, and Oregon from 1997 to 2004, the sentinel clinical laboratory selected the first *Campylobacter* isolate isolated each week for submission to NARMS; if no isolate was isolated in a week, then no isolate was submitted from that laboratory. From the other six FoodNet sites, one *Campylobacter* isolate among isolates received from participating clinical laboratories was also selected each week. Because none of the sentinel clinical laboratories used an isolation procedure that was more or less likely than the procedure of other clinical laboratories in their respective states to yield antimicrobial-resistant *Campylobacter* isolates, use of a sentinel clinical laboratory was unlikely to be associated with a change of antimicrobial resistance among *Campylobacter* isolates submitted to NARMS.

From 1997 to 2004, the NARMS participating public health laboratories in Georgia, Maryland, Minnesota, New Mexico, New York, and Tennessee, and sentinel clinical laboratories in all other FoodNet sites selected one *Campylobacter* isolate each week and forwarded the isolate to CDC. When the isolates were selected, the antimicrobial resistance pattern of the isolates was not known. Therefore, the antimicrobial resistance pattern of an isolate was unlikely to influence submission of the isolate to NARMS. However, the one-a-week sampling scheme could have resulted in oversampling or undersampling of antimicrobial-resistant isolates if the prevalence of such resistance was not uniform throughout the year. The impact of oversampling or undersampling can vary among states. In 2005, a representative sampling scheme was initiated in the 10 FoodNet sites.

Campylobacter isolates were forwarded to CDC by 10 states participating in FoodNet during 2005, representing approximately 45 million persons (15% of the U.S. population). Because NARMS 2005 *Campylobacter* surveillance was not nationwide, findings should be generalized to the U.S. population with caution because of possible regional differences in the prevalence of antimicrobial resistance among *Campylobacter*.

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APPENDIX A
Summary of *Escherichia coli* Resistance Surveillance Pilot Study, 2005

***E. COLI* WORKING GROUP**

Centers for Disease Control and Prevention

Frederick Angulo, Tim Barrett, Ezra Barzilay, Tom Chiller, Kathryn Gay, Patricia Griffin, Amy Krueger, Katie Joyce, Kevin Joyce, Amie ThurdeKoos, Terrell Miller, Felicita Medalla, Robert Tauxe
Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases
National Center for Infectious Diseases

Participating State and Local Health Departments

Maryland Department of Health and Mental Hygiene and University of Maryland
Karen Cuenco, Jonigene Ruark, David Torpey, Mary Warren

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 rod 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[1,2,3]. 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[4]. 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 2005 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.

Multidrug-Resistant *E. coli*

- 25.4% of 118 *E. coli* isolates tested were resistant to two or more subclasses of antimicrobial agents.
- 8.5% of 118 *E. coli* isolates tested were resistant to five or more subclasses of antimicrobial agents.

Clinically Important Resistance

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

- 0.8% of 118 *E. coli* isolates were resistant to ceftiofur (Table A.04).
- 7.6% of 118 *E. coli* isolates were resistant to ciprofloxacin (Table A.04).

SURVEILLANCE AND LABORATORY TESTING METHODS

Participating laboratories in Maryland and Michigan cultured 10 human stool samples each month for *E. coli* using Eosin Methylene Blue agar one *E. coli* isolate, if present, from each stool sample was sent to CDC for susceptibility testing to antimicrobial agents using broth microdilution (Sensititre®) to determine the minimum inhibitory concentration (MIC) for each of 15 antimicrobial agents: amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfamethoxazole, tetracycline, and trimethoprim-sulfamethoxazole (Table A.01). The resistance breakpoint for amikacin, according to CLSI[5] guidelines, is an MIC of 64 µg/mL.

Interpretive criteria from the Clinical Laboratory and Standards Institute (CLSI) were used (Table A.01). The 95% CIs for the percentage of resistant isolates calculated using the Clopper-Pearson exact method, are included in the MIC distribution tables. Similarly, multiclass resistance by CLSI antimicrobial subclass was defined as resistance to two or more subclasses.

