Government of Canada | Gouvernement du Canada

Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

2003

... working towards the preservation of effective antimicrobials for humans and animals…

Canada

Introduction

About CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) has been under development for several years beginning with the launch of program components in both the human and agri-food sectors. Information is being collected on antimicrobial resistance in enteric pathogens and commensal organisms from the agri-food sector (abattoir and retail levels), on antimicrobial resistance in enteric pathogens isolated from humans, and on antimicrobial use in humans and animals. The components are part of a representative, methodologically unified approach, modeled after international initiatives such as the National Antimicrobial Resistance Monitoring System (NARMS-USA) and the Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP-Denmark).

This document is available in CD version upon request, and is available at the Public Health Agency of Canada website: http://www.phac-aspc.gc.ca/cipars-picra/index.html

Aussi disponible en français sur le titre Programme Canadien Intégré de Résistance aux Antimicrobiens 2003.

We welcome feedback and suggestions. Please forward your comments and any address changes to: cipars-picra@phac-aspc.gc.ca.

Acknowledgements

Program Coordinators:
Kathryn Doré
Rebecca Irwin

Coordinating Author:
Carolee Bair

Authors:
Rafiq Ahmed
Brent Avery
Patrick Boerlin
Danielle Daignault
Kathryn Doré
Lucie Dutil
Rebecca Irwin
David Léger
Kendra Long
Leah Martin

External Reviewers:
John Conly
Serge Larivière
Scott McEwen
John Prescott

Internal Reviewers:
Rafiq Ahmed
Brent Avery
Carolee Bair
Anne Deckert
Walter Demczuk
Kathryn Doré
Lucie Dutil
Shiva Ghimire
Hema Gupta
Nisrine Haddad
Rebecca Irwin
Xianzhi Li
Elroy Mann
Leah Martin
Pascal Michel
Anne Muckle
Cornelius Poppe
André Ravel
Richard Reid-Smith

Data Analysis:
Brent Avery
Carolee Bair
Walter Demczuk
Lucie Dutil
Manon Fleury
Leah Martin

French Translation:
Ethel Perez

Communications:
Flavia Grego
Sarah Poirier
Jennifer Robertson
Lynn Vail
Victoria Weaver

The following additional people/committees assisted or provided support to CIPARS 2003:
Lateef Adewoye
Richard Arsenault
Tari Bhatia
Cesar Caballero
Manon Caron
Marie-Josée Champagne
Gail Christie
Ann-Marie Cochrane
Linda Cole
Angela Cook
Abigail Crocker
Huguette Croteau
Suzanne Demers
Andrea Desruisseau
Christine Forsberg
Jim Hutchinson
Jean Kamanzi
Mohamed Karmali
Ora Kendall
Devon Kuntz
Julie Légaré
Mike Mulvey
Travis Murphy
Amena Nabi
Manuel Navas
Lai-King Ng
Megan Peterson
Annie Raymond
Susan Read
Nancy Rheault
Joanne Riendeau
Paul Sockett
Geneviève Soly
David Sturrock
Lien Mi Tien
Alfonso Valdivieso
Marie Varughese
Rama Viswanathan
Mandy Weselak
Betty Wilkie

Canadian Committee on Antibiotic Resistance (CCAR)

Canadian Meat Council

Canadian Poultry & Egg Processors Council

National, provincial, territorial, university, industry and private laboratories and their collaborators.

National Steering Committee for Antimicrobial Resistance Surveillance in Enterics (NSCARE)
National Steering Committee for Monitoring Antimicrobial Use in Agriculture and Veterinary Medicine (interim committee name)

We are grateful for the participation of the Provincial Public Health Laboratory group for voluntarily forwarding human *Salmonella* isolates to the National Microbiology Laboratory (MB). This group includes Laboratory Services, British Columbia Centre for Disease Control; the Provincial Laboratory of Public Health (AB); the Saskatchewan Laboratory and Disease Control Services; Cadham Provincial Laboratory (MB); the Central Public Health Laboratory, Laboratory Services Branch, Ontario Ministry of Health and Long Term Care; Laboratoire de santé publique du Québec; the New Brunswick Enteric Reference Centre; the Microbiology Laboratory, Queen Elizabeth II Health Sciences Centre (NS); Laboratory Services, Queen Elizabeth Hospital (PE); and the Newfoundland Public Health Laboratory.

We thank the abattoir industry personnel and the Canadian Food Inspection Agency regional directors, inspection managers and onsite staff for their extensive voluntary participation in the CIPARS - Abattoir Component.

We recognize the US National Antimicrobial Resistance Monitoring System for sharing information and facilitating harmonization with CIPARS.

Additionally, we appreciate the effort of the producers participating in research projects, field workers, laboratory technicians and data management staff for their contributions. The careful collecting of samples, processing of isolates, and recording of results are essential to the ongoing success of CIPARS.

Financial Support for CIPARS 2003:
Public Health Agency of Canada (formerly part of Health Canada):
- Laboratory for Foodborne Zoonoses
- Centre for Infectious Disease Prevention and Control
- National Microbiology Laboratory

Health Canada: Health Products and Food Branch:
- Veterinary Drugs Directorate

Canadian Food Inspection Agency

We would also like to thank the meat processing industry and provincial public health laboratories for their in-kind support

Abbreviations Used Throughout the Report

A3C: resistance to amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and cephalothin
AKSSuT: resistance to ampicillin, kanamycin, streptomycin, sulfamethoxazole, and tetracycline
ACSSuT: resistance to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole, and tetracycline
ACKSSuT: resistance to ampicillin, chloramphenicol, kanamycin, streptomycin, sulfamethoxazole, and tetracycline
AMR: antimicrobial resistance
ATC: Anatomical Therapeutic Chemical
BPW: buffered peptone water
CCAR: Canadian Committee on Antibiotic Resistance
CDTI: Canadian Disease and Therapeutic Index
CFIA: Canadian Food Inspection Agency
CIDPC: Centre for Infectious Disease Prevention and Control
CIPARS: Canadian Integrated Program for Antimicrobial Resistance Surveillance
CPHLN: Canadian Public Health Laboratory Network
CPS: Compendium of Pharmaceuticals and Specialties
DANMAP: Danish Integrated Antimicrobial Resistance Monitoring and Research Programme
DDD: Defined Daily Dose
DPD: Drugs Product Database (Health Canada)
GSS-EQAS: Global Salm-Surv External Quality Assurance System
HACCP: Hazard Analysis Critical Control Point
ISO: International Standards Organization
IMS HEALTH: Intercontinental Medical Statistics
LB: Luria-Bertani agar
LFZ: Laboratory for Foodborne Zoonoses
MAC: MacConkey agar
MDR: multidrug-resistant
MICs: minimum inhibitory concentrations
MSRV: Modified Semi-Solid Rappaport Vassiliadis
NARMS: National Antimicrobial Resistance Monitoring System
NCCLS: National Committee on Clinical Laboratory Standards
NESP: National Enterics Surveillance Program
NML: National Microbiology Laboratory
NNDS: National Notifiable Disease Summary program
OIÉ: Office International des Épizooties
PFGE: pulse field gel electrophoresis
PPHL: Provincial Public Health Laboratory
PT: phagetype
STL: *Salmonella* Typing Laboratory
TSI: triple sugar iron
VDD: Veterinary Drugs Directorate
WHO: World Health Organization

Antimicrobial Abbreviations:

AMC	Amoxicillin-Clavulanic Acid	FOX	Cefoxitin
		GEN	Gentamicin
AMK	Amikacin	KAN	Kanamycin
AMP	Ampicillin	NAL	Nalidixic Acid
AZM	Azithromycin	SMX	Sulfamethoxazole
CEP	Cephalothin	STR	Streptomycin
CHL	Chloramphenicol	SXT	Trimethoprim-Sulfamethoxazole
CIP	Ciprofloxacin		
CLI	Clindamycin	TCY	Tetracycline
CRO	Ceftriaxone	TIO	Ceftiofur
ERY	Erythromycin		

Note: *Antimicrobial abbreviations are from WHONET*

Provincial Abbreviations:

AB: Alberta	NT: Northwest Territories
BC: British Columbia	NU: Nunavut
MB: Manitoba	ON: Ontario
NB: New Brunswick	PE: Prince Edward Island
NL: Newfoundland & Labrador	QC: Québec
	SK: Saskatchewan
NS: Nova Scotia	YT: Yukon

ISBN #: H39-1/3-2003E-PDF 0-662-37798-2

Table of Contents

List of Figures

List of Tables

Executive Summary

CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) was developed in response to recommendations of the 2002 Health Canada *Advisory Committee on Animal Uses of Antimicrobials and Impact on Resistance and Human Health.*[1] Modeled after initiatives in the United States and Europe, CIPARS has been designed to provide an ongoing, permanent, national surveillance system to monitor antimicrobial resistance trends among selected enteric organisms from humans, animals and animal-derived food sources across Canada. Antimicrobial use monitoring is also being undertaken to aid interpretation of antimicrobial resistance surveillance data from human and animal sources. This information is crucial to the development and evaluation of prudent-use policies and other risk management strategies.

This publication represents the second annual CIPARS report, now being released under the auspices of the newly formed Public Health Agency of Canada.

CIPARS Activities

The abattoir surveillance component involves the collection and analysis of isolates of generic *Escherichia coli* (*E. coli*) and *Salmonella* from the intestinal (caecal) contents of healthy animals at slaughter across Canada. The retail surveillance component involves the collection and analysis of isolates of generic *E. coli*, *Salmonella*, and *Campylobacter* from retail meat in Ontario and Quebec. These active agri-food surveillance activities provide an indirect measure of potential human exposure to resistance arising from the consumption of animal products.

CIPARS also includes passive surveillance of antimicrobial resistance (AMR) in *Salmonella* from human and diseased animal specimens collected in 2003 from laboratories across Canada.

As the widespread use of antimicrobials is considered to be a major contributor to antimicrobial resistance, analysis of human antimicrobial use data from IMS Health is contained in this report. Future reports will provide information on antimicrobial use in animals. The antimicrobials used in animals that are of most importance to human health include the fluoroquinolones and cephalosporins.

2003 CIPARS Results

Agri-food Surveillance : Generic *E. coli* from abattoir samples showed resistance to 1 or more antimicrobials in 88% of swine, 84% of chicken, and 34% of cattle isolates. These results did not differ significantly from those found in 2002. No resistance was observed to fluoroquinolones, but there was resistance to ceftiofur in 26 chicken (17%) and 2 cattle (1%) *E. coli* isolates. In the case of *Salmonella*, 41% of isolates from chickens and 49% from swine were resistant to 1 or more antimicrobials. One *Salmonella* isolate (0.3%) from swine and 8 (6%) from chickens were resistant to ceftiofur; 1 isolate from chickens (0.8%) was resistant to ceftriaxone.

For the retail meat samples collected, the percentage of *E. coli* isolates demonstrating resistance was lower overall than that seen among the abattoir samples. Resistance to ceftiofur in *E. coli* was highest among chicken (18% of Ontario and 33% of Quebec isolates).

In the case of *Salmonella*, ceftiofur resistance was detected in 3 Ontario (12%) and 14 Quebec isolates (50%) from chicken. For *Campylobacter* isolates from chicken, 56 from Ontario (72%) and 74 from Quebec (79%) were resistant to one or more antimicrobials. In particular, 3 *Campylobacter* isolates (4%) from Ontario and 3 from Quebec (3%) were resistant to ciprofloxacin. Provincial differences in the

[1] Report of the Advisory Committee available at http://www.hc-sc.gc.ca/vetdrugs-medsvet/amr_final_report_june27_cp_e.html

prevalence of resistance need to be investigated through further research and continued and expanded surveillance efforts in multiple provinces and over multiple years.

With respect to passive surveillance of *Salmonella* in animals, clinical isolates from cattle were more frequently resistant than those isolated from other species. This reflected an outbreak of *S. Newport* in three Ontario dairy herds from which isolates resistant to 9 or more antimicrobials were isolated. Notably, ceftiofur resistance and reduced susceptibility to ceftriaxone was observed among 100 (43%) of all *Salmonella* isolates from cattle. Ceftiofur resistance was also detected in *Salmonella* from 2 swine (2%), 3 chicken (9%) and 6 turkey (17%) clinical isolates.

Human Surveillance: A representative sample of 3056 clinical isolates from all provincial public health laboratories was collected during 2003 in order to establish a baseline for antimicrobial resistance in human *Salmonella*. The prevalence of resistance to 1 or more of 16 antimicrobials tested varied by serovar: 315/610 isolates (52%) of *S*. Typhimurium, 64/127 isolates (50%) of *S*. Typhi, 282/613 isolates (46%) of *S.* Heidelberg, 77/352 isolates (22%) of *S.* Enteritidis, and 28/175 isolates (16%) of *S*. Newport.

Resistance to ceftiofur was identified in 6% of all isolates. Resistance to ceftriaxone was identified in 3/613 *S*. Heidelberg isolates (<1%) but reduced susceptibility to ceftriaxone was observed in a number of serovars. Two *S*. Typhimurium isolates (< 1%) were resistant to ciprofloxacin.

The integration of the AMR information from retail meat and human surveillance highlighted that, for *S*. Heidelberg, resistance frequencies for most cephalosporins and for amoxicillin-clavulanic acid were in general higher among chicken than human isolates. Provincial differences observed at the retail level were also noted among human data. Comparisons of the resistance data for *S*. Typhimurium between the abattoir and the human components also tended to show a higher prevalence of resistance among isolates of animal than of human origin. Further characterisation of the animal, meat and human strains are needed to define the level of genetic relatedness of these strains.

Human Antimicrobial Use: Analysis of IMS Health data shows that in 2003, the human systemic antibacterial classes most frequently dispensed by retail pharmacies in Canada, as a proportion of total DDDs (Defined Daily Dose), were penicillins with extended spectrum (27%), macrolides (20%), tetracyclines (14%), fluoroquinolones (12%), and first and second-generation cephalosporins (10%). After controlling for population size, systemic antibacterial use appears to have increased between 2002 and 2003, evidenced by the higher number of DDDs, prescriptions, and dollars spent; however, use in both 2002 and 2003 was lower than that observed in 2001 (with the exception of the dollars spent per inhabitant for 2003). Nevertheless, Human Health Importance Category I drugs represented an increasing proportion of the total DDDs dispensed (primarily fluoroquinolones and glycopeptides): 11.0% in 2001, 11.7% in 2002, and 12.1% in 2003. In addition to annual variations, systemic antibacterial use appeared to differ by province, season, patient sex, and patient age. Of the total number of patient visits in which sampled physicians mentioned an antimicrobial therapy between July 1, 2002 and June 30, 2003, 43% of associated diagnoses were respiratory system diseases.

Conclusions and future plans

CIPARS 2003 establishes baselines for AMR in selected enteric bacteria collected from healthy animals at slaughter, from retail meat, and from humans. The frequency of resistance among bacteria varied according to host and species. Multidrug-resistance in numerous *Salmonella* serovars and the identification of strains resistant to ciprofloxacin and the cephalosporins are of particular concern, as is the presence of fluoroquinolone resistance in *Campylobacter* isolated from retail chicken. CIPARS 2003 also describes patterns in human antimicrobial use.

CIPARS is continuing to build the framework and partnerships for collection of relevant

and representative antimicrobial resistance data along the food chain. Future plans include the expansion of retail surveillance to other provinces, the addition of other relevant bacterial species and food-producing commodities, and the inclusion of farm-level data collection. Opportunities continue to be explored to resolve barriers to collection of antimicrobial use data in food-producing animals.

Continued AMR surveillance and concomitant monitoring of antimicrobial use will permit analysis of temporal trends and correlations among livestock and human populations. In future, more CIPARS data will be available to support enhanced analysis and guide further research and risk assessment studies. Collectively, these activities will elucidate factors in the development and spread of AMR along the food chain and inform risk management decisions.

Table 1. Summary of antimicrobial resistance surveillance findings across species.

Surveillance Program	Species	Bacterial Species	Number (%) of Isolates Resistant to One or More Antimicrobials Tested	Number (%) of Isolates Resistant to Five or More Antimicrobials*	Number (%) of Isolates Resistant to Category I[2] Antimicrobials	Number of Different Antimicrobial Resistance Patterns[3]
Enhanced Passive Surveillance of Clinical Isolates	Human	*Salmonella* [4]	1064/3056 (35%)	473/3056 (15%)	Ceftiofur: 187/3056 (6%) Ceftriaxone: 3/3056 (0.1%) Ciprofloxacin: 2/3056 (0.1%)	146
Active Abattoir Surveillance	Beef cattle	*E. coli*	50/150 (33%)	2/150 (1%)	Ceftiofur: 2/150 (1%)	13
	Swine	*E. coli*	137/155 (88%)	25/155 (16%)	none	40
	Swine	*Salmonella*	192/395 (49%)	67/395 (17%)	Ceftiofur: 1/395 (0.3%)	29
	Chickens	*E. coli*	126/150 (84%)	43/150 (29%)	Ceftiofur: 26/150 (17%)	61
	Chickens	*Salmonella*	52/126 (41%)	10/126 (8%)	Ceftiofur: 8/126 (6%) Ceftriaxone: 1/126 (0.8%)	19
Active Retail Surveillance	Beef	*E. coli*	46/184 (25%)	5/184 (3%)	Ceftiofur: 2/184 (1%)	24
	Pork	*E. coli*	91/152 (60%)	10/152 (7%)	Ceftiofur: 1/152 (0.7%)	37
	Chicken	*E. coli*	173/248 (70%)	80/248 (32%)	Ceftiofur: 61/248 (25%)	67
	Chicken	*Salmonella*	27/54 (50%)	17/54 (31%)	Ceftiofur: 17/54 (31%)	7
	Chicken	*Campylobacter*[1] *spp.*	130/172 (76%)	n/a	Ciprofloxacin: 6/172 (3%)	15
Passive Surveillance of Clinical Isolates	Bovine	*Salmonella*	160/234 (68%)	150/234 (64%)	Ceftiofur: 100/234 (43%) Ceftriaxone: 2/234 (0.9%)	20
	Swine	*Salmonella*	78/107 (73%)	48/107 (45%)	Ceftiofur: 2/107 (2%)	24
	Chicken	*Salmonella*	13/32 (41%)	5/32 (16%)	Ceftiofur: 3/32 (9%)	10
	Turkey	*Salmonella*	31/36 (86%)	13/36 (36%)	Ceftiofur: 6/36 (17%)	19

Note: *[1]The percentage of isolates resistant to five or more antimicrobials is not presented for Campylobacter spp.*

[2] Categories of human health importance are based upon a proposed classification system developed by the Veterinary Drugs Directorate; see Appendix A.1.

[3] This number must be interpreted in relation to the total number of isolates tested and the total number of resistant isolates. Further details on AMR patterns can be found at: http://www.phac-aspc.gc.ca/cipars-picra/index.html.

[4] This nomenclature convention is based on the recommendations of Le Minor and Popoff, WHO Collaborating Centre for Reference and Research on Salmonella, Institut Pasteur, Paris. (Threlfall et al, 1999).

Table 2. Summary of selected antimicrobial resistance patterns across species.

Surveillance Program	Species	Bacterial Species	A3C n (N%) n(n%)	ACSSuT n (N%) n(n%)	AKSSuT n (N%) n(n%)	ACKSSuT n (N%) n(n%)
Enhanced Passive Surveillance of Clinical Isolates	Human (N=3056)	*S.* Enteritidis (n=352)	1/3056 (<1%) 1/352 (<1%)	None	None	None
		S. Heidelberg (n=613)	130/3056 (4%) 130/613 (21%)	14/3056 (<1%) 14/613 (2%)	1/3056 (<1%) 1/613 (<1%)	None
		S. Newport (n=175)	17/3056 (1%) 17/175 (10%)	11/3056 (<1%) 11/175 (6%)	None	5/3056 (<1%) 5/175 (3%)
		S. Typhi (n=127)	1/3056 (<1%) 1/127 (1%)	9/3056 (<1%) 9/127 (7%)	None	None
		S. Typhimurium[1] (n=610)	9/3056 (<1%) 9/610 (1%)	140/3056 (5%) 140/610 (23%)	21/3056 (1%) 21/610 (3%)	48/3056 (2%) 48/610 (8%)
		"Other Serovars" (n=1179)	18/3056 (1%) 18/1179 (2%)	19/3056 (1%) 19/1179 (2%)	2/3056 (<1%) 2/1179 (<1%)	3/3056 (<1%) 3/1179 (<1%)
		Salmonella total	176/3056 (6%)	193/3056 (6%)	24/3056 (1%)	56/3056 (2%)
Active Abattoir Surveillance	Cattle (N=150)	*E. coli* (n=150)	2/150 (1%)	2/150 (1%)	None	None
	Swine (N=155)	*E. coli* (n=155)	None	4/155 (3%)	7/155 (5%)	4/155 (3%)
	Swine (N=395)	*S.* Enteritidis (n=5)	None	None	None	None
		S. Heidelberg (n=12)	None	None	None	None
		S. Newport (n=0)	None	None	None	None
		S. Typhimurium (n=112)	None	32/395 (8%) 32/112 (29%)	3/395 (1%) 3/112 (3%)	18/395 (5%) 18/112 (16%)
		"Other Serovars" (n=266)	1/395 (<1%) 1/266 (<1%)	2/395 (<1%) 2/266 (<1%)	None	2/395 (1%) 2/266 (1%)
		Salmonella total	1/395 (<1%)	34/395 (9%)	3/395 (1%)	20/395 (5%)
	Chickens (N=150)	*E. coli* (n=150)	36/150 (17%)	11/150 (7%)	3/150 (2%)	2/150 (1%)
	Chickens (N=126)	*S.* Enteritidis (n=0)	None	None	None	None
		S. Heidelberg (n=63)	4/126 (3.2%) 4/63 (6%)	None	None	None
		S. Newport (n=0)	None	None	None	None
		S. Typhimurium (n=4)	None	2/126 (2%) 2/4 (50%)	None	None
		"Other Serovars" (n=59)	3/126 (2%) 3/59 (5%)	None	None	None
		Salmonella total	7/126 (6%)	2/126 (2%)	None	None
Active Retail Surveillance	Beef (n=184)	*E. coli* (n=184)	1/184 (1%)	1/184 (1%)	None	None
	Pork (n=152)	*E. coli* (n=152)	1/152 (1%)	3/152 (2%)	None	None
	Chicken (n=248)	*E. coli* (n=248)	61/248 (25%)	21/248 (8%)	3/248 (1%)	5/248 (2%)
	Chicken (n=54)	*S.* Enteritidis (n=0)	None	None	None	None
		S. Heidelberg (n=39)	15/54 (28%) 15/39 (38%)	None	None	None
		S. Newport (n=0)	None	None	None	None
		S. Typhimurium (n=0)	None	None	None	None
		"Other Serovars" (n=15)	1/54 (2%) 1/15 (7%)	None	None	None
		Salmonella total	16/54 (30%)	None	None	None