RESULTS

In 2005, CDC received and tested 118 viable *E. coli* isolates (Table A.02). Minimum Inhibitory Concentrations (MIC) was determined for *E. coli* isolates for 15 antimicrobial agents (Table A.03).

Of the *E. coli* isolates, 26.3% were resistant to ampicillin; 19.5% to tetracycline; 17.7%, to sulfamethoxazole; and 9.3% to nalidixic acid (Table A.04).

In 2005, 22.9% of *E. coli* isolates were resistant to two or more CLSI subclasses, and 7.6% were resistant to five or more CLSI subclasses (Table A.05). The level of *E. coli* resistance in this pilot study differs than that observed in NARMS 2004. Because of the different sampling methods between this study and NARMS, this observation requires further investigation.

There is a difference in the level of resistance among *E. coli* isolates in this study compared with *E. coli* O157 isolates submitted to NARMS in 2005. Because of the different sampling methods employed between this study and NARMS, this observation requires further investigation.

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Table A.01: Antimicrobial agents used for susceptibility testing of *Escherichia coli*, 2005

CLSI Subclass	Antimicrobial Agent	Antimicrobial Agent Concentration Range (µg/mL)	Breakpoints		
			Susceptible	Intermediate	Resistant
Aminoglycosides	Amikacin*	0.5 – 4*	≤16	32	≥64
	Gentamicin	0.25 – 16	≤4	8	≥16
	Kanamycin	8 – 64	≤16	32	≥64
	Streptomycin	32 – 64	≤32		≥64
Aminopenicillins	Ampicillin	1 – 32	≤8	16	≥32
β-lactamase inhibitor combinations	Amoxicillin–Clavulanic acid	1/0.5 – 32/16	≤8/4	46/8	≥32/16
Cephalosporins (3rd Gen.)	Ceftiofur	0.12– 8	≤2	4	≥8
	Ceftriaxone	0.25 – 64	≤8	16-32	≥64
Cephamycins	Cefoxitin	0.5 – 16	≤8	16	≥32
Folate pathway inhibitors	Trimethoprim–Sulfamethoxazole	0.12/2.4 – 4/76	≤2/38		≥4/76
Phenicols	Chloramphenicol	2 – 32	≤8	16	≥32
Quinolones	Ciprofloxacin	0.015 – 4	≤1	2	≥4
	Nalidixic acid	0.5 – 32	≤16		≥32
Sulfonamides	Sulfisoxazole	16 – 512	≤256		≥512
Tetracyclines	Tetracycline	4 – 16	≤4	8	≥16

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

Table A.02: *Escherichia coli* isolates received and tested at CDC, by site, 2005

Site	2005 N	(%)
Maryland	69	(58.5%)
Michigan	49	(41.5%)
Total	**118**	**(100.0%)**

Table A.03: Minimum inhibition concentrations (MICs) of *Escherichia coli*, 2005 (N=118)

Antibiotic		% 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	[0.0–2.6]						0.8	44.1	50.8	4.2							
	Gentamicin	0.0	3.3	[2.2–8.3]					17.8	70.3	8.5				0.8	2.5				
	Streptomycin	NA	14.4	[9.6–19.2]												85.6	5.9	8.5		
Aminopenicillins	Ampicillin	2.5	26.3	[24.1–36.7]							7.6	44.1	16.9	2.5	2.5		26.3			
β-lactamase inhibitor	Amoxicillin-clavulanic acid	3.4	4.2	[1.6–7.2]							4.2	19.5	46.6	22.0	3.4	3.4	0.8			
Cephalosporins (3rd generation)	Ceftiofur	0.8	0.8	[0.0–2.6]				8.5	57.6	31.4	0.8		0.8	0.8						
	Ceftriaxone	0.8	0.0	[0.0–2.6]					98.3			0.8			0.8					
Quinolones	Ciprofloxacin	0.0	7.6	[5.7–13.9]	90.7				1.7				7.6							
	Nalidixic Acid	NA	9.3	[14.0–24.9]							22.9	61.0	6.8				9.3			
Aminoglycosides	Kanamycin	0.0	0.0	[0.8–5.3]										98.3	1.7					
Cephamycins	Cefoxitin	1.7	0.8	[1.3–6.6]							5.1	50.0	33.9	8.5	1.7		0.8			
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole	NA	14.2	[11.2–21.3]				76.1	8.8		0.9			14.2						
Phenicols	Chloramphenicol	0.8	2.5	[0.5–4.7]								4.2	66.1	26.3	0.8		2.5			
Sulfonamides	Sulfamethoxazole/Sulfisoxazole	NA	17.7	[17.7–29.4]											73.5	8.8				17.7
Tetracyclines	Tetracycline	1.7	19.5	[12.4–22.8]									78.8	1.7		5.1	14.4			

[*]Percent of isolates with intermediate susceptibility, NA if no MIC range of intermediate susceptibility exists
[†]Percent of isolates that were resistant
[‡]95% confidence intervals (CI) for percent resistant (%R) were calculated using the Clopper-Pearson exact method
[§]The unshaded areas indicate the dilution range of the Sensititre plates used to test isolates. Single vertical bars indicate the breakpoints for susceptibility, while double vertical bars indicate breakpoints for resistance. Numbers in the shaded areas indicate the percentages of isolates with MICs greater than the highest concentrations on the Sensititre plate. Numbers listed for the lowest tested concentrations represent the precentages of isolates with MICs equal to or less than the lowest tested concentration. CLSI breakpoints were used when available.

Figure A.01: Antibiotic resistance pattern for *Escherichia coli*, 2005

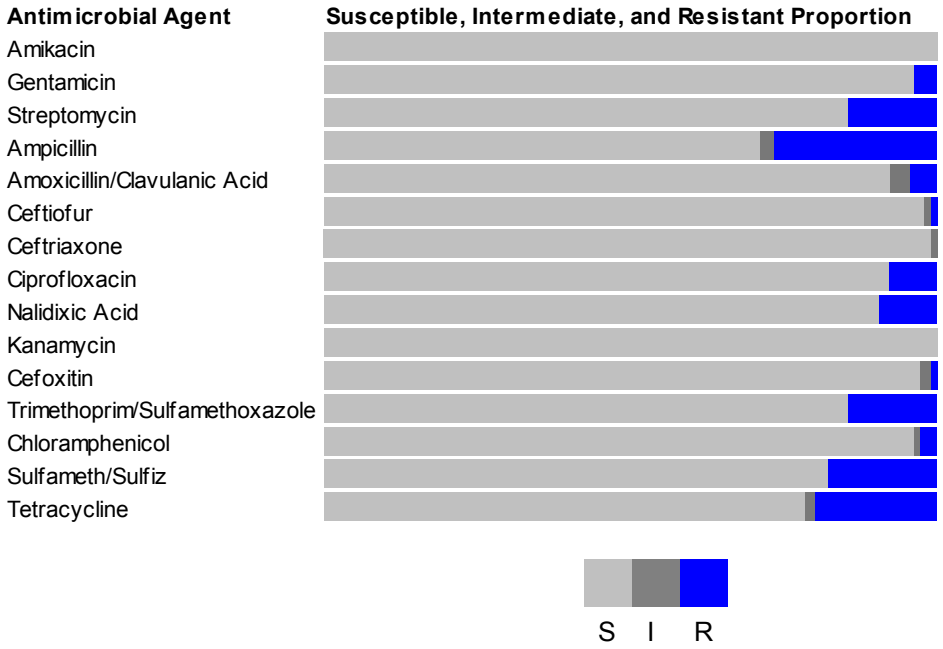


Table A.04: *Escherichia coli* isolates with antimicrobial resistance, 2005

Year Total Isolates		2004 151	2005 118/113*
Subclass	Antibiotic (Resistance breakpoint)		
Aminoglycosides	Amikacin (MIC ≥ 64)	0.0% 0	0.0% 0
	Gentamicin (MIC ≥ 16)	2.0% 3	3.4% 4
	Streptomycin (MIC ≥ 64)	10.6% 16	14.4% 17
Aminopenicillins	Ampicillin (MIC ≥ 32)	24.5% 37	26.3% 31
β-lactamase inhibitor combinations	Amoxicillin-clavulanic acid (MIC ≥ 32)	2.6% 4	4.2% 5
Cephalosporins (3rd generation)	Ceftiofur (MIC ≥ 8)	0.0% 0	0.8% 1
	Ceftriaxone (MIC ≥ 64)	0.0% 0	0.0% 0
Quinolones	Ciprofloxacin (MIC ≥ 4)	3.3% 5	7.6% 9
	Nalidixic Acid (MIC ≥ 32)	9.3% 14	9.3% 11
Aminoglycosides	Kanamycin (MIC ≥ 64)	2.0% 3	0.0% 0
Cephamycins	Cefoxitin (MIC ≥ 32)	2.6% 4	0.8% 1
Folate pathway inhibitors	Trimethoprim-sulfamethoxazole (MIC ≥ 4)	11.3% 17	14.2% 16
Phenicols	Chloramphenicol (MIC ≥ 32)	1.3% 2	2.5% 3
Sulfonamides	Sulfamethoxazole/Sulfisoxazole (MIC ≥ 512)	17.9% 27	17.7% 20
Tetracyclines	Tetracycline (MIC ≥ 16)	13.2% 20	19.5% 23

*Five isolates do not have test results for Trimethoprim-sulfamethoxazole and Sulfamethoxazole/Sulfisoxazole.

Table A.05: Antimicrobial agents resistant to *Escherichia coli*, 2005

Year Total Isolates	2004 151	2005 118
	% n	% n
No resistance detected	62.9% 95	63.6% 75
Resistance ≥1CLSI subclass*	37.7% 57	36.4% 43
Resistance ≥2 CLSI subclasses*	17.9% 27	22.9% 27
Resistance ≥3 CLSI subclasses*	9.9% 15	14.4% 17