Surveillance Program	Species	Bacterial Species	A3C n (N%) n(n%)	ACSSuT n (N%) n(n%)	AKSSuT n (N%) n(n%)	ACKSSuT n (N%) n(n%)
Passive Surveillance of	Cattle (n=234)	*S.* Enteritidis (n=0)	None	None	None	None
Clinical Isolates		*S.* Heidelberg (n=3)	None	None	None	None
		S. Newport (n=63)	62/234 (27%) 62/63 (98%)	6/234 (3%) 6/63 (10%)	1/234 (<1%) 1/63 (2%)	55/234 (24%) 55/63 (87%)
		S. Typhimurium (n=94)	34/234 (15%) 34/94 (36%)	41/234 (18%) 41/94 (44%)	8/234 (3%) 8/94 (9%)	35/234 (15%) 35/94 (37%)
		"Other Serovars" (n=74)	1/234 (<1%) 1/74 (1%)	1/234 (<1%) 1/74 (1%)	None	None
		Salmonella total	96/234 (41%)	49/234 (21%)	9/234 (4%)	90/234 (38%)
	Swine (n=107)	*S.* Enteritidis (n=1)	None	None	None	None
		S. Heidelberg (n=1)	None	None	None	None
		S. Newport (n=0)	None	None	None	None
		S. Typhimurium (n=76)	None	31/107 (29%) 31/76 (41%)	3/107(3%) 3/76 (4%)	8/107 (7%) 8/76 (11%)
		"Other Serovars" (n=29)	2/107 (2%) 2/29 7%)	2/107 (2%) 2/29 (7%)	None	1/107 (1%) 1/29 (3%)
		Salmonella total	2/107 (2%)	33/107 (31%)	3/107 (3%)	9/107 (8%)
	Chickens (n=32)	*S.* Enteritidis (n=0)	None	None	None	None
		S. Heidelberg (n=19)	2/32 (6%) 2/19 (11%)	None	None	None
		S. Newport (n=0)	None	None	None	None
		S. Typhimurium (n=2)	None	1/32 (3%) ½ (50%)	None	None
		"Other Serovars" (n=11)	1/32 (3%) 1/11 (9%)	None	None	None
		Salmonella total	3/32 (9%)	1/32 (3%)	None	None
	Turkeys (n=36)	*S.* Enteritidis (n=0)	None	None	None	None
		S. Heidelberg (n=7)	1/36 (3%) 1/7 (14%)	None	None	None
		S. Newport (n=1)	None	None	None	None
		S. Typhimurium (n=0)	None	None	None	None
		"Other Serovars" (n=28)	5/36 (14%) 5/28 (18%)	None	3/36 (8%) 3/28 (11%)	None
		Salmonella total	6/36 (17%)	None	3/36 (8%)	None

[1]*For the purpose of this table, S. Typhimurium var Copenhagen results have been combined with S. Typhimurium. Wherever possible, within the following body of the report, these have been separated and clearly identified.*

Note: *In this report, specific antimicrobial resistance patterns have been highlighted. One of these is the AC(K)SSuT pattern (resistance to AMP-CHL-(KAN)-STR-SMX-TCY). This antimicrobial resistance combination has been frequently described in the past, especially in S. Typhimurium DT104 and is encoded chromosomally. The AC(K)SSuT pattern was also observed alone or with other resistances in other phagetypes, serovars, and bacterial species. We have also reported on the A3C pattern (resistance to AMC-FOX-TIO-CEP). This pattern was commonly observed alone or with resistance to other antimicrobials in both E. coli and Salmonella in CIPARS 2003 isolates. It could be indicative of the presence of isolates producing Extended-Spectrum B-lactamases (ESBL) or Amp-C like B-lactamase.*

Table 3. Antimicrobial resistance and most frequent *Salmonella* serovars across species.

Surveillance Program/Species	Most Frequent[1] Serovars	Most Frequent[1] Serovars Showing No Resistance (n)	Most Frequent[1] Serovars Showing Resistance to 1 to 4 Antimicrobials (n)	Most Frequent Serovars Showing Resistance to 5 to 8 Antimicrobials (n)	Most Frequent Serovars Showing Resistance to 9 to 13 Antimicrobials (n)
Enhanced Passive Surveillance of Clinical Isolates					
Human	Heidelberg (613) Typhimurium (610) Enteritidis (352) Newport (175) Typhi (127) Hadar (101) Thompson (86) Agona (83) Oranienburg (70) Infantis (63) Saintpaul (60) Paratyphi A (59)	Heidelberg (332) Typhimurium[2] (295) Enteritidis (274) Newport (148) Thompson (82) Oranienburg (68) Typhi (64) Infantis (57) Saintpaul (56) Agona (55) Braenderup (36) Javiana (35) ssp. 4,5,12 :i - (32) Muenchen (31)	Heidelberg (137) Hadar (91) Typhimurium (90) Enteritidis (75) Typhi (50) Agona (25) Paratyphi A (19)	Typhimurium (220) Heidelberg (131) Typhi (13) Paratyphi B var. Jav (10) Berta (9) Newport (7)	Newport (15) Heidelberg (13) Typhimurium (5) 4,5,12:i:- (1) Agona (1) Rough-O:-:- (1) Rough-O:e,h:1,2 (1)
Active Abattoir Surveillance					
Swine	Typhimurium (112) Derby (79) Infantis (33) Brandenburg (19) Bovismorbificans (13) Heidelberg (12) Livingstone (11) Ohio (11) California (10) Give (10) Mbandaka (9) Schwarzengrund (9) Agona (6)	Derby (31) Infantis (30) Typhimurium (19) Brandenburg (13) Bovismorbificans (12) Livingstone (11) California (10) Give (9) Ohio (9) Heidelberg (6)	Derby (46) Typhimurium (38) Heidelberg (6) Schwarzengrund (6)	Typhimurium (55) Mbandaka (5) Derby (2) Brandenburg (1) ssp. I:4,12:i:- (1) Johannesburg (1) Krefeld (1)	Infantis (1)
Chickens	Heidelberg (63) Kentucky (18) Hadar (15) Infantis (5) Thompson (4) Typhimurium (4) Schwarzengrund (3) ssp.I:4,5,12:i:- (3) Braenderup (2) Mbandaka (2)	Heidelberg (38) Kentucky (17) Infantis (4) ssp. I:4,5,12:i:- (3) Thompson (3) Braenderup (2) Schwarzengrund (2)	Hadar (15) Heidelberg (21)	Heidelberg (4) Typhimurium (2) Agona (1) Derby (1) Thompson (1)	
Active Retail Surveillance					
Chicken	Heidelberg (39) Kentucky (5) Agona (2) Hadar (2) Thompson (2) Infantis (1) Schwarzengrund (1)	Heidelberg (17) Kentucky (4) Thompson (2) Schwarzengrund (1) Agona (1) ssp. I:rough-O:r1,2 (1) Infantis (1)	Heidelberg (6) Hadar (2) Kentucky (1) ssp. I:6,8:z10:- (1)	Heidelberg (16) Agona (1)	

Surveillance Program/Species	Most Frequent[1] Serovars	Most Frequent[1] Serovars Showing No Resistance (n)	Most Frequent[1] Serovars Showing Resistance to 1 to 4 Antimicrobials (n)	Most Frequent Serovars Showing Resistance to 5 to 8 Antimicrobials (n)	Most Frequent Serovars Showing Resistance to 9 to 13 Antimicrobials (n)
	ssp. I:6,8:z10:- (1)				
	ssp. I:rough-o:r:1,2 (1)				
Passive Surveillance of Clinical Isolates					
Bovine	Typhimurium (94) Newport (63) Kentucky (28) ssp. I:18:-:- (10) Muenster (8) Thompson (6)	Kentucky (23) ssp. I:18:-:- (10) Muenster (7) Thompson (6) Typhimurium (5)	Typhimurium (5)	Typhimurium (50) Kentucky (1) ssp. I:rough-O:i:z6 (1) ssp. I:rough-O:i:1,2 (1)	Newport (62) Typhimurium (34) Kentucky (1)
Swine	Typhimurium (76) Derby (9) Brandenburg (7) Infantis (3) London (3) Johannesburg (2)	Typhimurium (16) Brandenburg (3) London (3) Infantis (2)	Typhimurium (17) Derby (8) Brandenburg (4)	Typhimurium (43)	ssp. I:6,8:-:enx (1) Johannesburg (1)
Chickens	Heidelberg (19) Hadar (3) Kentucky (3) Typhimurium (2) Mbandaka (1) Orion (1) Senftenberg (1) ssp. I:4,5,12:i:- Untypable (1) ssp. I:4,5,12:r:- (1)	Heidelberg (13) Kentucky (2) Typhimurium (1) ssp. I:4,5,12:I:- (1) Mbandaka (1) Orion var. 15+34+ (1)	Heidelberg (4) Hadar (2) Kentucky (1) Senftenberg (1)	Heidelberg (2) Hadar (1) Typhimurium (1) ssp. I:4,5,12:r:- (1)	
Turkeys	Senftenberg (13) Heidelberg (7) Bredeney (4) Montevideo (4) Saintpaul (2) Agona (1) Hadar (1) Johannesburg (1) Litchfield (1) Newport (1) ssp. I:4,12:-:- (1)	Heidelberg (2) Senftenberg (1) Saintpaul (1) Newport (1)	Senftenberg (10) Heidelberg (4) Bredeney (1) Hadar (1) ssp. I:4,12:-:- (1) Johannesburg (1)	Montevideo (4) Senftenberg (2) Heidelberg (1) Saintpaul (1) Agona (1) Litchfield (1)	Bredeney (3)

Note: *[1]Most frequent serovars were those representing two percent or more of the isolates within each surveillance commodity and each category.*
[2]For the purpose of this table, S. Typhimurium var Copenhagen results were combined with S. Typhimurium. Wherever possible, within the following body of the report, these have been separated and clearly identified.

Section One – Antimicrobial Resistance

Human Antimicrobial Resistance

Salmonella - Enhanced Passive Surveillance

CIPARS *Enhanced Passive Surveillance* of antimicrobial resistance in human isolates of *Salmonella* began in January 2003. Throughout the year, all provincial public health laboratories forwarded a total of 3056 *Salmonella* isolates (141 serovars) to the National Microbiology Laboratory (NML) in Winnipeg, Manitoba for phagetyping and susceptibility testing (see Table 24, Appendix A.3, for more details on 2003 submissions and Appendix B.1 for methods). Antimicrobials on the testing panel were amoxicillin-clavulanic acid (AMC), amikacin (AMK), ampicillin (AMP), cephalothin (CEP), chloramphenicol (CHL), ciprofloxacin (CIP), ceftriaxone (CRO), cefoxitin (FOX), gentamicin (GEN), kanamycin (KAN), nalidixic acid (NAL), sulfamethoxazole (SMX), streptomycin (STR), trimethoprim-sulfamethoxazole (SXT), tetracycline (TCY), and ceftiofur (TIO) (see Appendix B.2 for ranges tested and breakpoints).

Notes: *1. CIPARS assumes that all Salmonella isolates reported here are Salmonella enterica. For the following descriptions of serovars and serotypes of Salmonella enterica, the "enterica" is dropped. 2. For interpretation of prevalence results, please note the small number of isolates in certain provinces.*

The objectives of the human AMR section are to determine individual, multiple drug resistance, and AMR patterns for all isolates. Summary results are provided for the three most frequently isolated serovars in Canada (*S*. Enteritidis, *S*. Heidelberg, and *S*. Typhimurium). *S*. Newport also receives particular attention because of recent outbreaks involving multidrug-resistant (MDR) strains, and *S*. Typhi because of its severe disease manifestations in humans. Antimicrobial resistance results are presented by province because of differences in isolate submission protocols between more populated and less populated provinces (Appendix B.1). Results are also available for rare *Salmonella* isolates cultured from two of the three Canadian territories. In addition, provincial incidence rates, patient age range (when available), frequencies of phagetypes, and number of outbreaks when identified by the province are provided.

Although outbreak definitions may vary slightly by province, the Public Health Agency of Canada (formerly part of Health Canada) has defined an outbreak as "*a group of cases that represents higher than expected incidence in time and/or space and for which an investigation is undertaken to determine source of the infections*" (Health Canada, 2003).

In general, samples were obtained from patients whose antimicrobial history was unknown; therefore sample submissions may have followed therapeutic failure.

Salmonella Enteritidis

(n=352)

Note: *for antimicrobial abbreviations see page 2*

The provincial incidence rates of *S.* Enteritidis varied from 0.19 and 3.74 cases per 100,000 inhabitant-years[1] (median=1.60). Most cases of *S.* Enteritidis were observed in patients who were 30-49 years of age (106/352 isolates; 30%) and less than five years of age (71/352 isolates; 20%). Among all isolates, the most frequent phagetypes were phagetype (PT) 4 (101/352 isolates; 29%), PT 8 (49/352 isolates; 14%), PT 1 (45/352 isolates; 13%) and PT 13 (37/352 isolates; 11%). None of the *S*. Enteritidis isolates were identified as outbreak related.

Antimicrobial Drug Resistance: AMR results for *S*. Enteritidis are presented in Table 4, Table 10, and Table 25 (Appendix A.3). No isolates were resistant to ceftriaxone, ciprofloxacin or

[1] The number of laboratory confirmed cases per 100,000 inhabitant-year in each province was calculated by dividing the total number of cases reported to the NESP database in each province by that province population (Stat. Can. Post-censal population estimates Jan, 1, 2003), multiplied by 100,000.

amikacin. Resistance to nalidixic acid was present in 66/352 isolates (19%). Eight to 43% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested.

AMR Patterns: Additional details on the AMR patterns will be made available on the CIPARS website (http://www.phac-aspc.gc.ca/cipars-picra/index.html). The most frequent AMR patterns were resistance to NAL alone (59/352 isolates; 17%) and to NAL-TCY (5/352 isolates; 1%); however, the patterns KAN-NAL-SXT (1/352 isolates; <1%) and CHL-KAN-NAL-STR-TCY (1/352 isolates; <1%) were also identified. One isolate (<1%) of PT 8 was resistant to 6 antimicrobials: A3C[1]-AMP-TCY. One isolate (<1%) of PT 8 showed the AMP-TIO-KAN-SMX-TCY pattern. No ACSSuT, AKSSuT, or ACKSSuT patterns were observed among the *S*. Enteritidis isolates.

Salmonella Heidelberg

(n=613)

The provincial incidence rates for *S*. Heidelberg varied between 0.73 and 6.66 cases per 100,000 inhabitant-years (median=2.84). *S.* Heidelberg was most frequently observed in patients less than five years of age (178/613 isolates; 29%), and between 30 to 39 years (105/613 isolates; 17%) and 5 to 12 years (103/613 isolates; 17%). The most frequent phagetypes were PT 19 (211/613 isolates; 34%), PT 29 (68/613 isolates; 11%), PT 26 (55/613 isolates; 9%), PT 11 (44/613 isolates; 7%) and phagetypes 32 and 35 (37/613 isolates each; 6% each). Among the isolates received at the NML, four outbreaks were identified, two in British Columbia (with two confirmed cases of PT 26 in each outbreak) and two in New Brunswick (one outbreak of 8 confirmed cases of PT 35 and one outbreak of 8 confirmed cases of PT 32).

Antimicrobial Drug Resistance: AMR results for *S*. Heidelberg are presented in Table 5, Table 10, and Table 25 (Appendix A.3). No isolates were resistant to ciprofloxacin or amikacin. Resistance to ceftiofur was present in 137/613 isolates (22%). Resistance to ceftriaxone was present in 3/613 isolates (<1%) but an additional 51/613 isolates (8%) showed reduced susceptibility (intermediate category). Twenty-eight to 56% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested.

AMR Patterns: The most frequent AMR pattern was AMP (96/613 isolates; 16%). This A3C-AMP pattern was mainly observed in Québec (48/166 Québec isolates; 29%), Ontario (25/172 Ontario isolates; 15%), and New Brunswick (12/57 New Brunswick isolates; 21%). Resistance to ACSSuT-A3C was observed in 12/613 isolates (2%). Ten were PT 54 (8 isolates from British Columbia and one each from Alberta and Saskatchewan), one PT 29 from Manitoba, and one PT AT03-4601 from Québec. One isolate resistant to ACSSuT-A3C-CRO was identified in British Columbia (*S*. Heidelberg PT 54). This isolate had an AMR pattern with the greatest number of antimicrobials among all *S.* Heidelberg received. Two additional isolates resistant to CRO were identified (*S*. Heidelberg PT 29) - one in Québec and one in Ontario. These isolates were also resistant to A3C-AMP.

Salmonella Newport

(n=175)

The provincial incidence rates of *S*. Newport varied between 0 and 2.18 cases per 100,000 inhabitant-years (median =0.46). Most cases of *S.* Newport were observed in patients less than five years of age (42/175 isolates; 24%), from 30 to 49 years of age (41/175 isolates; 23%) and from 50 to 69 years of age (37/175 isolates; 21%). The most frequent phagetypes were 9 (28/175 isolates; 16%), 16 (24/175 isolates; 14%) and 3 (19/175 isolates; 11%). There were no outbreak associated isolates.

Antimicrobial Drug Resistance: AMR results for *S*. Newport are presented in Table 6, Table 10, and Table 25 (Appendix A.3). Out of the 16 antimicrobials tested, resistance was not detected to ceftriaxone, ciprofloxacin, or amikacin. Resistance to ceftiofur was observed in 17/175 isolates (10%). Although resistance to ceftriaxone was not detected, 12/175 isolates (7%) showed reduced susceptibility (intermediate category) to ceftriaxone. Eight to 35% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested.

[1] A3C: resistance to amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and cephalothin.

AMR Patterns: Although most *S*. Newport isolates were susceptible to all antimicrobials tested, resistant isolates were generally resistant to five or more antimicrobials (22/27 of the resistant isolates; 81%). The most resistant isolates showed the ACKSSuT-A3C pattern and were of phagetypes 14a (four isolates from Ontario) and 14b (one isolate from Manitoba). The most frequent resistance pattern observed was ACSSuT-A3C for 7 isolates of PT 14a, two isolates of PT 17b, and one isolate that was non-typable. These were cultured in 6 different provinces.

Salmonella Typhi

(n=127)

Note: *S. Typhi is a human specific serovar; isolates were received from 6 provinces.*

The provincial incidence rates of *S*. Typhi varied between 0 and 0.94 cases per 100,000 inhabitant-years (median=0.11). Most cases of *S.* Typhi were observed in patients who were 30 to 49 years of age (40/127 isolates; 32%), less than five years of age (34/127 isolates; 27%), and 18 to 29 years of age (30/127 isolates; 24%). Among the 23 different phagetypes identified, the most frequent were PT E1 (51/127 isolates; 40%), PT A (9/127 isolates; 7%), PT E9 (8/127 isolates; 6%), and PT E14 (7/127 isolates; 6%). No isolates were associated with outbreaks.

Antimicrobial Drug Resistance: AMR results for *S*. Typhi are presented in Table 7, Table 10, and Table 25 (Appendix A.3). No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin or kanamycin. The antimicrobial most frequently involved in observed resistance patterns was nalidixic acid. Zero to 63% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested.

AMR Patterns: The most frequent AMR pattern observed was resistance to NAL alone (47/127 isolates; 37%). Seven (of 127) isolates (6%) were resistant to 7 antimicrobials (ACSSuT-NAL-SXT), 2/127 isolates (2%) were resistant to 6 antimicrobials (ACSSuT-SXT), 4/127 isolates (2%) were resistant to five antimicrobials, three were resistant to AMP-CHL-STR-SMX-SXT, and 1/127 isolates (1%) was resistant to A3C-AMP). Although there were few isolates, Québec was the only province where the resistance pattern, A3C-AMP, was identified (1/18 isolates; 6% of isolates within Québec).

Salmonella Typhimurium

(n=610)

The provincial incidence rates varied between 1.15 and 6.90 cases of *S*. Typhimurium per 100,000 inhabitant-years (median=2.75). Most cases of *S.* Typhimurium were observed in patients less than five years of age (175/610 isolates; 29%) and from 30 to 49 years of age (130/610 isolates; 21%). Among the 84 different phagetypes of *S*. Typhimurium identified, PT 104 was the most frequent (147/610 isolates; 24%), followed by 208 var. (27/610 isolates; 4%), 170 (26/610 isolates; 4%), 46 (26/610 isolates; 4%), and 124 var. (25/610 isolates; 4%). There were three recognized outbreaks of *S.* Typhimurium, one in British Columbia (15 confirmed cases of PT 164), one in Manitoba (five confirmed cases of PT 104), and one in Alberta (11 confirmed cases of PT 46).

Antimicrobial Drug Resistance: AMR results for *S*. Typhimurium are outlined in Table 8, Table 10, and Table 25 (Appendix A.3). No isolates were resistant to ceftriaxone or amikacin, but 5/610 isolates (1%) showed reduced susceptibility (intermediate category) to ceftriaxone. Twenty-seven to 59% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested. Two isolates were resistant to ciprofloxacin.

AMR Patterns: The most frequent patterns observed in *S.* Typhimurium from all provinces were ACSSuT (141/610 isolates; 23%), ACKSSuT (48/610 isolates; 8%), and AKSSuT (21/610 isolates; 3%). These patterns were observed alone or together with one or several other antimicrobials. The A3C pattern was identified in 9/610 isolates (1%) but was observed with resistance to other antimicrobials (ACSSuT, ACKSSuT, AMP-CHL-STR-TCY, GEN-SXT, SXT and/or AMP). The most resistant isolate was of PT 95 and was resistant to 11 antimicrobials (ACSSuT-A3C-GEN-SXT). Two (of 610) isolates (<1%) were resistant to 10 antimicrobials: one (PT 208 var.) was resistant to ACKSSuT-A3C, and one (PT 193) was resistant to ACSSuT-A3C-SXT. Two (of 610)

isolates (<1%) were resistant to ciprofloxacin: one PT 193 (ACSSuT-CIP-GEN-NAL-SXT) and one PT 12 (AMP-CHL-CIP-GEN-NAL-SMX-SXT).

"Other Serovars"

(n=1179)

Among all isolates forwarded to the NML in 2003, 1179 isolates belonged to serovars other than *S*. Enteritidis, *S*. Heidelberg, *S*. Newport, *S*. Typhi, or *S*. Typhimurium. Isolates from this category represented 38% of all isolates and 137 serovars. Most of these cases were observed in patients who were 30 to 49 years of age (305/1179 isolates; 26%) and less than five years of age (273/1179 isolates; 23%). Among these isolates, there was one large outbreak of *S.* Oranienburg PT 2/8 in New Brunswick (40 confirmed cases), one outbreak of *S.* Thompson PT 1 in Québec (8 confirmed cases), and one outbreak of *S.* Berta PT BT02 in Ontario (7 confirmed cases). See Table 26 (Appendix A.3) for a list of "Other Serovars" by province.