Resistance ≥4 CLSI subclasses*	5.3% 8	9.3% 11
Resistance ≥5 CLSI subclasses*	3.3% 5	7.6% 9
At least ACSSuT[†]	1.3% 2	0.8% 1
At least ACSuTm[‡]	1.3% 2	0.8% 1
At least ACSSuTAuCf[§]	0.0% 0	0.0% 0
At least AAuC[¶]	0.0% 0	0.0% 0
At least A3C**	0.0% 0	0.0% 0
At least MDR-AmpC[††]	0.0% 0	0.0% 0
Resistance to quinolone and cephalosporin (3rd generation)	0.0% 0	0.0% 0

*CLSI: Clinical and Laboratory Standards Institute

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

[‡]ACSuTm: resistance to ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole

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

[¶]AAuC: resistance to ampicillin, amoxicillin-clavulanic acid, ceftiofur

**A3C: resistance to amikacin, ampicillin, amoxicillin-clavulanic acid

[††]MDR-AmpC: resistance to ACSSuTAuCf + decreased susceptibility to ceftriaxone (MIC ≥2 µg/mL)

Among isolates of commensal *E. coli* ceftiofur resistance has increased from 0.0% in 2004 to 0.8% in 2005. Ciprofloxacin resistance increased from 3.3% in 2004 to 7.6% in 2005. A decrease in detected resistance was observed for two drugs; cefoxitin (2.7% to 0.8%) and kanamycin (2.0 to 0.0%).

APPENDIX B:
International Comparison of Antimicrobial MIC-Distributions

Several committees determine clinical antimicrobial MIC breakpoints. In the U.S., breakpoints have traditionally been determined by the Clinical Laboratory Standards Institute (CLSI, formerly NCCLS) and the FDA. In Europe, the ESCMID-formed authority EUCAST (European Committee on Antimicrobial Susceptibility Testing) has been tasked with harmonizing clinical breakpoints for existing drugs in Europe and to determine breakpoints for new antimicrobial agents as part of the regulatory process for approval of new drugs in Europe [1-3]. In addition to clinical breakpoints, EUCAST has introduced the concept of epidemiological cut-off values (ECOFFs) as a way of distinguishing bacteria without resistance mechanisms ("wild type") from those with mutational or acquired resistance [1, 4]. The ECOFF is expressed as WT ≤ Xmg/L and will divide the distribution into two groups; those that are wild type (WT) and those that are non-wild type (NWT). Thus, ECOFFs do not relate to clinical efficacy - instead they were introduced to allow the sensitive measurement and comparison of resistance as a biological phenomenon.

The EUCAST webpage displays MIC wild type-distributions for many organism-drug combinations (http://www.eucast.org). An example of a wild type MIC distribution is shown in Figure 1. EUCAST's wild type distributions are based on MIC-data collected from all over the world and from various sources, including humans, animals and plants. The typical wild type MIC distribution spans over 3-5 dilution steps.

In theory, the wild type MIC-distributions should, for a given organism-drug combination, be the same irrespective of the origin of the isolates. Below are some examples of how the CDC distributions of *Escherichia coli* compare to the distributions defined by EUCAST (Figure 2). Even though the CDC-distributions do not represent full range MIC-distributions (hence leaving one or the other end of the distribution truncated) a good correlation between EUCAST and CDC distributions can be observed. This confirms that *E. coli* wild type distributions are similar regardless of origin and source. NARMS is currently participating in international discussions on how to harmonize antimicrobial resistance surveillance.

Figure 1. Wild type distribution for *Escherichia coli* and amikacin (www.eucast.org).

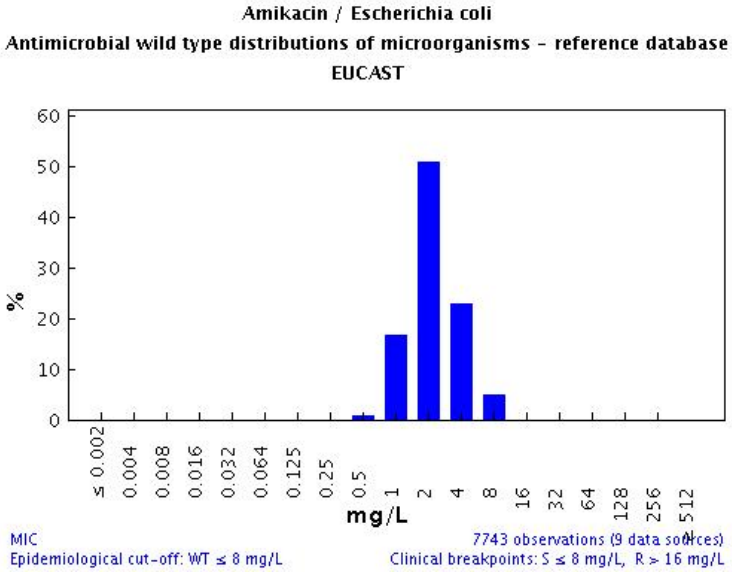
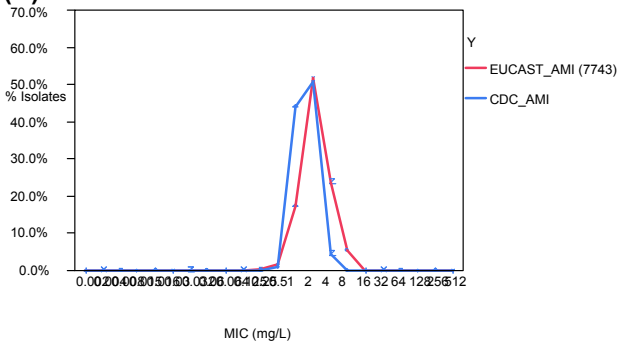


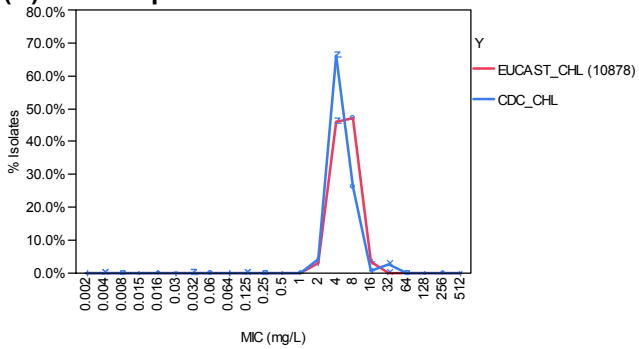
Figure 2 A-D. Comparison between NARMS *E. coli* MIC-distributions and EUCAST wild-type distributions.