Antimicrobial Drug Resistance: AMR results for 'Other Serovars' are presented in Table 9, Table 10, and Table 25 (Appendix A.3). No isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. However, 4/1179 isolates (<1%; serovars Agona, Paratyphi B var. Java, Rough-O:-:-, and Rough-O:e,h:1,2) showed reduced susceptibility (intermediate category) to ceftriaxone. Resistance to ceftiofur was observed in the following serovars: Berta (9/1179 isolates; <1%), ssp. 4,5,12:i:- and Thompson (2/1179 isolates each; <1%); and Infantis, Oranienburg, Paratyphi B var Java, Putten, Rough-O:-:- and Rough-O:e,h:1,2 (1/1179 isolates each, <1%). Five to 50% of the isolates from the different provinces were resistant to one or more of the antimicrobials tested. Three (of 1179) isolates (one *S*. Durban, one *S*. Infantis, and one *S*. Thompson) were cultured in the Northwest Territories and were susceptible to all antimicrobials tested.

AMR Patterns: The ACSSuT (19/1179 isolates; 2%), A3C (18/1179 isolates; 2%), AKSSuT (2/1179 isolates; <1%), and ACKSSuT (3/1179 isolates; <1%) patterns were the most frequently observed. Four (of 1179) isolates (<1%) were resistant to 9 or more antimicrobials. The resistance patterns were ACSSuT-A3C-GEN-SXT (1/1179 isolates; <1%; serotype 4,5,12:I:-), ACKSSuT-A3C (1/1179 isolates; <1%; serovar *S*. Agona), and ACSSuT-A3C (1/1179 isolates; <1%; serovar 'Rough-O:-:-; and 1/1179 isolates; <1% isolate, serovar Rough-O:e,h). Sixty-two (of 1179) isolates (5%) were resistant to five to 8 antimicrobials. The most frequent serovars within this last group were Paratyphi B (10/1179 isolates; 1%), Berta (9/1179 isolates; 1%), Hadar (5/1179 isolates; <1%), Albany (5/1179 isolates; <1%), and Stanley (4/1179 isolates; <1%).

For 2003, the prevalence of resistance to one or more of 16 antimicrobials tested was 315/610 isolates (52%) for *S*. Typhimurium, 64/127 isolates (50%) for *S*. Typhi, 282/613 isolates (46%) for *S.* Heidelberg, 307/1179 isolates (26%) for "Other Serovars, 77/352 isolates (22%) for *S.* Enteritidis, and 28/175 isolates (16%) for *S*. Newport. Among antimicrobials of very high human health importance, resistance to ceftiofur (a third generation cephalosporin) was identified in 6% of all isolates, but was more frequent in *S*. Berta (9/18 isolates; 50%, *S*. Heidelberg (137/613 isolates; 22%), *S*. Newport (16/175 isolates; 9%), and *S*. Typhimurium (31/610 isolates; 5%). Resistance to ceftriaxone was identified in 3/613 (<1%) *S*. Heidelberg isolates. Reduced susceptibility (intermediate category) to ceftriaxone was observed in 51/613 (8%) *S*. Heidelberg isolates, 12/175 (7%) *S*. Newport isolates, 5/610 (<1%) *S*. Typhimurium isolates, and 4/1179 (<1%) of "Other Serovars". Two *S*. Typhimurium isolates (<1%) were resistant to ciprofloxacin. [1]

Note: *For Tables 4-9, Roman numerals I-IV indicate the ranking of human importance, VDD, Health Canada (see Appendix A.1).*

[1] *See Appendix A.1 for classification of antimicrobials according to their human health importance (source: Veterinary Drugs Directorate, Health Canada).*

Table 4 Individual antimicrobial drug resistance for *S. Enteritidis* (N=352) by province.

Category of human health importance	Antimicrobial	BC N=47 n(%)	AB N=56 n(%)	SK N=13 n(%)	MB N=11 n(%)	ON N=143 n(%)	QC N=59 n(%)	NB N=7 n(%)	NS N=11 n(%)	PE N=3 n(%)	NL N=2 n(%)	Canada** (%)
I	ceftiofur	1 (2.1)	0	0	0	1 (0.7)	0	0	0	0	0	0.6
	ceftriaxone	0	0	0	0	0	0	0	0	0	0	0.0
	ciprofloxacin	0	0	0	0	0	0	0	0	0	0	0.0
II	amikacin	0	0	0	0	0	0	0	0	0	0	0.0
	amoxicillin-clavulanic acid	1 (2.1)	0	0	0	1 (0.7)	0	0	0	0	0	0.6
	gentamicin	1 (2.1)	0	0	0	0	0	0	0	0	0	0.3
	kanamycin	0	1 (1.8)	0	0	3 (2.1)	1 (1.7)	0	0	0	0	1.5
	nalidixic acid	8 (17)	8 (14)	1 (7.7)	1 (9.1)	34 (24)	10 (17)	3 (43)	0	1 (33)	0	19.2
	streptomycin	1 (2.1)	0	0	0	3 (2.1)	1 (1.7)	0	0	0	0	1.5
	trimethoprim-sulfamethoxazole	3 (6.4)	0	0	0	1 (0.7)	1 (1.7)	0	0	0	0	1.5
III	ampicillin	4 (8.5)	0	0	0	3 (2.1)	1 (1.7)	0	0	0	0	2.4
	cefoxitin	1 (2.1)	0	0	0	0	0	0	0	0	0	0.3
	cephalothin	1 (2.1)	0	0	0	1 (0.7)	0	0	0	0	0	0.6
	chloramphenicol	1 (2.1)	0	0	0	1 (0.7)	0	0	0	0	0	0.6
	sulfamethoxazole	4 (8.5)	0	0	0	4 (2.8)	0	0	0	0	0	2.4
	tetracycline	3 (6.4)	2 (3.6)	0	0	6 (4.2)	0	0	0	0	0	3.3
IV												

Note: *** = estimated percentage corrected for non-proportional submission scheme between provinces (see Appendix B.1).**

Table 5. Individual antimicrobial drug resistance for *S. Heidelberg* by province (N=613).

Category of human health importance	Antimicrobial	BC N=49 n(%)	AB N=78 n(%)	SK N=20 n (%)	MB N=44 n(%)	ON n=172 n(%)	QC n=167 n(%)	NB n=57 n(%)	NS n=11 n(%)	PE n=1 n(%)	NL n=14 n(%)	Canada* (%)
I	ceftiofur	15 (30.6)	10 (13)	2 (10)	2 (4.5)	31 (18)	52 (31)	24 (42)	1 (9)	0	0	22.6
	ceftriaxone	1 (2)	0	0	0	1 (0.6)	1 (0.6)	0	0	0	0	0.6
	ciprofloxacin	0	0	0	0	0	0	0	0	0	0	0.0
II	amikacin	0	0	0	0	0	0	0	0	0	0	0.0
	amoxicillin-clavulanic acid	15 (30.6)	9 (12)	2 (10)	3 (6.8)	30 (17)	55 (33)	25 (44)	1 (9)	0	0	2.3
	gentamicin	1 (2)	1 (1.3)	1 (5)	1 (2.3)	9 (5.2)	7 (4.2)	6 (11)	0	0	0	3.9
	kanamycin	1 (2)	9 (12)	2 (10)	5 (11)	2 (1.2)	2 (1.2)	0	0	0	0	3.3
	nalidixic acid	2 (4.1)	0	0	1 (2.3)	4 (2.3)	0	0	0	0	0	1.2
	streptomycin	13 (26.5)	14 (18)	7 (35)	9 (21)	13 (7.6)	7 (4.2)	11 (19)	0	0	0	11.0
	trimethoprim-sulfamethoxazole	0	2 (2.6)	0	2 (4.5)	1 (0.6)	1 (0.6)	0	0	0	0	0.9
III	ampicillin	21 (42.9)	18 (23)	6 (30)	10 (23)	48 (28)	80 (48)	28 (49)	2 (18)	0	4 (29)	35.7
	cefoxitin	13 (26.5)	8 (10)	2 (10)	1 (2.3)	29 (17)	52 (31)	24 (42)	1 (9)	0	0	21.4
	cephalothin	19 (38.8)	14 (18)	2 (10)	3 (6.8)	35 (20)	57 (34)	24 (42)	1 (9)	0	0	25.9
	chloramphenicol	11 (22.4)	2 (2.6)	1 (5)	2 (4.5)	0	1 (0.6)	1 (2)	0	0	0	3.0
	sulfamethoxazole	13 (26.5)	6 (7.7)	2 (10)	4 (9.1)	12 (7)	8 (4.8)	3 (5)	0	0	0	8.2
	tetracycline	12 (24.5)	22 (28)	9 (45)	7 (16)	16 (9.3)	12 (7.2)	16 (28)	2 (18)	0	0	14.4
IV												

Note: ** = estimated percentage corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

Table 6. Individual antimicrobial drug resistance for *S.* Newport by province (N=175).

Category of human health importance	Antimicrobial	BC N=19 n(%)	AB N=17 n(%)	SK N=2 n(%)	MB N=6 n(%)	ON N=103 n(%)	QC N=14 n(%)	NB N=3 n(%)	NS N=8 n(%)	PE N=3 n(%)	NL N=0 n(%)	Canada N=175 (%)
I	ceftiofur	1 (5.3)	4 (24)	0	3 (50)	7 (6.8)	0	1 (33)	0	1 (33)		9.7
	ceftriaxone	0	0	0	0	0	0	0	0	0		0.0
	ciprofloxacin	0	0	0	0	0	0	0	0	0		0.0
II	amikacin	0	0	0	0	0	0	0	0	0		0.0
	amoxicillin-clavulanic acid	1 (5.3)	4 (24)	0	3 (50)	7 (6.8)	0	1 (33)	0	1 (33)		9.7
	gentamicin	0	1 (5.9)	0	0	0	0	0	0	0		0.6
	kanamycin	0	2 (12)	0	1 (17)	6 (5.8)	0	0	0	0		5.1
	nalidixic acid	1 (5.3)	2 (12)	0	0	2 (1.9)	1 (7.1)	0	0	0		3.4
	streptomycin	1 (5.3)	3 (18)	0	3 (50)	8 (7.8)	0	1 (33)	0	1 (33)		9.7
	trimethoprim-sulfamethoxazole	0	0	0	0	2 (1.9)	0	0	0	0		1.1
III	ampicillin	1 (5.3)	6 (35)	0	3 (50)	10 (9.7)	0	1 (33)	0	1 (33)		12.6
	cefoxitin	1 (5.3)	4 (24)	0	3 (50)	7 (6.8)	0	1 (33)	0	1 (33)		9.7
	cephalothin	1 (5.3)	4 (24)	0	3 (50)	8 (7.8)	0	1 (33)	0	1 (33)		10.3
	chloramphenicol	1 (5.3)	5 (29)	0	2 (33)	8 (7.8)	0	1 (33)	0	1 (33)		10.3
	sulfamethoxazole	1 (5.3)	5 (29)	0	3 (50)	10 (9.7)	0	1 (33)	0	1 (33)		12.0
	tetracycline	1 (5.3)	5 (29)	0	3 (50)	11 (11)	0	1 (33)	0	1 (33)		12.6
IV												

Table 7. Individual antimicrobial drug resistance for *S.* Typhi by province (N=127).

Category of human health importance	Antimicrobial	BC N=38 n(%)	AB N=14 n (%)	SK N=0 n (%)	MB N=1 n (%)	ON N=55 n (%)	QC N=18 n (%)	NB N=1 n (%)	NS N=0 n (%)	PE N=0 n (%)	NL N=0 n (%)	Canada* N=127 (%)
I	ceftiofur	0	0		0	0	1 (5.6)	0				0.8
	ceftriaxone	0	0		0	0	0	0				0.0
	ciprofloxacin	0	0		0	0	0	0				0.0
II	amikacin	0	0		0	0	0	0				0.0
	amoxicillin-clavulanic acid	0	0		0	0	1 (5.6)	0				0.8
	gentamicin	0	0		0	0	0	0				0.0
	kanamycin	0	0		0	0	0	0				0.0
	nalidixic acid	21 (55.3)	5 (35.7)		1 (100)	25 (45.5)	4 (22)	0				43.3
	streptomycin	6 (15.8)	2 (14.3)		0	5 (9.1)	0	0				10.2
	trimethoprim-sulfamethoxazole	5 (13.2)	2 (14.3)		0	5 (9.1)	0	0				9.4
III	ampicillin	5 (13.2)	2 (14.3)		0	5 (9.1)	1 (5.6)	0				10.2
	cefoxitin	0	0		0	0	1 (5.6)	0				0.8
	cephalothin	0	0		0	0	1 (5.6)	0				0.8
	chloramphenicol	5 (13.2)	2 (14.3)		0	6 (10.9)	0	0				10.2
	sulfamethoxazole	5 (13.2)	2 (14.3)		0	5 (9.1)	0	0				9.4
	tetracycline	5 (13.2)	0		0	6 (10.9)	0	0				8.7
IV												

Table 8. Individual antimicrobial drug resistance for *S. Typhimurium* by province (N=610).

Category of human health importance	Antimicrobial	BC N=73 n(%)	AB N=110 n(%)	SK N=20 n(%)	MB N=46 n(%)	ON N=231 n(%)	QC N=83 n(%)	NB N=17 n(%)	NS N=16 n(%)	PE N=4 n(%)	NL N=9 n(%)	Canada * %
I	ceftiofur	1 (1.4)	3 (2.7)	0	1 (2.2)	2 (0.9)	2 (2.4)	1 (5.9)	0	0	0	1.7
	ceftriaxone	0	0	0	0	0	0	0	0	0	0	0.0
	ciprofloxacin	0	0	0	0	1 (0.4)	1 (1.2)	0	0	0	0	0.4
II	amikacin	0	0	0	0	0	0	0	0	0	0	0.0
	amoxicillin-clavulanic acid	2 (2.7)	4 (3.6)	0	1 (2.2)	6 (2.6)	3 (3.6)	1 (5.9)	0	0	0	3.0
	gentamicin	1 (1.4)	0	0	2 (4.3)	1 (0.4)	1 (1.2)	0	0	0	0	1.1
	kanamycin	4 (5.5)	35 (31.8)	0	7 (15.2)	35 (15.2)	28 (33.7)	3 (17.6)	2 (12.5)	0	2 (22.2)	20.6
	nalidixic acid	2 (2.7)	0	0	0	1 (0.4)	4 (4.8)	0	0	0	0	1.3
	streptomycin	11 (15.1)	28 (34.5)	11 (55)	21 (45.7)	95 (41.1)	43 (51.8)	7 (41.2)	5 (31.3)	2 (50)	2 (22.2)	39.6
	trimethoprim-sulfamethoxazole	7 (9.6)	12 (11)	0	3 (6.5)	8 (3.5)	7 (8.4)	0	1 (6.3)	0	0	6.8
III	ampicillin	15 (20.5)	55 (50)	10 (50)	23 (50)	104 (45)	43 (51.8)	8 (47.1)	7 (43.8)	2 (50)	3 (33.3)	45.7
	cefoxitin	1 (1.4)	2 (1.8)	0	1 (2.2)	2 (0.9)	2 (2.4)	1 (5.9)	0	0	0	1.5
	cephalothin	6 (8.2)	12 (10.9)	0	1 (2.2)	3 (1.3)	3 (3.6)	1 (5.9)	0	0	0	4.7
	chloramphenicol	10 (13.7)	31 (28.2)	7 (35)	17 (37)	81 (35.1)	35 (42.2)	6 (35.3)	5 (31.3)	2 (50)	1 (11.1)	33.0
	sulfamethoxazole	16 (21.9)	57 (51.8)	10 (50)	22 (47.8)	106 (45.9)	42 (50.6)	8 (47.1)	6 (37.5)	2 (50)	3 (33.3)	46.3
	tetracycline	15 (20.5)	58 (52.7)	10 (50)	20 (43.5)	116 (50.2)	45 (54.2)	10 (58.8)	6 (37.5)	2 (50)	3 (33.3)	48.8
IV												

Note: ** = estimated percentage corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

Table 9. Individual antimicrobial drug resistance for "Other Serovars" of *Salmonella* by province (N=1179).

Category of human health importance	Antimicrobial	BC N=169 n(%)	AB N=107 n(%)	SK N=63 n(%)	MB N=75 n(%)	ON N=446 n(%)	QC N=167 n(%)	NB N=50 n(%)	NS N=81 n(%)	PE N=10 n(%)	NL N=8 n(%)	NWT N=3 n(%)	Canada* %
I	ceftiofur	2 (1.2)	1 (0.9)	1 (1.6)	2 (2.7)	11 (2.5)	2 (1.2)	1 (2)	0	0	0	0	1.2
	ceftriaxone	0	0	0	0	0	0	0	0	0	0	0	0.0
	ciprofloxacin	0	0	0	0	0	0	0	0	0	0	0	0.0
II	amikacin	0	0	0	0	0	0	0	0	0	0	0	0.0
	amoxicillin -clavulanic acid	1 (0.6)	2 (1.9)	1 (1.6)	2 (2.7)	13 (2.9)	2 (1.2)	1 (2)	0	0	1 (12.5)	0	1.4
	gentamicin	4 (2.4)	1 (0.9)	4 (6.3)	1 (1.3)	8 (1.8)	2 (1.2)	0	0	0	1 (12.5)	0	1.8
	kanamycin	3 (1.8)	2 (1.9)	0	1 (1.3)	13 (2.9)	5 (3)	0	1 (1.2)	0	0	0	2.4
	nalidixic acid	23 (13.6)	5 (4.7)	1 (1.6)	1 (1.3)	26 (5.8)	7 (4.2)	2 (4)	1 (1.2)	0	0	0	6.3
	streptomycin	20 (11.8)	14 (13)	9 (14.3)	5 (6.7)	49 (11)	24 (14.4)	5 (10)	2 (2.5)	0	3 (37.5)	0	11.9
	trimethoprim-sulfamethoxazole	11 (6.5)	1 (0.9)	2 (3.2)	1 (1.3)	29 (6.5)	3 (1.8)	0	0	0	0	0	4.5
III	ampicillin	18 (10.7)	6 (5.6)	3 (4.8)	4 (5.3)	35 (7.8)	13 (7.8)	2 (4)	2 (2.5)	0	1 (12.5)	0	7.2
	cefoxitin	1 (0.6)	1 (0.9)	1 (1.6)	2 (2.7)	10 (2.2)	2 (1.2)	1 (2)	0	0	0	0	1.0
	cephalothin	4 (2.4)	3 (2.8)	1 (1.6)	2 (2.7)	15 (3.4)	2 (1.2)	1 (2)	0	0	0	0	2.0
	chloramphenicol	7 (4.1)	2 (1.9)	3 (4.8)	2 (2.7)	17 (3.8)	7 (4.2)	1 (2)	1 (1.2)	0	1 (12.5)	0	3.7
	sulfamethoxazole	25 (14.8)	7 (6.5)	6 (9.5)	5 (6.7)	49 (11)	17 (10.2)	3 (6)	0	0	3 (37.5)	0	10.6
	tetracycline	42 (24.9)	26 (24)	16 (25.4)	9 (12)	82 (18)	38 (22.8)	9 (18)	3 (3.7)	0	3 (37.5)	0	20.8
IV													

Note: ** = estimated percentage corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

Table 10. *Salmonella* serovars isolated from humans; *Enhanced Passive Surveillance* of clinical isolates, by province.

Serovar	n (%total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
		Number of isolates			
British Columbia (N=395)					
Typhimurium	73 (18.5)	53	10	9	1
Heidelberg	49 (12.4)	25	8	7	9
Enteritidis	47 (11.9)	34	12	1	0
Typhi	38 (9.6)	14	19	5	0
Newport	19 (4.8)	17	1	0	1
Hadar	13 (3.3)	0	11	2	0
Agona	12 (3)	6	4	1	1
Infantis	11 (2.8)	9	1	1	0
Paratyphi A	11 (2.8)	1	10	0	0
Saintpaul	11 (2.8)	10	0	1	0
Stanley	11 (2.8)	6	2	3	0
"Less common serovars*"	100 (25.3)	76	19	5	0
Totals		**251**	**97**	**35**	**12**
Alberta (N=382)					
Typhimurium	110 (28.8)	45	26	38	1
Heidelberg	78 (20.4)	42	25	10	1
Enteritidis	56 (14.7)	47	9	0	0
Newport	17 (4.5)	11	0	3	3
Hadar	14 (3.7)	1	13	0	0
Saintpaul	14 (3.7)	14	0	0	0
Typhi	14 (3.7)	7	5	2	0
Agona	8 (2.1)	2	6	0	0
"Less common serovars*"	71 (19.5)	59	9	3	0
Totals		**228**	**93**	**56**	**5**
Saskatchewan (N=118)					
Heidelberg	20 (16.9)	7	10	2	1
Typhimurium	20 (16.9)	9	4	7	0
Hadar	15 (12.7)	2	13	0	0
Enteritidis	13 (11)	12	1	0	0
Saintpaul	10 (8.5)	9	1	0	0
Agona	4 (3.4)	4	0	0	0
Muenchen	4 (3.4)	4	0	0	0
Infantis	3 (2.5)	3	0	0	0
Javiana	3 (2.5)	3	0	0	0
Oranienburg	3 (2.5)	3	0	0	0
"Less common serovars*"	23 (19.5)	20	1	1	1
Totals		**76**	**30**	**10**	**2**
Manitoba (N=183)					
Typhimurium	46 (25.1)	22	4	19	1
Heidelberg	44 (24)	29	12	2	1
Enteritidis	11 (6)	10	1	0	0
4,5,12:i:-	7 (3.8)	7	0	0	0
Agona	6 (3.3)	4	2	0	0
Newport	6 (3.3)	3	0	1	2
Saintpaul	5 (2.7)	4	0	1	0

Serovar	n (%total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
		Number of isolates			
Virchow	5 (2.7)	5	0	0	0
Mbandaka	4 (2.2)	4	0	0	0
Schwarzengrund	4 (2.2)	3	1	0	0
Thompson	4 (2.2)	4	0	0	0
“Less common serovars*”	41 (22.4)	34	5	0	2
Totals		**129**	**25**	**23**	**6**
Ontario (N=1150)					
Typhimurium	231 (20.1)	107	31	93	0
Heidelberg	172 (15)	109	31	32	0
Enteritidis	143 (12.4)	104	37	2	0
Newport	103 (9)	90	3	3	7
Typhi	55 (4.8)	29	21	5	0
Hadar	34 (3)	1	31	2	0
Thompson	34 (3)	33	0	1	0
Agona	30 (2.6)	21	9	0	0
Infantis	28 (2.4)	25	1	2	0
“Less common serovars*”		249	45	26	0
Totals		**768**	**209**	**166**	**7**
Québec (N=508)					
Heidelberg	167 (32.9)	76	37	53	1
Typhimurium	83 (16.3)	34	9	39	1
Enteritidis	59 (11.6	48	11	0	0
Thompson	20 (3.9)	19	0	1	0
Hadar	18 (3.5)	1	16	1	0
Typhi	18 (3.5)	13	4	1	0
Newport	14 (2.8)	13	1	0	0
Agona	13 (2.6)	10	2	1	0
Paratyphi B	12 (2.4)	6	0	6	0
Saintpaul	10 (2)	9	1	0	0
“Less common serovars*”	94 (18.5)	78	15	1	0
Totals		**307**	**96**	**103**	**2**
New Brunswick (N=135)					
Heidelberg	57 (42.2)	25	8	24	0
Typhimurium	17 (12.6)	7	3	6	1
Agona	9 (6.7)	8	1	0	0
Minnesota	8 (5.9)	8	0	0	0
Enteritidis	7 (5.2)	4	3	0	0
Havana	6 (4.4)	6	0	0	0
Braenderup	3 (2.2)	2	1	0	0
Newport	3 (2.2)	2	0	0	1
Schwarzengrund	3 (2.2)	1	2	0	0
Thompson	3 (2.2	2	0	1	0
“Less common serovars*”	19 (14.1)	12	6	1	0
Totals		**77**	**24**	**32**	**2**
Nova Scotia (N=127)					
Oranienburg	42 (33.1)	42	0	0	0
Thompson	16 (12.6)	16	0	0	0
Typhimurium	16 (12.6)	9	2	5	0
Enteritidis	11 (8.7)	11	0	0	0

Serovar	n (%total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
		Number of isolates			
Heidelberg	11 (8.7)	8	2	1	0
Newport	8 (6.3)	8	0	0	0
"Less common serovars*"	23 (18.1)	19	4	0	0
Totals		**113**	**8**	**6**	**0**
Prince Edward Island (N=21)					
Typhimurium	4 (19)	2	0	2	0
Enteritidis	3 (14.3)	2	1	0	0
Newport	3 (14.3)	2	0	0	1
Braenderup	2 (9.5)	2	0	0	0
Group B	2 (9.5)	2	0	0	0
4,5,12:i:-	1 (4.8)	1	0	0	0
Heidelberg	1 (4.8)	1	0	0	0
Infantis	1 (4.8)	1	0	0	0
Oranienburg	1 (4.8)	1	0	0	0
Paratyphi B	1 (4.8)	1	0	0	0
Saintpaul	1 (4.8)	1	0	0	0
Senftenberg	1 (4.8)	1	0	0	0
Totals		**17**	**1**	**2**	**1**
Newfoundland and Labrador (N=33)					
Heidelberg	14 (42.4)	10	4	0	0
Typhimurium	9 (27.3)	6	1	2	0
Enteritidis	2 (6.1)	2	0	0	0
Agona	1 (3)	0	1	0	0
Brandenburg	1 (3)	0	1	0	0
Haardt	1 (3)	1	0	0	0
Hadar	1 (3)	0	1	0	0
Infantis	1 (3)	1	0	0	0
Montevideo	1 (3)	1	0	0	0
Paratyphi B	1 (3)	0	0	1	0
Sandiego	1 (3)	1	0	0	0
Totals		**22**	**8**	**3**	**0**
Northwest Territories (N=3)					
Durban	1 (33.3)	1	0	0	0
Infantis	1 (33.3)	1	0	0	0
Thompson	1 (33.3)	1	0	0	0
Totals		**3**	**0**	**0**	**0**
Yukon (N=1)					
Typhimurium	1 (100)	1	0	0	0

***Note**: [a]Serovars with 2% prevalence within a province are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars".*

Susceptibility and Specimen Source

Salmonella isolates received in 2003 were cultured from feces (2000/3056 isolates; 65%), unknown sources (807/3056 isolates; 26%), blood (152/3056 isolates; 5%), urine (86/3056 isolates; 3%), and other types of specimens (aspirate; cerebral spinal fluid, peritoneal fluid, fluid; 10/3056 isolates; <1%). A comparison of the susceptibility of *Salmonella* isolates across specimen sources showed that results were generally similar between isolates cultured from blood and other extra-intestinal sources (aspirate; cerebral spinal fluid, peritoneal fluid, fluid), urine, stool, and unknown sources except for nalidixic acid where the prevalence of

resistance was higher among blood and other extra-intestinal isolates (Figure 1). This was mainly attributable to serovars Typhi and Paratyphi A, which represented 52/163 (32%) and 10/163 (6%) of the blood and other extra-intestinal isolates respectively. *S*. Heidelberg, representing 53/163 (33%) of the blood and other extra-intestinal isolates, did not show any resistance to nalidixic acid. In the case of *S*. Typhi, isolates cultured from blood and other extra-intestinal sources were also more often resistant to nalidixic acid than *S*. Typhi isolates cultured from feces. This higher prevalence of resistance to nalidixic acid has clinical implications because extra-intestinal strains of *Salmonella* resistant to nalidixic acid have the potential for reduced susceptibility to fluoroquinolones (NCCLS M100-S14).

Higher frequencies of resistance to cephalosporins, amoxicillin-clavulanic acid, and ampicillin in *Salmonella* isolated from blood and other extra-intestinal sources, and from urine were also noted. This resistance was mainly attributable to *S.* Heidelberg, which represented 53/163 (33%) of the blood and other extra-intestinal isolates; and 24/86 (28%) of the isolates from urine. As discussed previously in this report, *S*. Heidelberg isolates were often resistant to several cephalosporins, amoxicillin-clavulanic acid, and ampicillin. No clear differences in the resistance levels to ceftiofur, cefoxitin, cephalothin, were noted between *S*. Heidelberg isolates from different sources.

Note: *It is assumed that blood and other extra-intestinal specimens were obtained from hospitalized patients. The information available does not indicate if the specimen collection was obtained before or after treatment or when samples were obtained during the course of the hospitalization. It is therefore not possible to differentiate those resistant to nalidixic acid or the β-lactams at onset of the disease from those that developed it later on during the course of antimicrobial therapy.*

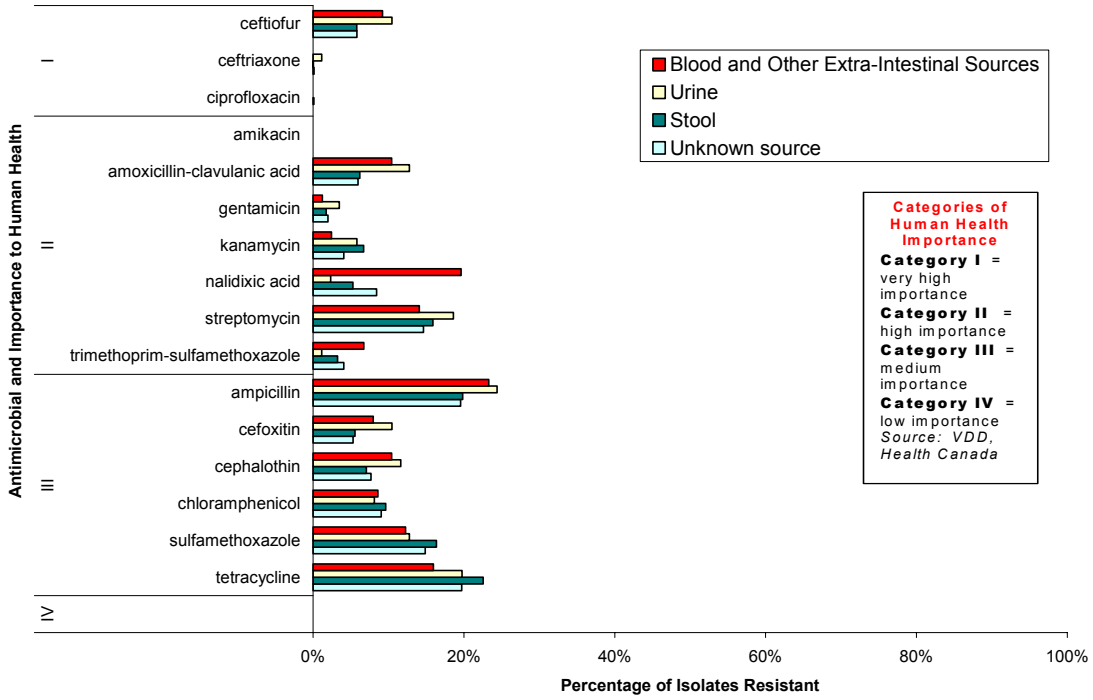

Figure 1. Antimicrobial resistance in *Salmonella* isolates of human origin from blood and other extra-intestinal sources (n=163), urine (n=86), feces (n=2000), and unknown specimens (n=807); *Enhanced Passive Surveillance* of clinical isolates.

Note: *Aminoglycosides may appear active in vitro but are not effective clinically against Salmonella (NCCLS, M100-S14, Table 2A, M7-A6-MIC Testing section).*

Antimicrobial Resistance in the Agri-food Sector

CIPARS relies primarily on *Active Surveillance* to monitor the occurrence of AMR in the agri-food sector. *Active Surveillance* includes two components: *Abattoir Surveillance,* which collects AMR data from animals at the point of entry into the food chain, and *Retail Surveillance,* which targets AMR present in fresh meat available for consumers. The *Abattoir Surveillance* began in September 2002 and involves voluntary participation of federally inspected abattoirs. At the beginning of 2003, 49 abattoirs were sampling, while at the end of 2003, 55 abattoirs were sampling. This change in abattoir numbers accommodated plant closures and minor adjustments in sample sizes. Currently, this surveillance component collects caecal samples from cattle, swine and broiler chickens, and investigates AMR in generic *E. coli* (all commodities) and *Salmonella* (swine and broiler chickens). The *Retail Surveillance* component was launched in the summer of 2003 and collects fresh store samples of ground beef, pork (shoulder chops), and chicken (legs or wings, skin on) and investigates AMR in generic *E. coli* (all commodities), *Salmonella* (chicken), and *Campylobacter* spp. (chicken). Isolation of *Enterococcus* spp. was conducted on the retail samples and antimicrobial susceptibility testing was initiated, however due to concerns regarding laboratory methods these results will be presented at a later date.

CIPARS also reports on isolates obtained through the *Passive Surveillance* of *Salmonella* in animals. These isolates are clinical *Salmonella* submitted to the *Salmonella* Typing Laboratory of LFZ. This laboratory is an ISO (International Standards Organization) 17025 accredited laboratory and an Office Internationale des Epizooties (OIÉ) Reference Laboratory for salmonellosis. It receives isolates from veterinary diagnostic laboratories across Canada. Please see Appendix B.2 for further details on methodology for *Active* (*Abattoir and Retail*) and *Passive Surveillance.*

The objectives of the agri-food AMR section are to present the individual antimicrobial drug resistance, multiple drug resistance and AMR patterns for the sampled bacterial species and food animal commodities, and to describe trends across bacterial species and across commodity groups. Additional details on AMR patterns will be made available on the CIPARS website http://www.phac-aspc.gc.ca/cipars-picra/index.html. The data in this section are presented in three parts: Part I - *Abattoir*, Part II - *Retail*, and Part III - *Passive Surveillance*.

Part I – Abattoir Surveillance

Beef Cattle – Generic *E. coli*

(*Abattoir Surveillance* n=150)

Note: *Generic E. coli isolates were recovered from 97% of the beef cattle caecal samples; five isolates identified as having been recovered from "veal" calf samples were excluded from the analysis.*

Antimicrobial Drug Resistance: See Figure 2, Figure 3, and Table 27 (Appendix A.4). The prevalence of resistance to one or more antimicrobials tested was 24/78 isolates (31%) in 2002 and 50/150 isolates (33%) in 2003. In 2002 no resistance to ceftiofur, cefoxitin, ceftriaxone, trimethoprim-sulfamethoxazole, nalidixic acid, ciprofloxacin, amikacin, gentamicin, kanamycin, or amoxicillin-clavulanic acid was detected. A greater number of isolates were analyzed in 2003 and resistance was detected to ceftiofur (2/150 isolates; 1%), cefoxitin (3/150 isolates; 2%), trimethoprim-sulfamethoxazole (2/150 isolates; 1%), and amoxicillin-clavulanic acid (2/150 isolates; 1%). Although no resistance to ceftriaxone was detected among the 2003 isolates, reduced susceptibility (intermediate category) was observed in 1/150 isolates (<1%). There were no significant differences between prevalences of resistance to individual antimicrobial drugs between 2002 and 2003 (i.e. confidence intervals overlapped for all antimicrobials tested).

AMR Patterns: There were 13 different resistance patterns observed in the abattoir isolates. The most common patterns were resistance to SMX-TCY (13/150 isolates; 9%) and resistance to TCY alone (13/150 isolates; 9%). The isolates with AMR patterns including the greatest number of antimicrobials were resistant to ACSSuT-A3C-SMX (2/150 isolates;

1%). No ACSSuT or A3C patterns were identified in the 2002 data.

For 2003, results from *Abattoir Surveillance* showed that 50/150 (33%) of generic *E. coli* isolates from bovine caecal samples were resistant to one or more antimicrobials tested. Of the antimicrobials Very High Importance to Human Health (Category I), ceftiofur resistance was detected in 2/150 isolates (1%). These same two isolates were resistant to five or more antimicrobials.

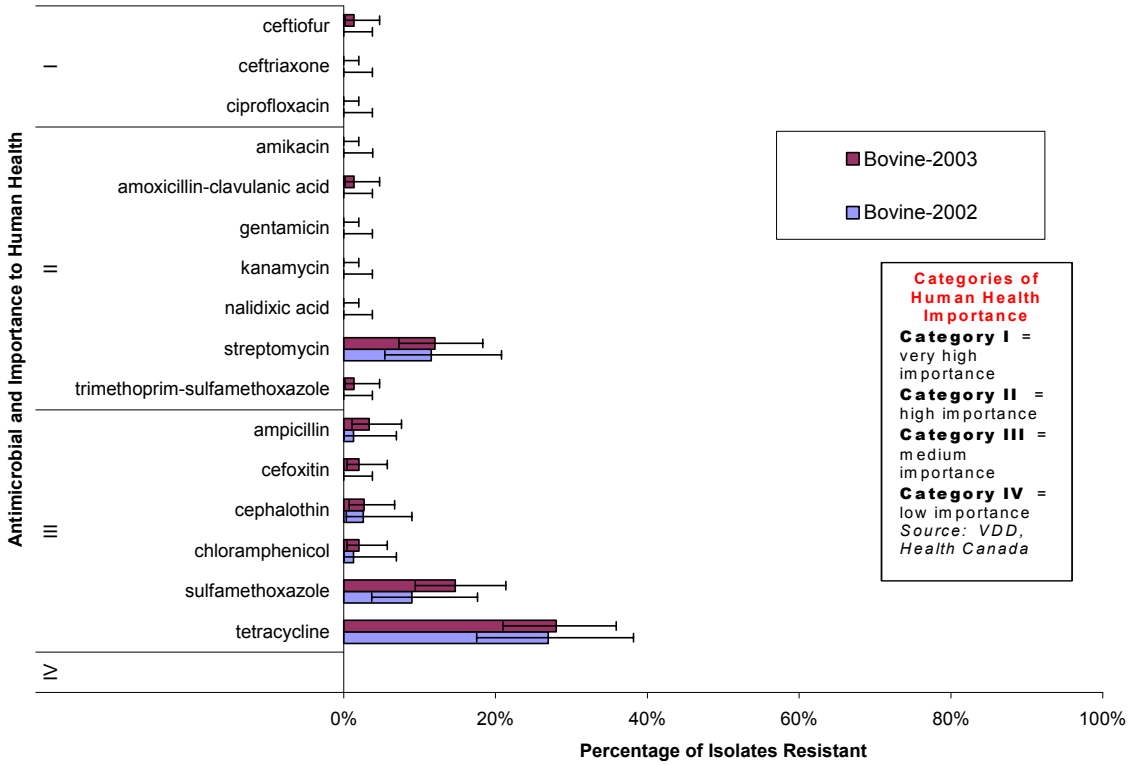

Figure 2. Individual antimicrobial drug resistance in generic *E. coli* from bovine *abattoir* isolates, including confidence intervals; 2002 (n=78) and 2003 (n=150).

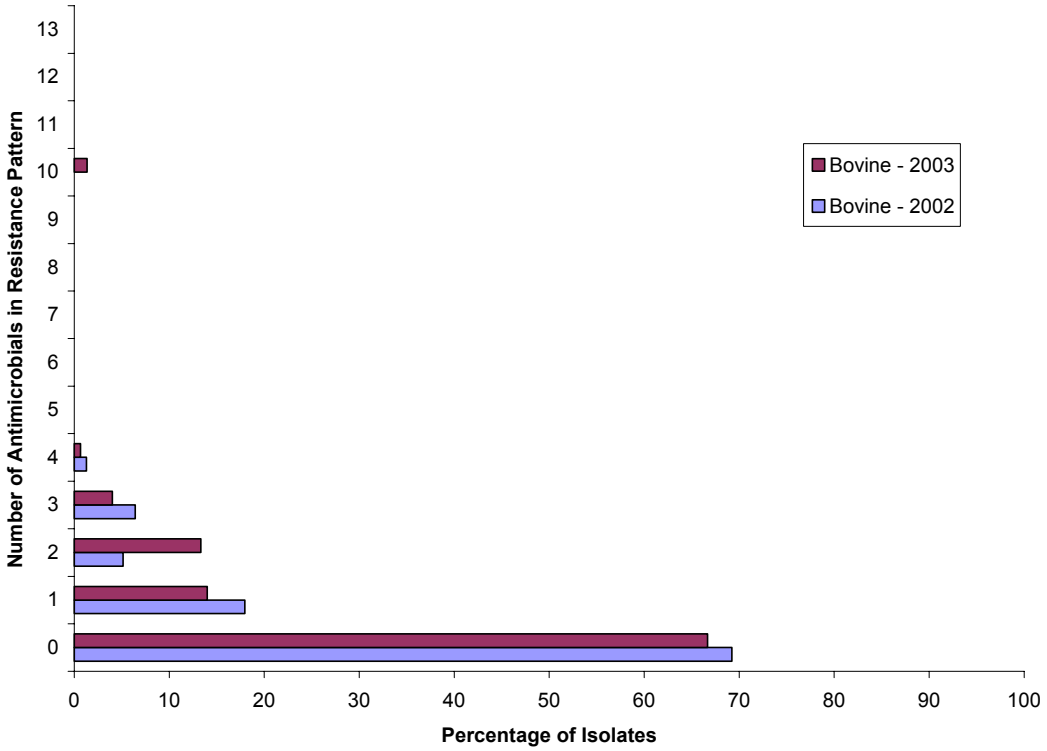

Figure 3. **Multiple drug resistance in generic *E. coli* from bovine *abattoir* isolates; 2002 (n=78) and 2003 (n=150).**

Swine – Generic *E. coli*

(*Abattoir Surveillance* n=155)

Note: *Generic E. coli isolates were recovered from 98% of the swine caecal samples.*

Antimicrobial Drug Resistance: See Figure 4, Figure 5, and Table 28 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 30/38 isolates (79%) in 2002 and 137/155 isolates (88%) in 2003. No resistance to antimicrobials of Very High Human Health Importance (ceftiofur, ceftriaxone, and ciprofloxacin) was observed in 2002 or 2003. Resistance to cefoxitin and nalidixic acid, not detected in 2002, was observed in 2003. There were no significant differences between prevalences of resistance to individual antimicrobial drugs between 2002 and 2003.

AMR Patterns: There were 40 different resistance patterns observed among the abattoir isolates. The most common patterns were resistance to TCY alone (25/155 isolates; 16%) and resistance to SMX-TCY (12/155 isolates; 8%). The isolates with AMR patterns including the greatest number of antimicrobials were resistant to ACSSuT-GEN-SXT (1/155 isolates; <1%) and to ACKSSuT-SXT (1/155 isolates; <1%). Alone or in combination with other antimicrobials, the ACSSuT pattern was observed in 4/155 isolates (3%), the ACKSSuT pattern in 4/155 isolates (3%), and the AKSSuT pattern in 7/155 isolates (5%). In contrast, in 2002, the ACKSSuT pattern was detected in 1/38 isolates (3%) and there were no isolates showing the ACSSuT or AKSSuT patterns.

For 2003, results from *Abattoir Surveillance* showed that 137/155 (88%) of generic *E. coli* isolates from swine caecal samples were resistant to one or more antimicrobials tested. There was no resistance to antimicrobials of Very High Importance to Human Health (Category I). Twenty-five isolates (16%) were resistant to five or more antimicrobials.

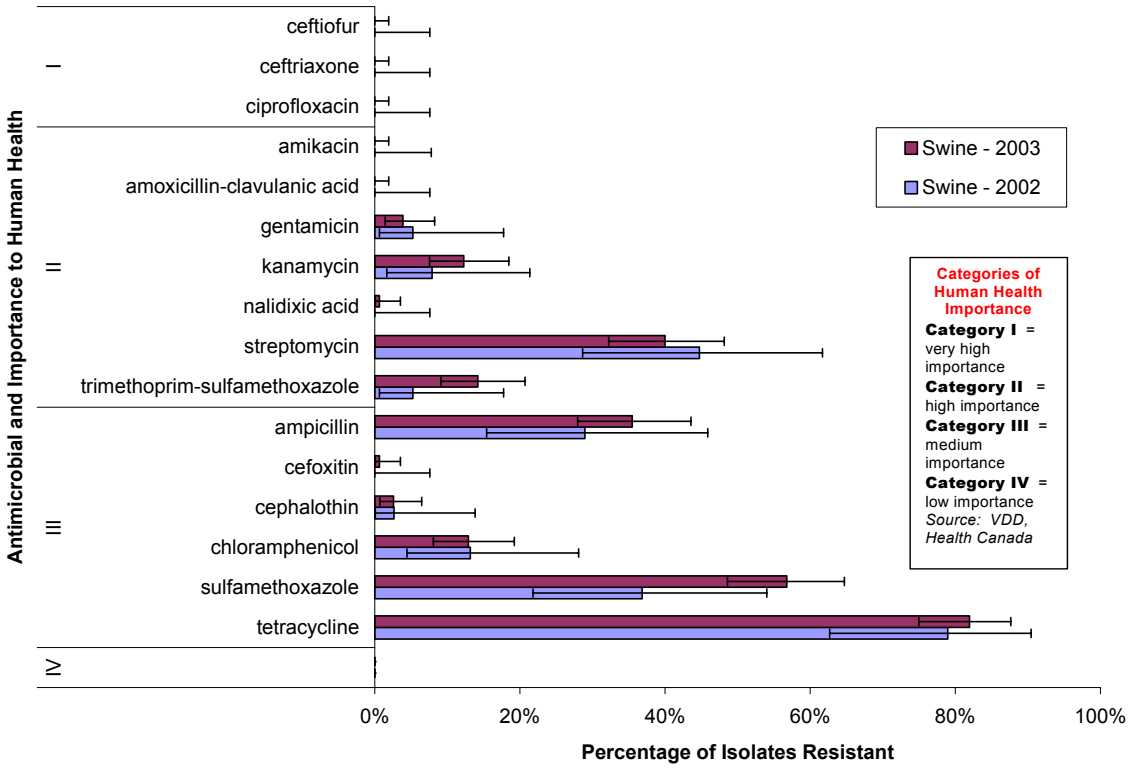

Figure 4. Individual antimicrobial drug resistance in generic *E. coli* from swine *abattoir* isolates, including confidence intervals; 2002 (n=38) and 2003 (n=155).