(A) amikacin



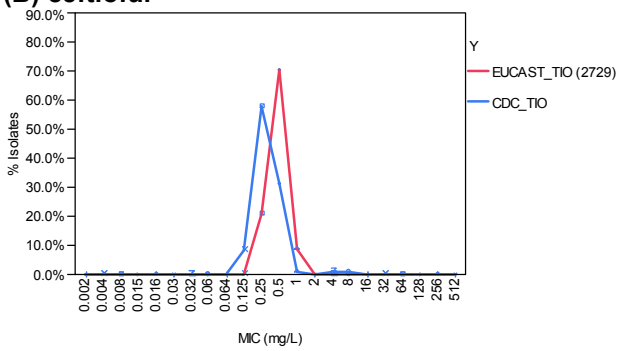
NARMS concentration test range: 0.5-64 mg/L

(C) chloramphenicol



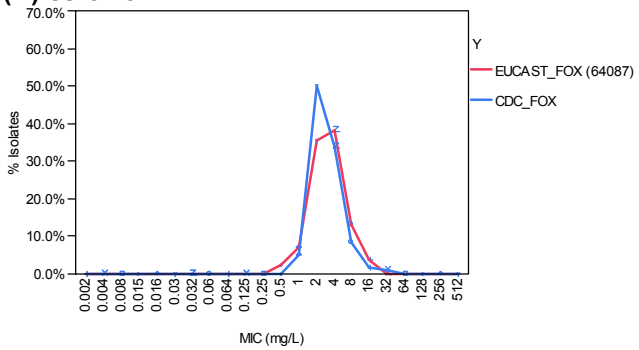
NARMS concentration test range: 2-32 mg/L

(B) ceftiofur



NARMS concentration test range: 0.125-8 mg/L

(D) cefoxitin



NARMS concentration test range: 0.5-32 mg/L

References

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2. Kahlmeter G, Brown D. Harmonization of Antimicrobial breakpoints in Europe - can it be achieved? Clinical Microbiology Newsletter 2004;26:187-92.
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4. Kahlmeter G, Brown DF, Goldstein FW, MacGowan AP, Mouton JW, Odenholt I, Rodloff A, Soussy CJ, Steinbakk M, Soriano F, and Stetsiouk O. European Committee on Antimicrobial Susceptibility Testing (EUCAST) Technical Notes on antimicrobial susceptibility testing. Clinical Microbiology and Infection 2006;12(6):501-3.

APPENDIX C:
List of Abbreviations

ACSSuT	Resistance to at least ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole, and tetracycline
ACSSuTAuC	Resistance to at least ACSSuT , amoxicillin-clavulanic acid, and ceftiofur
ACSuTm	Resistance to at least ampicillin, chloramphenicol, 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
EMB	Eosin methylene blue
ENTFM	*Enterococcus faecium*
ENTFS	*Enterococcus faecalis*
ERS	Enterococci Resistance Surveillance
FDA	Food and Drug Administration
FoodNet	Foodborne Diseases Active Surveillance Network
MDR-AmpC	Resistance to at least ACSSuT, amoxicillin-clavulanic acid, and ceftiofur, and decreased susceptibility to ceftriaxone (MIC ≥ 2 µg/mL)
MIC	Minimum inhibitory concentration
NARMS	National Antimicrobial Resistance Monitoring System for Enteric Bacteria
OR	Odds ratio
PCR	Polymerase chain reaction
PHLIS	Public Health Laboratory Information System
VRE	Vancomycin-resistant enterococci