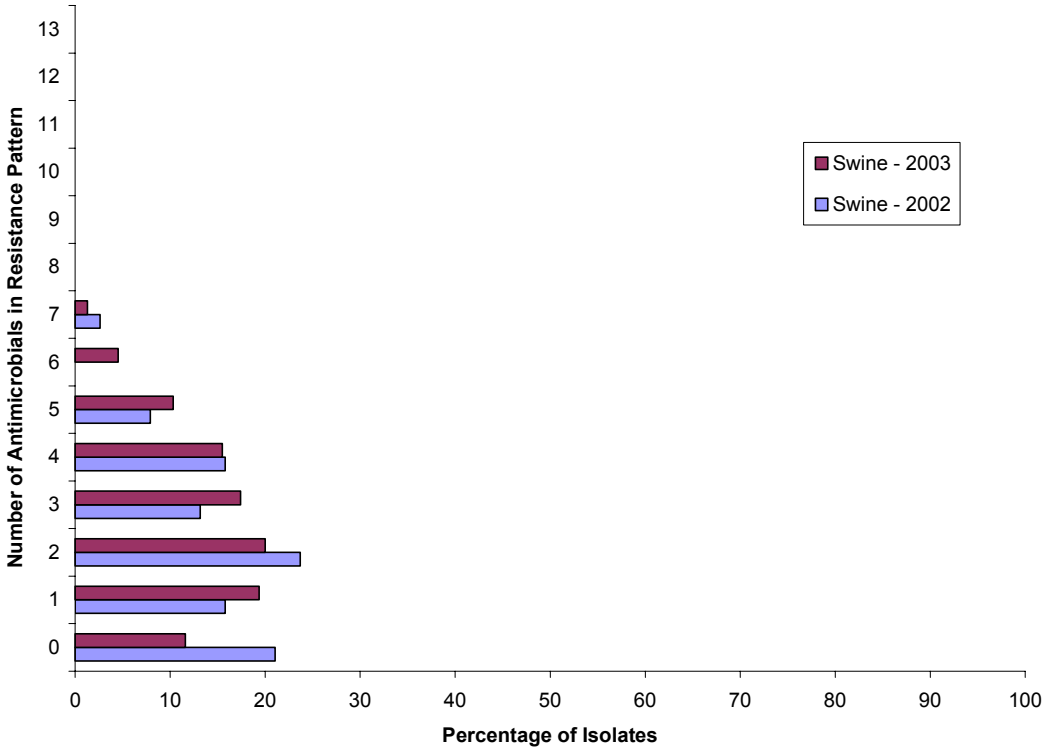

Figure 5. Multiple drug resistance in generic *E. coli* from swine *abattoir* isolates; 2002 (n=38) and 2003 (n=155).

Swine – Salmonella

(*Abattoir Surveillance* n=395)

Note: *Salmonella isolates were recovered from 28% of the swine caecal samples.*

Antimicrobial Drug Resistance: See Figure 6, Figure 7, Table 11, and Table 29 (Appendix A.4). The prevalence of resistance to one or more antimicrobials tested was 45/101 isolates (45%) in 2002 and 192/395 isolates (49%) in 2003. Resistance to ceftiofur was detected in 2003 (1/395 isolates; <1%), but not in 2002. Although no resistance to ceftriaxone was detected among the 2003 isolates, one isolate (<1%) with reduced susceptibility (intermediate category) was identified. There were no significant differences between prevalences of resistance to individual antimicrobial drugs between 2002 and 2003.

AMR Patterns: There were 29 different resistance patterns observed among the swine abattoir isolates. The most common patterns observed were resistance to TCY alone (47/395 isolates; 12%) and resistance to STR-SMX-TCY (34/395 isolates; 9%). Resistance patterns ACSSuT, AKSSuT, and ACKSSuT (57/395 isolates; 14%) were as frequent in 2003 as in 2002 (18/101 isolates; 18%). Resistance to A3C was not identified in 2002 but was found in one isolate (<1%) in 2003 (*S*. Infantis). The AMR patterns with the greatest number of antimicrobials were ACSSuT-A3C (one *S*. Infantis isolate), ACKSSuT-SXT (five *S*. Typhimurium isolates), and ACKSSuT (11 *S*. Typhimurium var. Copenhagen, two *S*. Typhimurium, one *S*. Johannesburg, and one *S*. Krefeld).

Serovars: One *S*. Infantis showed a reduced susceptibility (intermediate category) to ceftriaxone. Among the "Less Common Serovars" class, those resistant to five to 8 antimicrobials were ssp. 'i:4,12:i:- , *S*. Johannesburg, and *S*. Krefeld.

For 2003, results from *Abattoir Surveillance* showed that 192/395 (49%) of *Salmonella* isolates from swine caecal samples were resistant to one or more antimicrobials tested. Of the antimicrobials of Very High Importance to Human Health (Category I), ceftiofur resistance was detected in 1/395 isolates (<1%). Sixty-seven isolates (17%) were resistant to five or more antimicrobials.

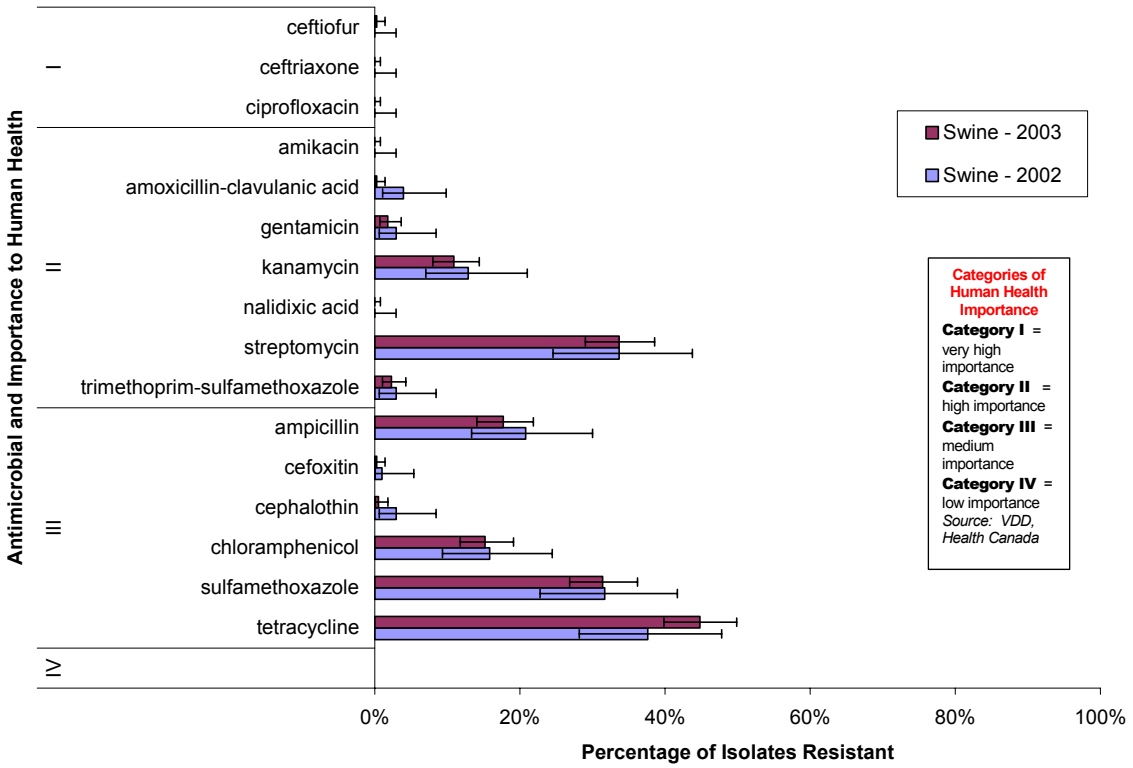

Figure 6. **Individual antimicrobial drug resistance in *Salmonella* from swine *abattoir* isolates, including confidence intervals; 2002 (n=101) and 2003 (n=395).**

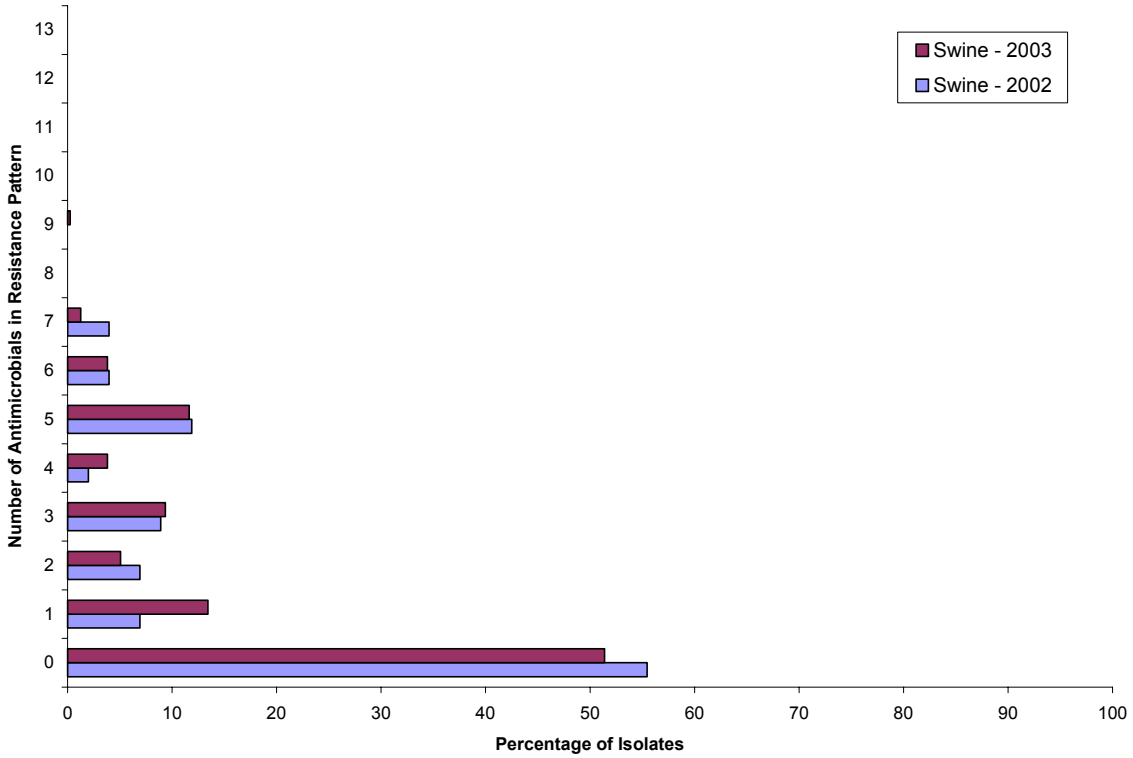

Figure 7. **Multiple drug resistance in *Salmonella* from swine *abattoir* isolates; 2002 (n=101) and 2003 (n=395).**

Table 11. *Salmonella* serovars from swine; *Abattoir Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
***Abattoir Surveillance* (n=395)**		Number of isolates			
Typhimurium var. Copenhagen	80 (20.3)	7	28	45	0
Derby	79 (20)	31	46	2	0
Infantis	33 (8.4)	30	2	0	1
Typhimurium	32 (8.1)	12	10	10	0
Brandenburg	19 (4.8)	13	5	1	0
Bovismorbificans	13 (3.3)	12	1	0	0
Heidelberg	12 (3)	6	6	0	0
California	10 (2.5)	10	0	0	0
Give	9 (2.3)	9	0	0	0
Livingstone var.14+	9 (2.3)	9	0	0	0
Mbandaka	9 (2.3)	3	1	5	0
Schwarzengrund	9 (2.3)	3	6	0	0
Ohio	8 (2)	6	2	0	0
"Less Common Serovars"	73 (18.5)	52	18	3	0
Totals		**203**	**125**	**66**	**1**

Note: [a]Serovars with greater than 2% prevalence are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars".

Broiler Chickens – Generic *E. coli*

(*Abattoir Surveillance* n=150)

Note: *Generic E. coli isolates were recovered from 97% of the chicken caecal samples.*

Antimicrobial Drug Resistance: See Figure 8, Figure 9 and Table 30 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 32/40 isolates (80%) in 2002 and 126/150 isolates (84%) in 2003. In both 2002 and 2003, no resistance to ceftriaxone or ciprofloxacin was observed, but ceftiofur resistance was observed in 4/40 isolates (10%) in 2002 and in 26/150 isolates (17%) in 2003. Resistance to nalidixic acid, not detected in 2002, was observed in 2003 in 6/150 isolates (4%). Although no resistance to ceftriaxone was detected among isolates in 2003, 13/150 isolates (9%) showed reduced susceptibility (intermediate category). Five isolates (3%) also demonstrated reduced susceptibility (intermediate category) to ceftiofur. There were no significant differences between prevalences of resistance to individual antimicrobial drugs between 2002 and 2003.

AMR Patterns: There were 61 different resistance patterns observed among the abattoir isolates. The most common patterns were resistance to STR-TCY (12/150 isolates; 8%), resistance to TCY alone (11/150 isolates; 7%), and resistance to ACSSuT-A3C (9/150 isolates; 6%). The isolates with AMR patterns including the greatest number of antimicrobials were resistant to A3C-AMP-GEN-KAN-NAL-SMX-TCY-SXT (1/150 isolates; <1%) and ACKSSuT-A3C-GEN (1/150 isolates; <1%). Alone or in combination with other antimicrobials, the ACSSuT pattern was observed in 11/150 isolates (7%), the ACKSSuT pattern in 2/150 isolates (1%), the AKSSuT pattern in 3/150 isolates (2%), and the A3C pattern in 26/150 isolates (17%). In contrast, in 2002, the ACSSuT pattern was detected in 1/40 isolates (3%), the AKSSuT pattern was detected in 1/40 isolates (3%), and the A3C pattern was detected in 4/40 isolates (10%) isolates.

For 2003, results from *Abattoir Surveillance* showed that 126/150 (84%) of generic *E. coli* isolated from broiler chicken caecal samples were resistant to one or more antimicrobials tested. Of the antimicrobials of Very High Importance to Human Health (Category I), ceftiofur resistance was detected in 26/150 isolates (17%). Forty-three isolates (29%) were resistant to five or more antimicrobials.

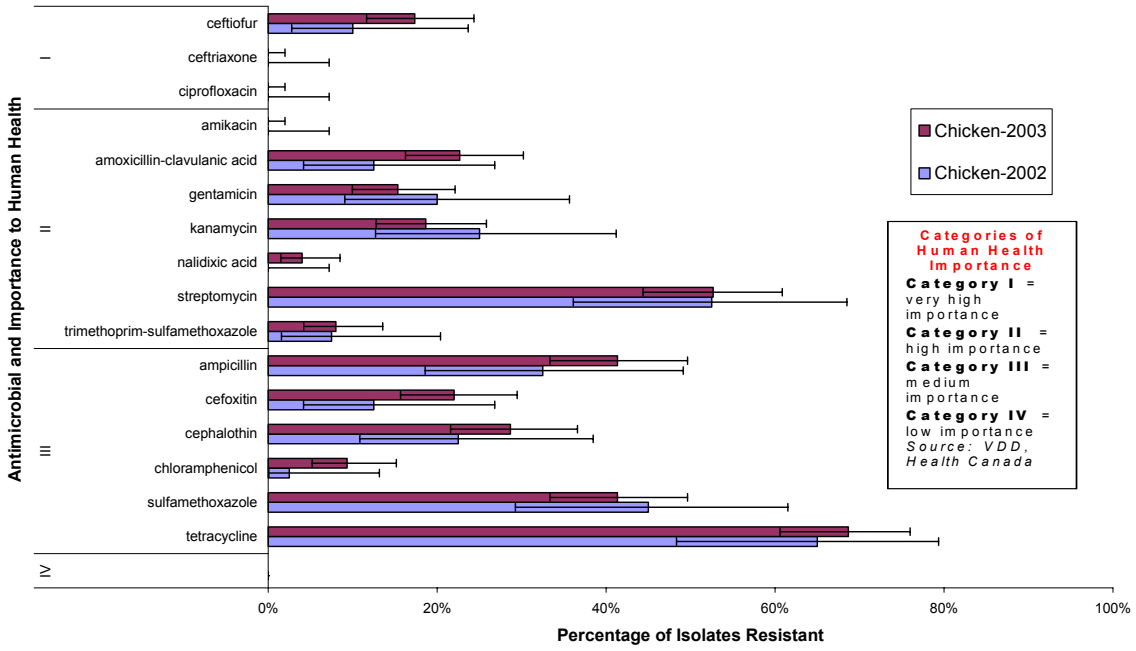

Figure 8. **Individual antimicrobial drug resistance in generic *E. coli* from broiler chicken *abattoir* isolates, including confidence intervals; 2002 (n=40) and 2003 (n=150).**

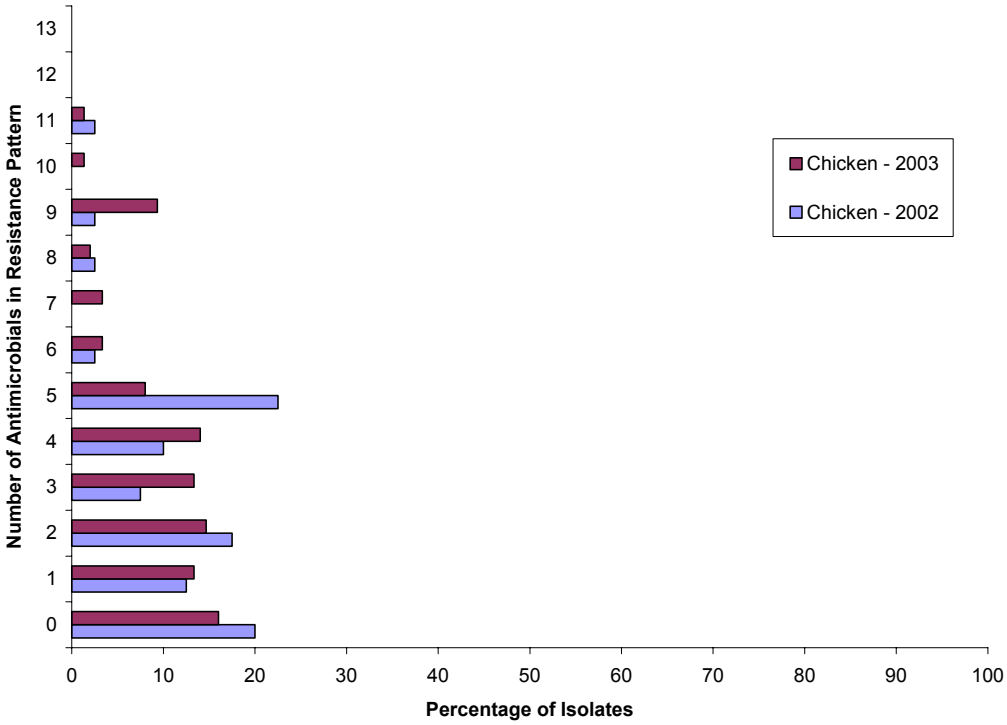

Figure 9. **Multiple drug resistance in generic *E. coli* from broiler chicken *abattoir* isolates; 2002 (n=40) and 2003 (n=150).**

Broiler Chickens – *Salmonella*

(*Abattoir Surveillance* n=126)

Note: *Salmonella isolates were recovered from 16% of the chicken caecal samples.*

Antimicrobial Drug Resistance: See Figure 10, Figure 11, Table 12 and Table 31 (Appendix A.4). The prevalence of resistance to one or more antimicrobials tested was 12/25 isolates (48%) in 2002 and 52/126 isolates (41%) in 2003. Resistance to ceftriaxone (1/126 isolates; <1%), chloramphenicol (2/126 isolates; 2%), kanamycin (4/126 isolates; 3%), and trimethoprim-sulfamethoxazole (1/126 isolates; <1%) was detected in 2003 but not in 2002. Resistance to nalidixic acid was detected in 2002 (1/25 isolates; <1%), but not in 2003. Six of 126 isolates (5%) from 2003 showed reduced susceptibility (intermediate category) to ceftriaxone. There were no significant differences between prevalence of resistance to individual antimicrobial drugs between 2002 and 2003.

AMR Patterns: There were 19 different resistance patterns observed among the abattoir isolates. The most common patterns observed were STR-TCY (10/126 isolates; 8%) and A3C-AMP (7/126 isolates; 6%). This A3C-AMP pattern was found in four *S.* Heidelberg isolates, one *S.* Derby isolate, one *S.* Agona isolate, and one *S.* Thompson isolate. The same resistance pattern (A3C-AMP) was observed in 3/25 isolates (12%) from 2002. Resistance to ACSSuT, not identified in 2002, was observed in two *S.* Typhimurium isolates in 2003. The serovar with an AMR pattern conferring resistance to the greatest number of antimicrobials (AMP-TIO-CRO-CEP-GEN-STR-SMX) was *S.* Oranienburg (1/126 isolates; <1%).

Serovars: Among the "Less Common Serovars", those resistant to five to 8 antimicrobials were *S.* Typhimurium, *S.* Agona, *S.* Derby, and *S.* Oranienburg.

For 2003, results from *Abattoir Surveillance* showed that 52/126 (41%) isolates of *Salmonella* isolated from chicken caecal samples were resistant to one or more antimicrobials tested. Of the antimicrobials of Very High Importance to Human Health (Category I), 8/126 isolates (6%) were resistant to ceftiofur and 1/126 isolates (<1%) were resistant to ceftriaxone. Ten isolates (8%) were resistant to five or more antimicrobials.

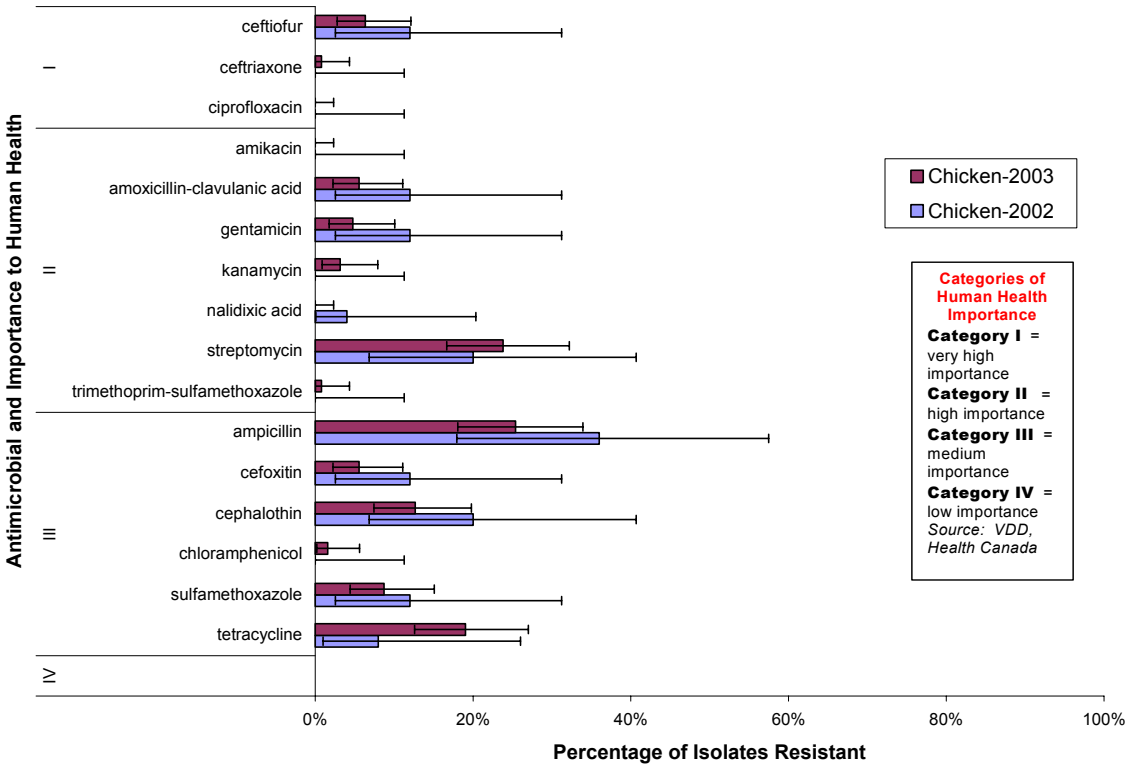

Figure 10. Individual antimicrobial drug resistance in *Salmonella* from broiler chicken *abattoir* isolates, including confidence intervals; 2002 (n=25) and 2003 (n=126).

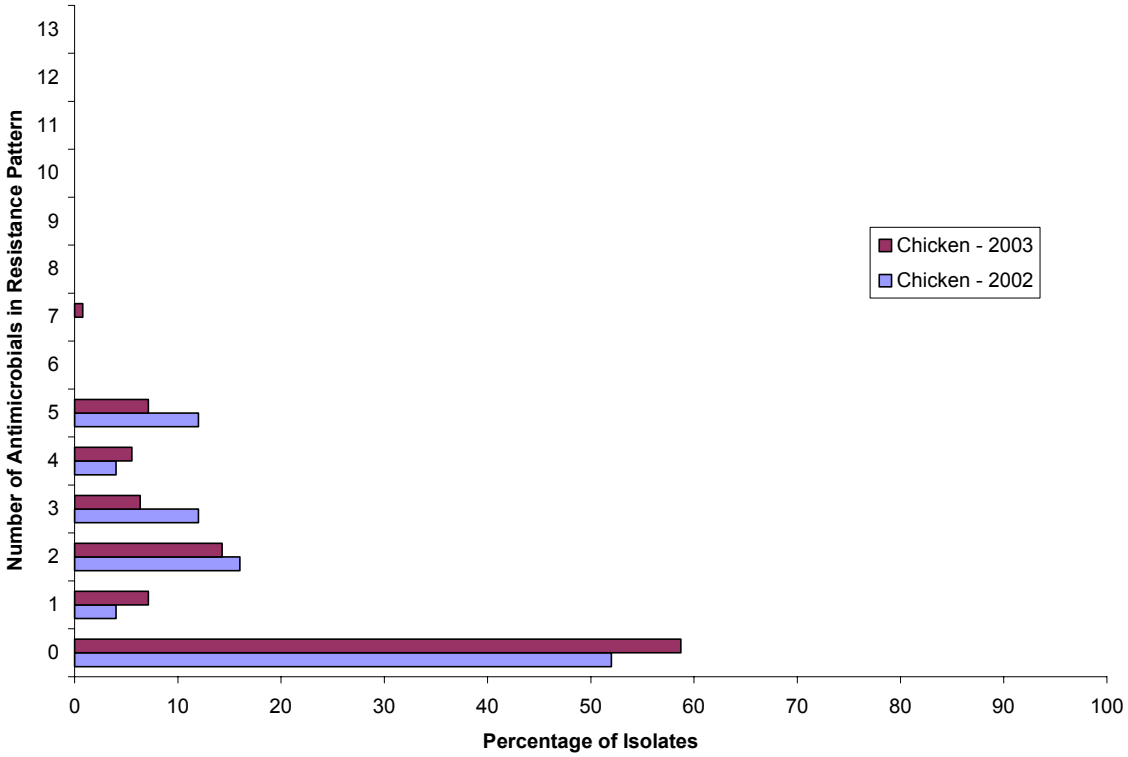

Figure 11. Multiple drug resistance in *Salmonella* from broiler chicken *abattoir* isolates; 2002 (n=25) and 2003 (n=126).

Table 12. *Salmonella* serovars from chickens; *Abattoir Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
***Abattoir Surveillance* (n=126)**		Number of isolates			
Heidelberg	63 (50)	38	21	4	0
Kentucky	18 (14.3)	17	1	0	0
Hadar	15 (11.9)	0	15	0	0
Infantis	5 (4.0)	4	1	0	0
Thompson	4 (3.2)	3	0	1	0
ssp. I:4,5,12:i:-	3 (2.4)	3	0	0	0
Schwarzengrund	3 (2.4)	2	1	0	0
"Less Common Serovars"	15 (11.9)	7	3	5	0
Totals		**74**	**42**	**10**	**0**

Note: [a]Serovars with greater than 2% prevalence are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars".

Part II – Retail Surveillance of Food of Animal Origin

Beef – Generic *E. coli*

(Ontario n=100; Québec n=84)

Note: *Generic E. coli isolates were recovered from 66% and 57% of the ground beef samples from Ontario and Québec respectively.*

Antimicrobial Drug Resistance: See Figure 12, Figure 13, and Table 32 (Appendix A.4). There were no significant differences between prevalences of resistance to individual antimicrobial drugs between the Ontario and Québec isolates. In addition to the 2/100 Ontario isolates (2%) resistant to ceftiofur, one isolate (1%) showed reduced susceptibility (intermediate category) to ceftiofur. All isolates from Québec were fully susceptible to ceftiofur.

AMR Patterns: There were 18 different resistance patterns observed in the Ontario isolates and 13 patterns in the Québec isolates. The most common patterns observed both in the Ontario and Québec isolates were TCY (10/184 isolates; 5%) and SMX-TCY (9/184 isolates; 5%). One isolate from Ontario showed the ACSSuT-A3C pattern.

For retail ground beef generic *E. coli* isolates, 27/100 Ontario isolates (27%) and 19/84 Québec isolates (23%) were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 2/100 Ontario isolates (2%). Four Ontario isolates (4%) and one Québec isolate (1%) were resistant to five or more antimicrobials.

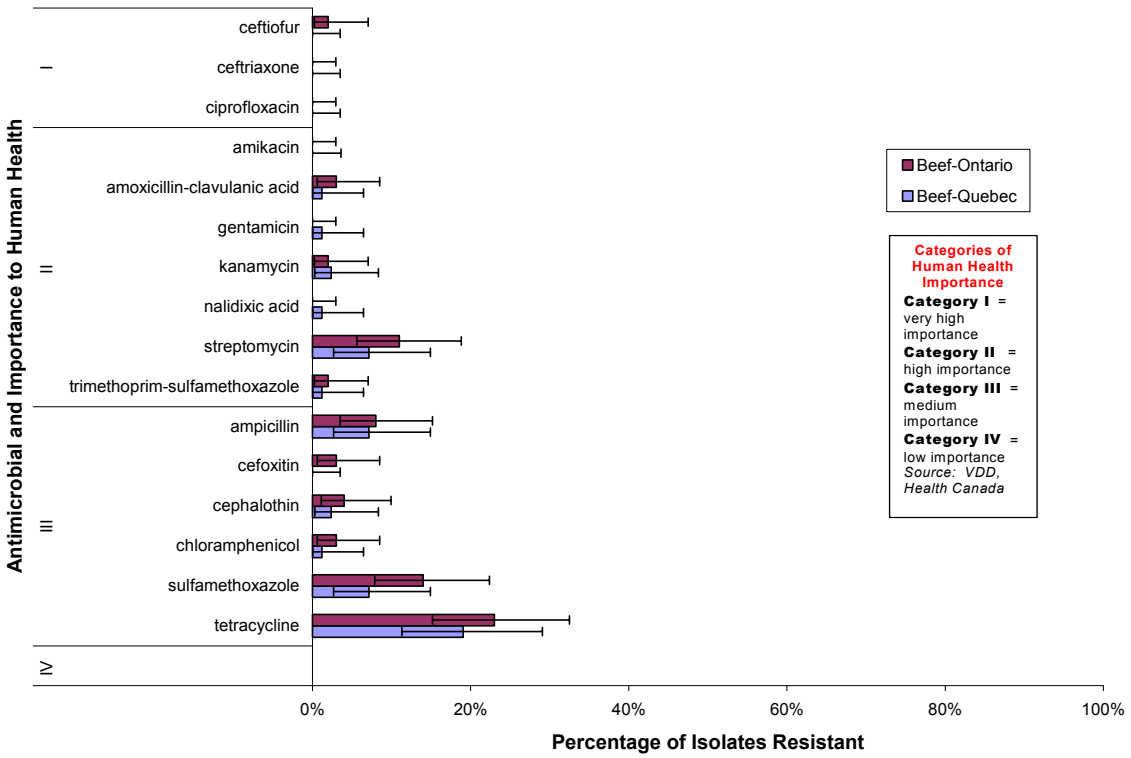

Figure 12. Individual antimicrobial drug resistance in *E. coli* from retail ground beef, including confidence intervals; Ontario (n=100), Québec (n=84).

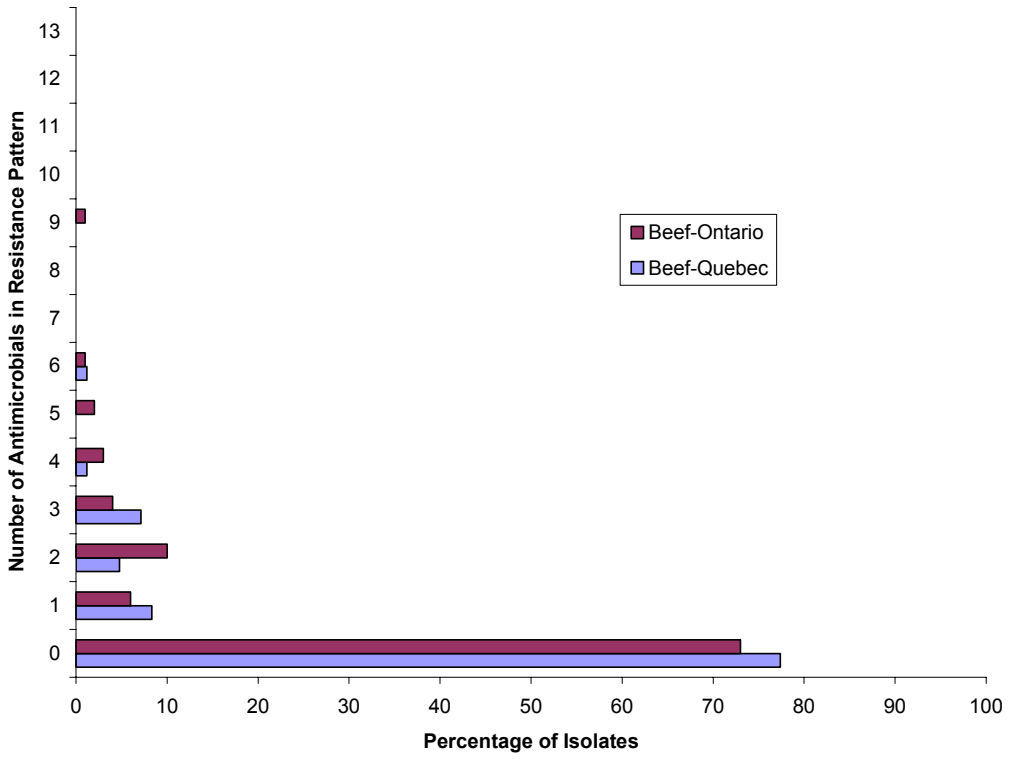

Figure 13. Multiple drug resistance in *E. coli* from *retail* ground beef; Ontario (n=100), Québec (n=84).

Pork – Generic *E. coli*

(Ontario n=91; Québec n=61)

Note: *Generic E. coli isolates were recovered from 58% and 42% of the pork samples from Ontario and Québec respectively.*

Antimicrobial Drug Resistance: See Figure 14, Figure 15, Table 33 (Appendix A.4). There were no significant differences between the prevalences of resistance to individual antimicrobials between isolates from Ontario and Québec. The prevalence of resistance to one or more antimicrobials was 58/91 isolates (64%) in Ontario and 33/61 isolates (54%) in Québec. One Ontario isolate (1%) was resistant to ceftiofur, and one Ontario isolate (1%) and one Québec isolate (2%) showed reduced susceptibility (intermediate category) to ceftiofur. The same isolate from Québec also showed reduced susceptibility (intermediate category) to ceftriaxone.

AMR Patterns: There were 27 different resistance patterns observed in the Ontario isolates and 21 patterns observed in the Québec isolates. The most common patterns in the Ontario isolates were TCY (16/91 isolates; 18%) and SMX-TCY (7/91 isolates; 8%). The most common patterns in the Québec isolates were STR-TCY (5/61 isolates; 8%) and SMX-TCY (3/61 isolates; 5%).

For Ontario, 1/91 isolates (1%) showed the ACKSSuT pattern (plus additional resistance to other antimicrobials) and 1/91 isolates (1%) showed the ACSSuT pattern. For Québec, 2/61 isolates (3%) showed resistance to the ACSSuT pattern (plus additional resistance to other antimicrobials). The isolate with resistance to the greatest number of antimicrobials was resistant to ACKSSuT-AMC-TIO-CEP and was isolated from pork sampled in Ontario.

For retail pork generic *E. coli* isolates, 58/91 isolates (64%) from Ontario and 33/61 isolates (54%) from Québec were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 1/91 isolates (1%) from Ontario. Five isolates (5%) from Ontario and five isolates (8%) from Québec were resistant to five or more antimicrobials.

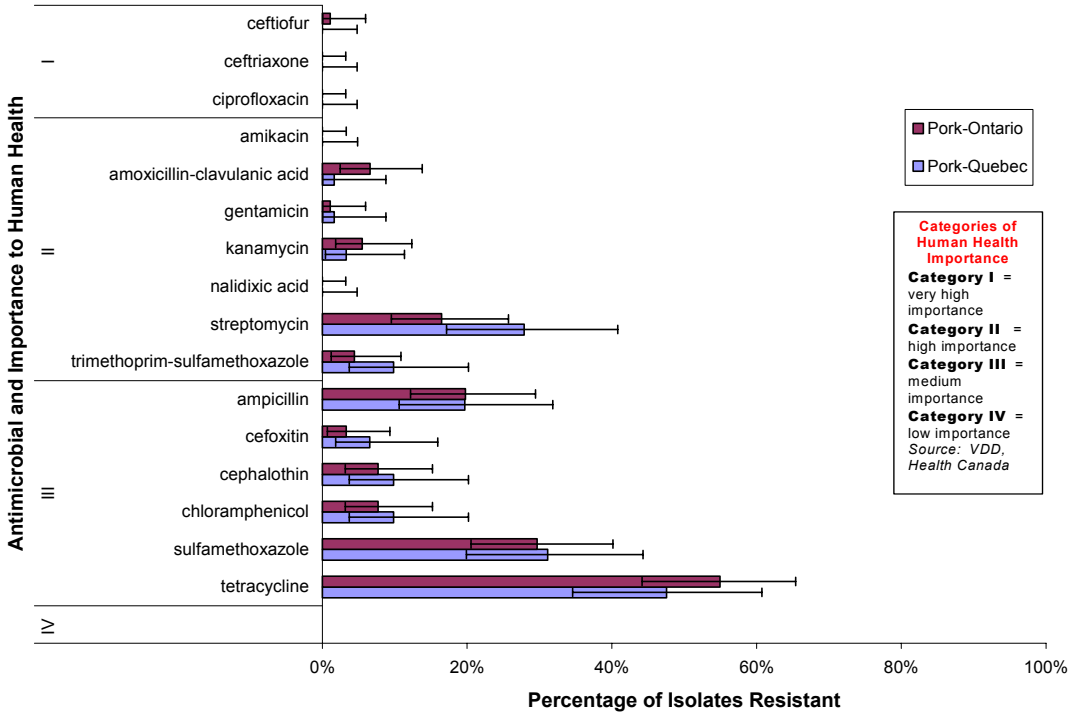

Figure 14. Individual antimicrobial drug resistance in *E. coli* from *retail* pork, including confidence intervals; Ontario (n=91), Québec (n=61).

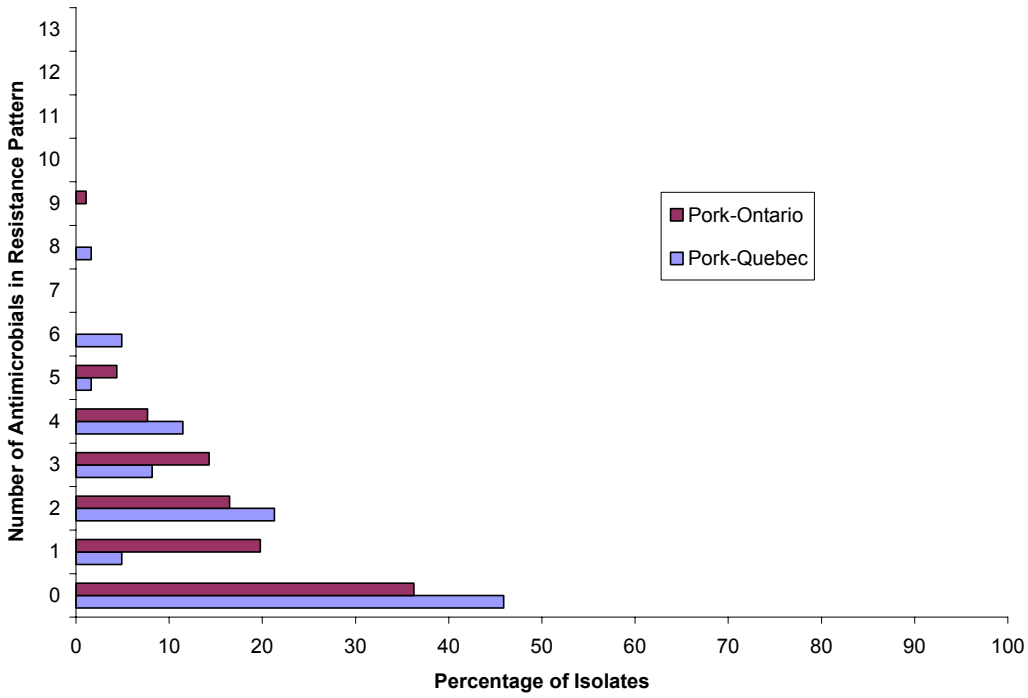

Figure 15. **Multiple drug resistance in *E. coli* from *retail* pork; Ontario (n=91), Québec (n=61).**

Chicken – Generic *E. coli*

(Ontario n=136; Québec n=112)

Note: *Generic E. coli isolates were recovered from 95% and 89% of the chicken leg samples from Ontario and Québec respectively.*

Antimicrobial Drug Resistance: See Figure 16, Figure 17, and Table 34 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 88/136 isolates (65%) in Ontario and 85/112 isolates (76%) in Québec. Although no resistance to ceftriaxone was detected in either province, reduced susceptibility (intermediate category) was observed in 11/136 (8%) Ontario isolates and in 11/112 (10%) Québec isolates. Ceftiofur resistance was detected in 24/136 (18%) Ontario isolates and 37/112 (33%) Québec isolates. There were significant differences in the prevalence of resistance between Ontario and Québec for amoxicillin-clavulanic acid, cefoxitin, cephalothin, chloramphenicol, and sulfamethoxazole.

AMR Patterns: There were 49 different resistance patterns observed in the Ontario isolates and 47 patterns in the Québec isolates. In Ontario, the most common resistance patterns observed were to TCY alone (11/136 isolates; 8%) and AMP-STR-TCY (8/136 isolates; 6%). In Québec, the most common resistance patterns observed were the ACSSuT-A3C pattern (10/112 isolates; 9%) and TCY alone (5/112 isolates; 4%).

In Ontario, 24/136 isolates (18%) showed resistance to the A3C pattern (always in combination with resistance to other antimicrobials), the ACSSuT pattern was observed in 6/136 isolates (4%), the ACKSSuT pattern in 1/136 isolates (<1%), and the AKSSuT pattern in 1/136 isolates (<1%). In Québec, 37/112 isolates (33%) showed resistance to the A3C pattern (always in combination with resistance to other antimicrobials), the ACSSuT pattern was observed in 15/112 isolates (13%), the ACKSSuT pattern in 4/112 isolates (4%), and the AKSSuT pattern in 2/112 isolates (2%). The isolates with AMR patterns conferring resistance to the greatest number of antimicrobials were resistant to ACKSSuT-A3C-GEN (2/248 isolates; <1%; one from Ontario and one from Québec) and AKSSuT-A3C-GEN-SXT (1/248 isolates; <1%; a Québec isolate).

For retail chicken generic *E. coli* isolates, 88/136 isolates (65%) from Ontario and 85/112 isolates (76%) from Québec were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 24/136 (18%) Ontario isolates and 37/112 (33%) Québec isolates. Thirty isolates (22%) from Ontario and fifty isolates (45%) from Québec were resistant to five or more antimicrobials. In Québec, the most common resistance pattern was the ACSSuT-A3C (14/112 isolates; 12%). This pattern was identified in 5/136 isolates (4%) from Ontario. There were some differences between the provinces in terms of prevalence of resistance to individual antimicrobial drugs, highlighting the need to conduct surveillance in multiple provinces.

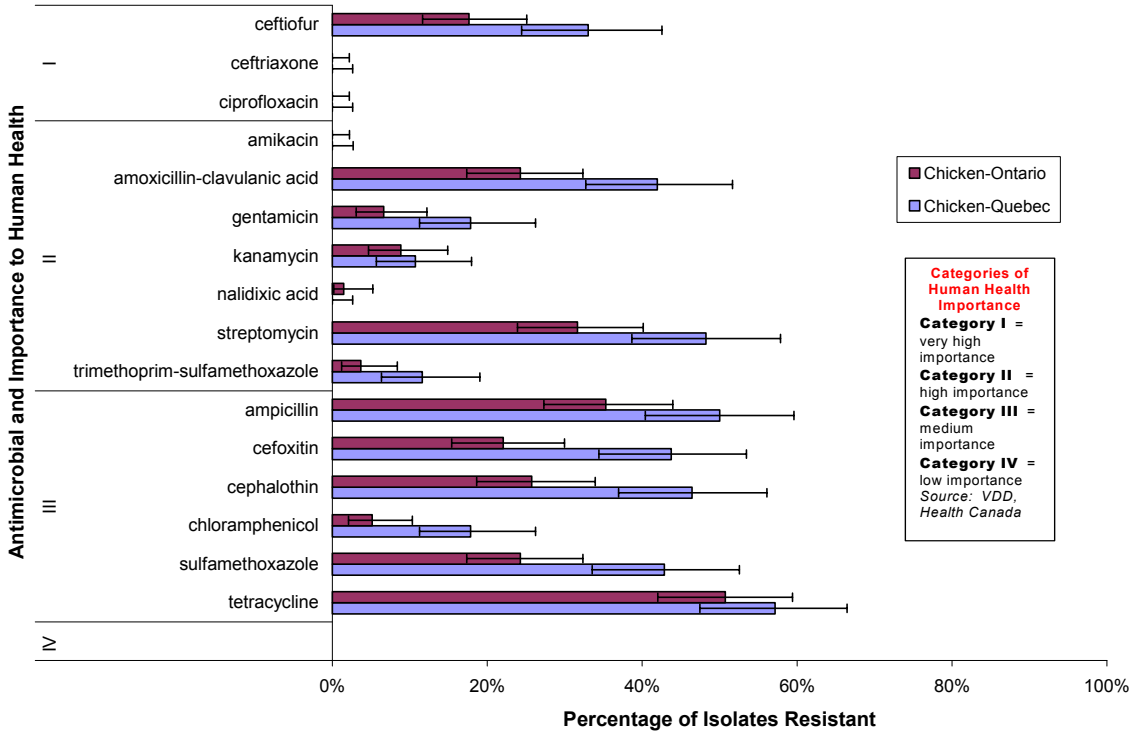

Figure 16. Individual antimicrobial drug resistance in *E. coli* from *retail* chicken, including confidence intervals; Ontario (n=136), Québec (n=112).

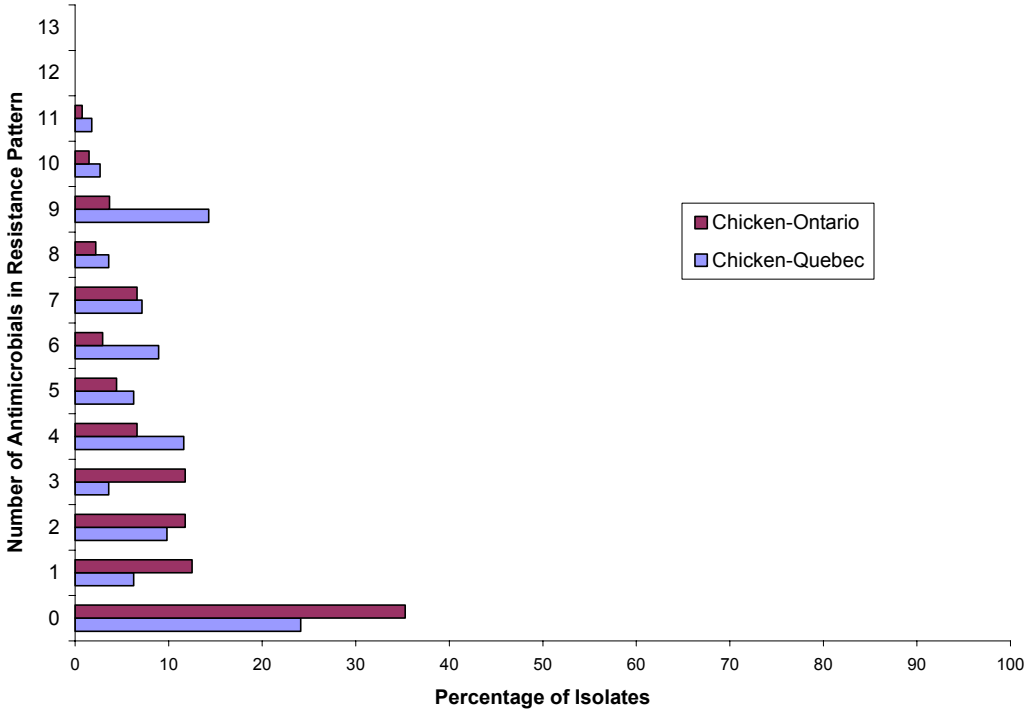

Figure 17. Multiple drug resistance in *E. coli* from *retail* chicken; Ontario (n=136), Québec (n=112).

Chicken – *Salmonella*

(Ontario n=26; Québec n=28)

Note: *Salmonella isolates were recovered from 16% of the chicken leg samples received from Ontario and Québec.*

Antimicrobial Drug Resistance: See Figure 18, Figure 19, Table 13, and Table 35 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 5/26 isolates (19%) in Ontario and 22/28 isolates (79%) in Québec. Although no resistance to ceftriaxone was detected in isolates from either province, 2/26 (8%) isolates from Ontario and 13/28 (46%) isolates from Québec showed reduced susceptibility (intermediate category) to ceftriaxone. In addition to the 2/26 (8%) Ontario isolates and the 14/28 (50%) Québec isolates showing resistance to ceftiofur, 1/26 (4%) Ontario isolates also showed reduced susceptibility (intermediate category) to ceftiofur. There were significant differences in the prevalence of resistance between Ontario and Québec for ceftiofur, amoxicillin-clavulanic acid, ampicillin and cefoxitin.

AMR Patterns: There were four different resistance patterns observed among the five Ontario resistant isolates and four patterns among the 22 Québec resistant isolates. In Ontario, the resistance patterns observed were to AMP-CEP (1/26 isolates; 4%), AMC-AMP-TIO-CEP (1/26 isolates; 4%), AMP-CEP-GEN-STR-SMX (1/26 isolates; 4%), and A3C-AMP (2/26 isolates; 8%). In Québec, the resistance patterns were A3C-AMP (13/28 isolates; 46%), A3C-AMP-GEN-STR-TCY (1/28 isolates; 4%), STR-TCY (5/28 isolates; 18%), and AMP (3/28 isolates; 11%).

Serovars: Heidelberg was the most frequent serovar in both provinces. It was the only serovar in Ontario showing resistance to five or more antimicrobials (one isolate was PT 18, resistant to AMP-CEP-GEN-STR-SMX; two isolates were PT 29, resistant to A3C-AMP pattern). In Québec, the serovar showing resistance to five or more antimicrobials was predominantly serovar Heidelberg (PT 4 - three isolates; PT 29 – 7 isolates; PT 32 – two isolates; PT 53 – one isolate). All these showed resistance to the A3C-AMP pattern except one PT 32 isolate that was resistant to A3C-AMP-GEN-STR-TCY. *S.* Agona was also resistant to five or more antimicrobials (one isolate; pattern A3C-AMP).

For retail chicken *Salmonella* isolates, 5/26 (19%) isolates from Ontario and 22/28 (79%) isolates from Québec were resistant to one or more antimicrobials tested. For antimicrobials of Very High Importance to Human Health (Category I), ceftiofur resistance was detected in 3/26 (12%) Ontario isolates and 14/28 (50%) Québec isolates. Three (12%; all *S.* Heidelberg) Ontario isolates and 14 (50%; 13 isolates were *S.* Heidelberg) Québec isolates were resistant to five or more antimicrobials. There were some differences between the provinces in terms of prevalence of resistance to individual antimicrobial drugs, highlighting the need to conduct surveillance in multiple provinces.

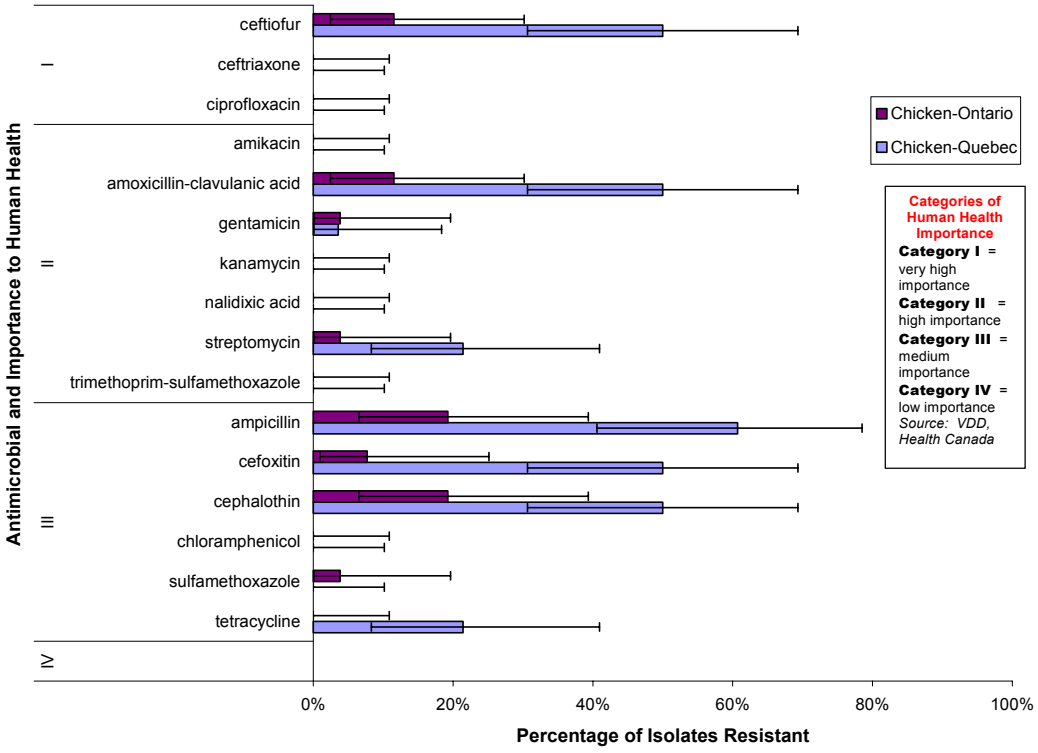

Figure 18. Individual antimicrobial drug resistance in *Salmonella* from *retail* chicken, including confidence intervals; Ontario (n=26), Québec (n=28).

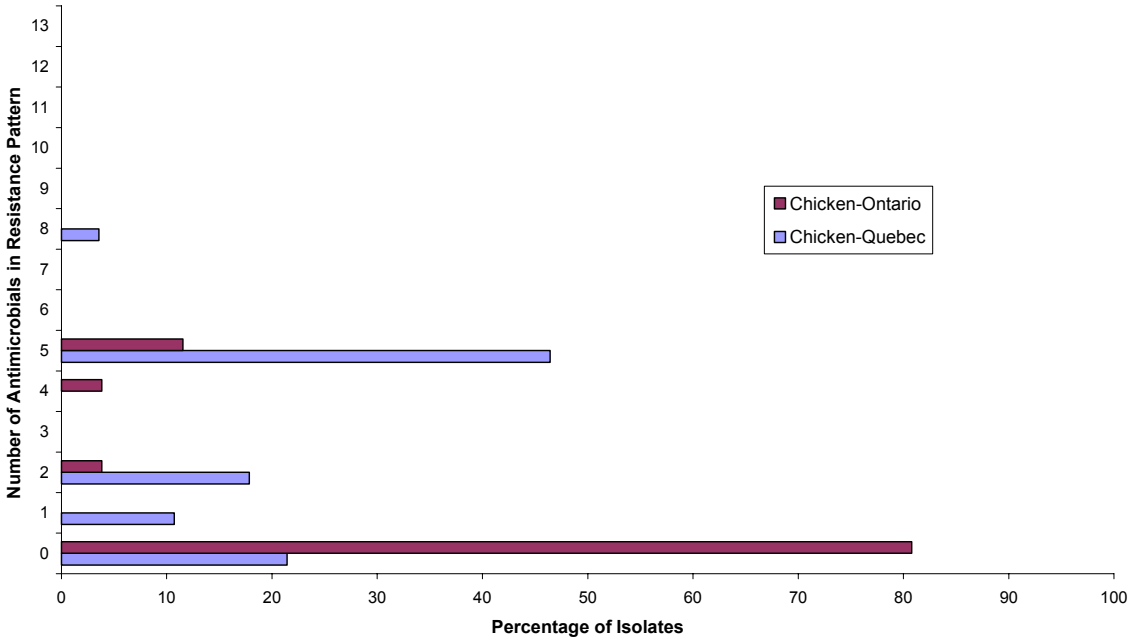

Figure 19. Multiple drug resistance in *Salmonella* from *retail* chicken; Ontario (n=26), Québec (n=28).

Table 13. *Salmonella* serovars from chicken; *Retail Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
Ontario (n=26)		Number of isolates			
Heidelberg	19 (73.1)	14	2	3	0
Kentucky	3 (11.5)	3	0	0	0
Agona	1 (3.8)	1	0	0	0
ssp. I:rough-O:r:1,2	1 (3.8)	1	0	0	0
Infantis	1 (3.8)	1	0	0	0
Thompson	1 (3.8)	1	0	0	0
Totals		**21**	**2**	**3**	**0**
Québec (n=28)					
Heidelberg	20 (71.4)	3	4	13	0
Hadar	2 (7.1)	0	2	0	0
Kentucky	2 (7.1)	1	1	0	0
Agona	1 (3.6)	0	0	1	0
ssp. I:6,8:z10:-	1 (3.6)	0	1	0	0
Schwarzengrund	1 (3.6)	1	0	0	0
Thompson	1 (3.6)	1	0	0	0
Totals		**6**	**8**	**14**	**0**

Campylobacter spp.

There was one *Campylobacter jejuni* isolate from ground beef and it was resistant to TCY. There were three *Campylobacter jejuni* isolates from pork, and two of these isolates were resistant to TCY only. Due to the low recovery rate, attempts to isolate *Campylobacter* spp. from ground beef and pork were discontinued.

Chicken – *Campylobacter* spp.

(Ontario n=78; Québec n=94)

Note: *Campylobacter spp. isolates were recovered from 47% and 55% of the chicken leg samples received from Ontario and Québec respectively.*

Antimicrobial Drug Resistance: See Figure 20, Figure 21, Table 14, and Table 36 (Appendix A.4). There were no significant differences between the prevalences of resistance to individual antimicrobials between Ontario and Québec isolates. Resistance to ciprofloxacin was detected in both provinces (3/78 Ontario isolates, 4%; 3/94 Québec isolates, 3%). Resistance to gentamicin was only detected in Québec (1/94 isolates; 1%), and resistance to chloramphenicol was only detected in Ontario (1/78 isolates; 1%).

AMR Patterns: There were 11 resistance patterns observed in the Ontario isolates and 9 patterns in the Québec isolates. The most frequent resistance pattern across all the isolates was TCY alone (40/78 Ontario isolates, 51%; 48/94 Québec isolates, 51%), followed by resistance to AZM-CLI-ERY (4/78 Ontario isolates, 5%; 6/94 Québec isolates; 6%).

For the six isolates showing ciprofloxacin resistance, all were *Campylobacter* spp (i.e. not identified as *C. jejuni* or *C. coli*). Two of these isolates showed resistance to the CIP-NAL pattern, three isolates showed resistance to CIP-NAL-TCY pattern, and one isolate from Québec was resistant AZM-CIP-CLI-ERY-GEN-NAL-TCY pattern (the isolate with the AMR pattern conferring resistance to the greatest number of antimicrobials).

For retail chicken *Campylobacter* spp. isolates, 56/78 (72%) isolates from Ontario and 74/94 (79%) isolates from Québec were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), 3/78 (4%) isolates from Ontario and 3/94 (3%) isolates from Québec were resistant to ciprofloxacin.

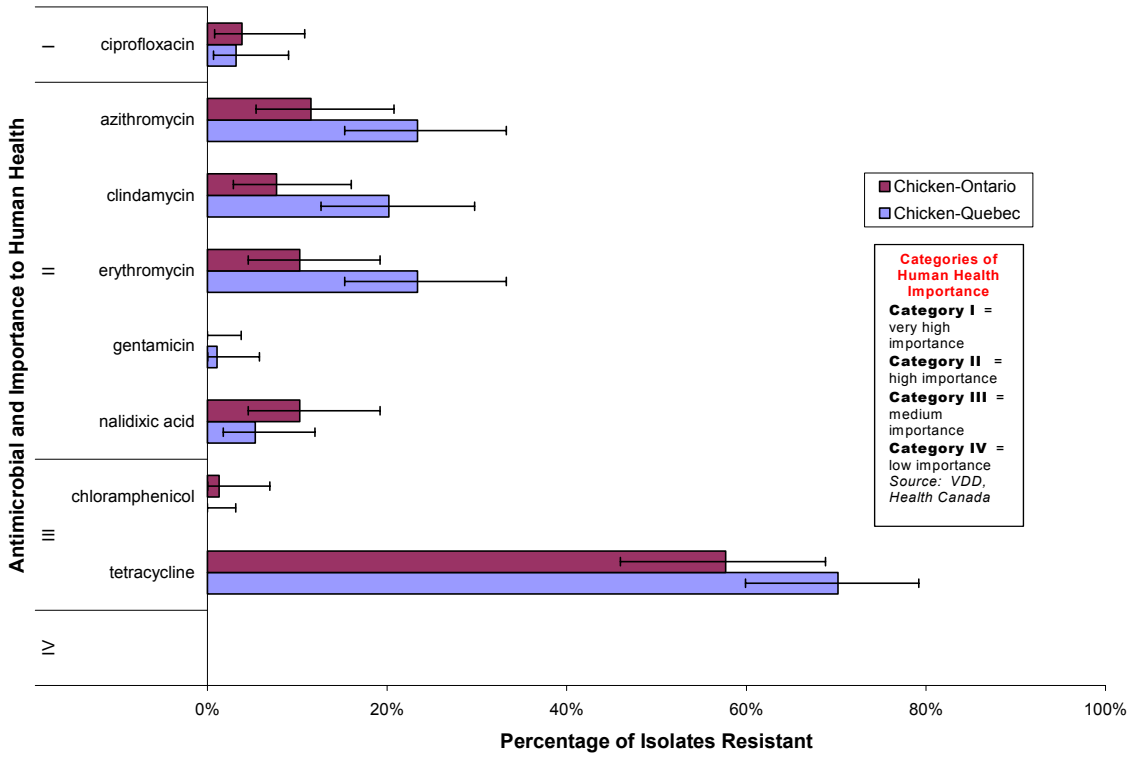

Figure 20. Individual antimicrobial drug resistance in *Campylobacter* spp. from *retail* chicken, including confidence intervals; Ontario (n=78), Québec (n=94).

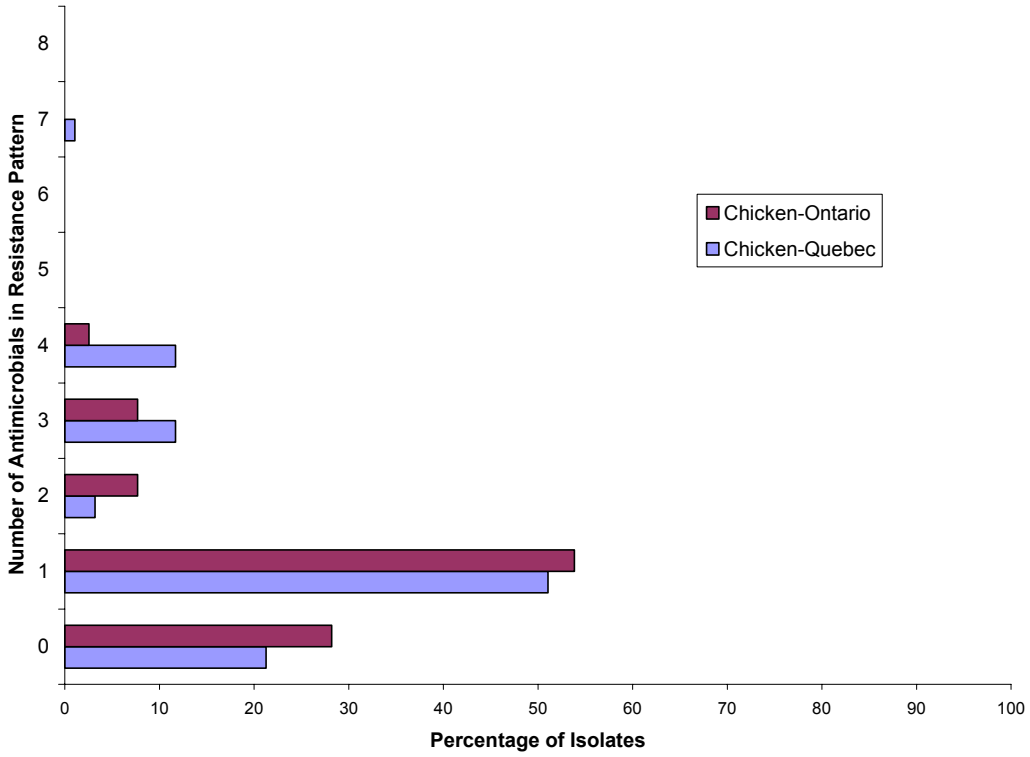

Figure 21. Multiple drug resistance in *Campylobacter* spp. from *retail* chicken; Ontario (n=78), Québec (n=94).

Table 14. *Campylobacter* spp. from chicken; *Retail Surveillance.*

Campylobacter species	n %(n)	No. of antimicrobials in resistance pattern			
		0	1-2	3-4	5-8
Ontario (n=78)		Number of isolates			
C. jejuni	65 (83.3)	21	39	5	0
Campylobacter spp.	7 (9.0)	1	4	2	0
C. coli	6 (7.7)	0	5	1	0
Totals		**22**	**48**	**8**	**0**
Québec (n=94)					
C. jejuni	75 (79.8)	19	40	16	0
C. coli	10 (10.6)	1	5	4	0
Campylobacter spp.	9 (9.6)	0	6	2	1
Totals		**20**	**51**	**22**	**1**

Part III – Diseased Animals
Passive Surveillance of Salmonella spp. from Clinical Isolates

Salmonella isolates from *Passive Surveillance* originated mainly from veterinary diagnostic submissions. Most samples were likely obtained from diseased animals that may or may not have received antimicrobials before sample collection. Sample submissions may have also followed therapeutic failure. These possibilities could give biased results. Furthermore, the reason for submission may have varied by region, animal species, or veterinarian/producer. Because of these external validity (representativeness) concerns, clinical isolates are not well suited for assessing the prevalence of AMR or the magnitude of the problem in healthy animals. They are, however, ideal for emerging AMR problems, detecting AMR to new compounds,

identifying new multiple drug resistance patterns and assessing the occurrence of AMR resulting from veterinary therapy.
The 2003 *Passive Surveillance* data were compared to the *Passive Surveillance* data presented in the 2002 CIPARS report (isolates collected from 1999 to 2002; referred to as 2002 isolates). These comparisons should be interpreted with caution for the reasons described above. Numbers of isolates by province (most isolates came from Ontario) and specimen source are presented in Table 37 (Appendix A.4).

Cattle - Clinical *Salmonella*

(*Passive Surveillance* n=234)

Note: *The proportions of cattle samples were as follows: Dairy n=139; Veal n=2; Beef n=12; unknown n=81 isolates.*

Note: *14 S. Newport isolates were collected from the same farm on the same date but from different animals, during the course of an outbreak investigation involving human cases. These isolates were included in the analysis.*

Antimicrobial Drug Resistance: See Table 15 and Table 38 (Appendix A.4). In 2002, no bovine isolates were resistant to ceftriaxone but resistance to ceftiofur was observed in 40/478 isolates (8%), whereas in 2003, 2/234 isolates (<1%) were resistant to ceftriaxone and 100/234 isolates (43%) to ceftiofur. Although ceftriaxone resistance was rare in 2003, 93/234 isolates (40%) showed a reduced susceptibility (intermediate category) to this antimicrobial. In 2003, 53/234 isolates (23%) were resistant to five to 8 antimicrobials and 97/234 isolates (41%) were resistant to 9 or more antimicrobials. In contrast, in 2002, 231/478 isolates (48%) were resistant to five to 8 antimicrobials and 36/478 isolates (8%) were resistant to 9 or more antimicrobials. This change is partly due to the numerous multidrug-resistant *S*. Newport isolates among 2003 isolates.

AMR Patterns: There were 20 different resistance patterns in the 2003 isolates. The most common resistance patterns were ACKSSuT-A3C (57/234 isolates; 24%), ACSSuT (32/234 isolates; 14%), and ACKSSuT-A3C-GEN-SXT (15/234 isolates; 6%). Ceftriaxone resistance was observed in 2/234 isolates (<1%; *S*. Typhimurium var. Copenhagen) with the following pattern: ACKSSuT-A3C-CRO, which was a pattern not seen in the 2002 isolates. All isolates showing reduced susceptibility (intermediate category) to ceftriaxone also showed resistance to the A3C pattern and one of the following patterns: ACKSSuT (55 *S*. Newport and two *S*. Typhimurium var Copenhagen isolates), ACKSSuT-GEN-SXT (14 S. Typhimurium var Copenhagen isolates), ACKSSuT-SXT (8 *S*. Typhimurium var Copenhagen isolates), ACSSuT (six *S*. Newport isolates), ACSSuT-SXT (five *S*. Newport and one *S*. Kentucky isolates), or AKSSuT (one *S*. Newport isolate and one *S*. Typhimurium isolate). Relative to 2002, there were 6 new AMR patterns observed in 2003 but the only one of these involving antimicrobials of highest health importance (Category I) was the pattern AKSSuT-A3C (2/234 isolates; <1%).

Serovars: The most frequent serovar was *S*. Newport (27% of isolates; 63 isolates; 14 isolates from the same herd on the same date). followed by *S*. Typhimurium var. Copenhagen (26% of isolates; 60 isolates). All but one of the *S*. Newport isolates showed resistance to one of the following patterns ACKSSuT-A3C, AKSSuT-A3C, or ACSSuT-A3C. These were of PT 14a (90%; 56 isolates) and 17 (10%; 6 isolates). Fifty-three of the *S*. Typhimurium var. Copenhagen isolates (88%) were resistant to five or more antimicrobials. In comparison, in 2002, the most common serovars were *S*. Typhimurium and *S*. Typhimurium var. Copenhagen. There were 12 serovars identified in 2003 that were not seen in 2002.

For 2003, results from *Passive Surveillance* showed that 160/234 (68%) bovine clinical *Salmonella* isolates were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 100/234 isolates (43%) and ceftriaxone was detected in 2/234 isolates (<1%). Ninety-three isolates (40%) showed reduced susceptibility (intermediate category) to ceftriaxone. One hundred and fifty isolates (64%) were resistant to five or more antimicrobials. *S*. Newport and *S*. Typhimurium var Copenhagen were the most common serovars (several isolates including 14 *S*. Newport isolates were collected from the same farm during an outbreak investigation), with multidrug-resistant *S*. Newport being an emerging cause for public health concern.

Table 15. ***Salmonella*** **serovars from cattle;** ***Passive Surveillance.***

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	**1-4**	**5-8**	**9-13**
Passive Surveillance **(n=234)**		**Number of isolates**			
Newport	63 (26.9)	1	0	0	62 [b]
Typhimurium var. Copenhagen	60 (25.6)	3	4	25	28
Typhimurium	34 (14.5)	2	1	25	6
Kentucky	28 (12.0)	23	3	1	1
ssp. I:18:-:-	10 (4.3)	10	0	0	0
Muenster	7 (3.0)	7	0	0	0
Thompson	6 (2.6)	6	0	0	0
"Less Common Serovars"	26 (11.1)	22	2	2	0
Totals		**74**	**10**	**53**	**97**

Note: [a]*Serovars with greater than 2% prevalence within a province are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars";*
[b]*Several isolates including 14 S. Newport isolates were collected from the same farm during an outbreak investigation*

Multidrug-resistant Strains of Salmonella Newport in Cattle
Public Health Concerns

Multidrug-resistant (MDR) strains of *Salmonella* Newport were reported in cattle from Canada during the year of 2003. The MDR-strains of S. Newport were resistant to 9 or 10 of the 16 antimicrobials tested, showing the ACSSuT, ACKSSuT or AKSSuT resistance patterns as well as resistance to amoxicillin-clavulanic acid, cephalothin, cefoxitin, and ceftiofur and reduced susceptibility to ceftriaxone (MIC equal to 16 or 32 μg/ml). The predominant MDR Newport phagetype in cattle was PT 14a (56 of 62 isolates), which was cultured from Ontario animals between February and December 2003 (note: in 2003, *CIPARS Passive Surveillance data* were mainly from Ontario submissions). Human cases of MDR Newport PT 14a were mainly observed in Ontario (6 cases), a few cases being also identified in other provinces (Alberta three cases; Manitoba, Prince Edward Island, and New Brunswick: one case each). Some of the Ontario human cases were epidemiologically linked to two dairy farms involved in a dairy cattle outbreak. Another frequent phagetype observed among cattle MDR Newport isolates was PT 17 (6 isolates). Two human cases involving the same AMR pattern (ACSSuT+A3C) but PT 17b were also identified in Ontario among *Human CIPARS Passive Surveillance* isolates.

Since 1998, strains of *Salmonella* Newport with an MDR-AmpC PGFE patterns have emerged in the United States despite an overall decrease in *Salmonella* incidence during the same period. These strains were isolated from humans, cattle and ground beef and were resistant to at least 9 antimicrobials, showing either decreased susceptibility or resistance to ceftriaxone and being in some cases also resistant to trimethoprim-sulfamethoxazole.

Cattle appear to be an important reservoir of MDR *S.* Newport. In addition to the 62 cattle isolates received at the *Salmonella* Typing Laboratory (Guelph, Ontario) in 2003, only one environmental isolate (building sample, ACSSuT-A3C pattern), one equine isolate (ACSSuT-A3C pattern), and one water isolate (ACKSSuT-A3C pattern) were identified. Because of the possibility of transmission from cattle to humans and the clinical importance of MDR *S*. Newport strains, veterinarians must remain vigilant when investigating episodes of diarrhea in cattle and provide adequate information to all persons in direct contact with those animals. Not all cattle will develop clinical signs and some can remain healthy carriers of the strain. Indirect transmission through meat or raw milk is also a possibility. Although not all cases of human salmonellosis require treatment with antimicrobials, some studies have demonstrated that resistant *Salmonella* infections are associated with an increased burden of illness.

Resistance to ceftriaxone is a concern in itself since it is a drug of choice for the treatment of invasive *Salmonella* disease in children where fluoroquinolones are not approved. Ceftriaxone is a third generation cephalosporin used exclusively in human medicine. Ceftiofur, a drug exclusively used in veterinary medicine, is also a third generation cephalosporin. In-vitro susceptibility testing performed by CIPARS on *Salmonella* strains in 2003 showed similar MIC levels for ceftiofur and ceftriaxone.

Sources:

CIPARS 2003 data

Archambault A, Godkin A. (2003) Outbreak of clinical salmonellosis in tow Ontario daiyr herds caused by a multidrug-resistant (MDR) *Salmonella* Newport isolate. AHL Newsletter 7(3):29-30.

Innes P. Veterinary Scientist, Epidemiology/ Ontario Ministry of Agriculture and Food, (http://www.gov.on.ca/OMAFRA/english/livestock/vet/facts/ahsn5.htm#11).

Gupta A, Fontana J, Crowe C, Bolstorff B, Stout A, Van Duyne S, Hoekstra M, Whichard J, Barrett T, and F Angulo. (2003). Emergence of multidrug-resistant *Salmonella* enterica serotype Newport infections resistant to expanded-spectrum cephalosporins in the United States. The National Antimicrobial Resistance Monitoring System PulseNet Working Group. J Infect Dis. 1;188(11):1707-16. Epub 2003 Nov 18.

Martin L, Fyfe M, Doré K, Buxton J, Pollari F, Henry B, Middleton D, Ahmed R, Jamieson F, Ciebin B, McEwen S, and J Wilson. (2004). Increased burden of illness associated with antimicrobial-resistant *Salmonella* enterica serotype typhimurium infections. Multi-Provincial *Salmonella* Typhimurium Case-Control Study Steering Committee. J Infect Dis. 1;189(3):377-84. Epub 2004 Jan 20.

Swine - Clinical *Salmonella*

(*Passive Surveillance* n=107)

Antimicrobial Drug Resistance: See Table 16 and Table 39 (Appendix A.4). In 2002, 9/309 (3%) porcine clinical isolates were resistant to ceftiofur, in comparison to 2/107 isolates (2%) in 2003. No resistance to ceftriaxone was detected but reduced susceptibility (intermediate category) to ceftiofur was observed in 1/107 isolates (<1%) in 2003. In 2002, 207/309 isolates (67%) were resistant to one or more antimicrobials tested in comparison to 78/107 isolates (73%) in 2003.

AMR Patterns: There were 24 different resistance patterns observed in the 2003 porcine clinical isolates. The most common resistance patterns observed were ACSSuT alone (32/107 isolates; 30%), STR-SMX-TCY (8/107 isolates; 7%), and ACKSSuT alone (7/107 isolates; 7%). Alone and in combination with other antimicrobials, the ACSSuT pattern was present in 33/107 isolates (31%), the ACKSSuT pattern was present in 9/107 isolates (8%), the AKSSuT pattern was present in 3/107 isolates (3%), and the A3C pattern was present in 2/107 isolates (2%). The serovars that most frequently showed the patterns ACSSuT, AKSSuT, and ACKSSuT were *S*. Typhimurium and *S*. Typhimurium var. Copenhagen. One *S*. Ohio isolate showed the ACSSuT pattern, one *S*. Johannesberg isolate the ACSSuT-A3C pattern (also expressed reduced susceptibility to ceftriaxone), and one *S*. ssp. I:6,8:-:enx the ACKSSuT-A3C-SXT pattern (the AMR pattern with the greatest number of antimicrobials - a pattern not seen in 2002). In comparison to 2002, 9 new AMR patterns were identified in 2003; of note, AKSSuT-GEN was present in 1/107 isolates (<1%).

Serovars: The most frequent serovars in 2003 were *S*. Typhimurium var. Copenhagen (53/107 isolates; 50%) followed by *S*. Typhimurium (23/107 isolates; 21%). Thirty-two of the 53 *S*. Typhimurium var. Copenhagen isolates (60%) were resistant to five or more antimicrobials and 11/23 of the *S*. Typhimurium isolates (48%) were resistant to five or more antimicrobials. Similarly, the most frequent serovars in 2002 were *S*. Typhimurium and *S*. Typhimurium var. Copenhagen. There were five additional serovars identified in 2003 in comparison to 2002.

For 2003, results from *Passive Surveillance* showed that 78/107 (73%) porcine clinical *Salmonella* isolates were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 2/107 isolates (2%), along with a reduced susceptibility to ceftriaxone (1/107 isolates; <1%). Forty-eight isolates (45%) were resistant to five or more antimicrobials. *S*. Typhimurium var. Copenhagen and *S*. Typhimurium were the most common serovars isolated and the ACSSuT pattern was a common phenotype.

Table 16. *Salmonella* serovars from swine; *Passive Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
Passive Surveillance (n=107)		Number of isolates			
Typhimurium var. Copenhagen	53 (49.5)	10	11	32	0
Typhimurium	23 (21.5)	6	6	11	0
Derby	9 (8.4)	1	8	0	0
Brandenburg	7 (6.5)	3	4	0	0
Infantis	3 (2.8)	2	1	0	0
London	3 (2.8)	3	0	0	0
"Less Common Serovars"	9 (8.4)	4	0	3	2
Totals		**29**	**30**	**46**	**2**

Note: [a]Serovars with greater than 2% prevalence are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars".

Chickens - Clinical *Salmonella*

(*Passive Surveillance* n=32)

Antimicrobial Drug Resistance: See Table 17 and Table 40 (Appendix A.4). In 2002, 4/146 chicken clinical isolates (3%) were resistant to ceftiofur, in comparison to 3/32 isolates (9%) in 2003. No resistance to ceftriaxone was detected but reduced susceptibility (intermediate category) to this antimicrobial drug was observed in 1/32 isolates (3%) in 2003. In 2002, 63/146 isolates (43%) were resistant to one or more antimicrobials tested, whereas in 2003, 13/32 isolates (41%) were resistant to one or more antimicrobials tested.

AMR Patterns: There were 10 different resistance patterns observed in the 2003 chicken clinical isolates. The most common resistance patterns observed were A3C-AMP (3/32 isolates; 9%) and AMP alone (2/32 isolates; 6%). The A3C-AMP pattern was observed in *S*. Heidelberg (two isolates) and *S*. ssp. I:4,5,12:r:- (one isolate with reduced susceptibility to ceftriaxone). The ACSSuT pattern (the AMR pattern with the greatest number of antimicrobials) was observed in one *S*. Typhimurium isolate. In comparison to 2002, five new AMR patterns were identified in 2003; the most noteworthy being A3C-AMP.

Serovars: The most frequent serovars were *S*. Heidelberg (19/32 isolates; 59%), *S*. Hadar (3/32 isolates; 9%), and *S*. Kentucky (3/32 isolates; 9%). The most frequent serovars in 2002 were *S*. Heidelberg and *S*. Typhimurium. There were five additional serovars identified in 2003 in comparison to 2002.

For 2003, results from *Passive Surveillance* showed that 13/32 (41%) chicken clinical *Salmonella* isolates were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 3/32 isolates (9%), as well as reduced susceptibility for ceftriaxone (1/32 isolates; 3%). Five isolates (16%) were resistant to five or more antimicrobials. *S*. Heidelberg, *S*. Hadar and *S*. Kentucky were the most common serovars isolated.

Table 17. *Salmonella* serovars from chickens; *Passive Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
***Passive Surveillance* (n=32)**		Number of isolates			
Heidelberg	19 (59.4)	13	4	2	0
Hadar	3 (9.4)	0	2	1	0
Kentucky	3 (9.4)	2	1	0	0
Typhimurium	2 (6.3)	1	0	1	0
ssp. I:4,5,12:i:-	1 (3.1)	1	0	0	0
ssp. I:4,5,12:r:-	1 (3.1)	0	0	1	0
Mbandaka	1 (3.1)	1	0	0	0
Orion var. 15+34+	1 (3.1)	1	0	0	0
Senftenberg	1 (3.1)	0	1	0	0
Totals		**19**	**8**	**5**	**0**

Turkeys - Clinical *Salmonella*

(*Passive Surveillance* n=36)

Antimicrobial Drug Resistance: See Figure 22, Figure 23, Table 18, and Table 41 (Appendix A.4). In 2002, 5/87 turkey clinical isolates (6%) were resistant to ceftiofur, compared to 6/36 isolates (17%) in 2003. In 2002, 1/87 isolates (1%) were resistant to ceftriaxone, but no isolates were resistant to ceftriaxone in 2003. However, 6/36 isolates (17%) showed reduced susceptibility (intermediate category) to ceftriaxone in 2003, as compared to 4/87 isolates (5%) in 2002. In 2002, 55/87 isolates (63%) were resistant to one or more

antimicrobials tested, compared to 31/36 isolates (86%) isolates in 2003.

AMR Patterns: There were 19 different resistance patterns observed in the 2003 turkey clinical isolates. The most common resistance patterns observed were GEN alone (4/36 isolates; 11%) and TCY alone (4/36 isolates; 11%). The AKSSuT pattern in combination with A3C-GEN, the resistance pattern with the greatest number of antimicrobials - was observed in 3/36 isolates (8%; all *S*. Bredeney and also showing reduced susceptibility to ceftriaxone). The A3C pattern was observed in combination with other antimicrobials in an additional 3/36 isolates (8%; *S*. Agona, *S*. Litchfield, and *S*. Heidelberg). These isolates also showed reduced susceptibility (intermediate category) to ceftriaxone. In comparison to 2002, there were 11 new AMR patterns identified in 2003; of note A3C-AMP was identified in 2/36 isolates (6%) and A3C-AMP-TCY was identified in 1/36 isolates (3%).

Serovars: In 2003, the most frequently observed serovars were *S*. Senftenberg (13/36 isolates; 36%) and *S*. Heidelberg (7/36 isolates; 19%). In 2003, three additional serovars were identified compared to 2002.

For 2003, results from *Passive Surveillance* showed that 31/36 (86%) turkey clinical *Salmonella* isolates were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health importance (Category I), ceftiofur resistance was detected in 6/36 isolates (17%) and 6/36 isolates (17%) showed reduced susceptibility to ceftriaxone. Thirteen isolates (36%) were resistant to five or more antimicrobials. *S*. Senftenberg and *S*. Heidelberg were the most common serovars isolated.

Table 18. *Salmonella* serovars from turkeys; *Passive Surveillance.*

Serovar	n (%n)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-13
***Passive Surveillance* (n=36)**		Number of isolates			
Senftenberg	13 (36.1)	1	10	2	0
Heidelberg	7 (19.4)	2	4	1	0
Bredeney	4 (11.1)	0	1	0	3
Montevideo	4 (11.1)	0	0	4	0
Saintpaul	2 (5.6)	1	0	1	0
Agona	1 (2.8)	0	0	1	0
Hadar	1 (2.8)	0	1	0	0
ssp. I:4,12:-:-	1 (2.8)	0	1	0	0
Johannesburg	1 (2.8)	0	1	0	0
Litchfield	1 (2.8)	0	0	1	0
Newport	1 (2.8)	1	0	0	0
Totals		**5**	**18**	**10**	**3**

Discussion of Human and Agri-Food Antimicrobial Resistance Results

Differences of Antimicrobial Resistance Between Animal Species

Results from the 2003 *Abattoir Surveillance* component were used to examine individual antimicrobial resistance across commodities. These data were considered to be the most nationally representative for 2003 because the abattoirs were selected randomly across the country, sampling was proportional to slaughter volume, and sampling occurred throughout the year. Furthermore, the sampling protocol ensured that the abattoir data were representative of each commodity since only beef cattle, broiler chickens and finished pigs were selected. Any other animal types for these commodities were excluded at the sampling point.

The 2003 *Abattoir Surveillance* data showed that there was no resistance to ciprofloxacin or amikacin detected in *Salmonella* or *E. coli* isolated from any commodity. However, at least one isolate was resistant to one or more of each of the other 14 antimicrobials. The highest prevalences of resistance were to tetracycline, sulfamethoxazole, streptomycin and ampicillin except among chicken *Salmonella* isolates (Figures 22 and 23). For all *E. coli* isolates and for swine *Salmonella* isolates, antimicrobials ordered by decreasing prevalence of resistance were tetracycline, streptomycin or sulfamethoxazole, and then ampicillin. However, for chicken *Salmonella* isolates, resistance to ampicillin was most frequent, followed by resistance to streptomycin, tetracycline, and cephalothin.

Differences in prevalence of individual antimicrobial resistances between commodities were noted for several antimicrobials for both *E. coli* and *Salmonella* isolates (Figures 22 and 23). Confidence intervals have been provided in most figures to reflect the precision of the prevalence estimates generated from the random sampling strategies. In general, among 2003 abattoir isolates, resistance appeared more frequently among isolates recovered from broiler chicken and swine than from beef cattle. Chicken and swine *E. coli* isolates were resistant to a greater number of antimicrobials among the 16 antimicrobials tested. Resistance results also showed higher prevalence levels to certain antimicrobials. Chicken *E. coli* and *Salmonella* tended to show resistance to several cephalosporins (including one case of ceftriaxone resistance in *Salmonella)* and to amoxicillin-clavulanic acid more frequently than beef or swine isolates.

It is well recognized that resistance among *Salmonella* isolates is often linked to specific serovars or even phagetypes. These serovars/phagetypes are, in turn, often associated with a specific animal species (Hilton and Braoudaki, 2004). The same is also true for *E. coli* isolates (Larkin *et al*., 2004), although CIPARS *E. coli* isolates were not serotyped in 2003. These animal species/bacterial species/ serovars/antimicrobial resistance relationships may explain some of the differences in prevalence of AMR observed between commodities. The spread of a particular serovar/clone in a given commodity could potentially modify the resistance pattern for this commodity. In the future, CIPARS intends to perform molecular studies on these isolates to ascertain the degree of genetic relationship among the strains or their resistance genes.

The impact of antimicrobial use in each commodity on AMR results cannot be ascertained due to the absence of representative antimicrobial use data in food-producing animals in Canada. CIPARS is actively pursuing methods to acquire antimicrobial use information (see Animal Antimicrobial Use Section). Other potential risk factors for AMR such as the length of the production cycle, the time elapsed between antimicrobial administration and slaughter, and husbandry techniques may also play a role in the level of resistance observed in each commodity. The identification of links between antimicrobial use and other risk factors and AMR will require surveillance at the farm level and good quality data. Collection of such information is a current goal of CIPARS on-farm surveillance activities and affiliated research projects incorporating on-farm antimicrobial use and resistance data.

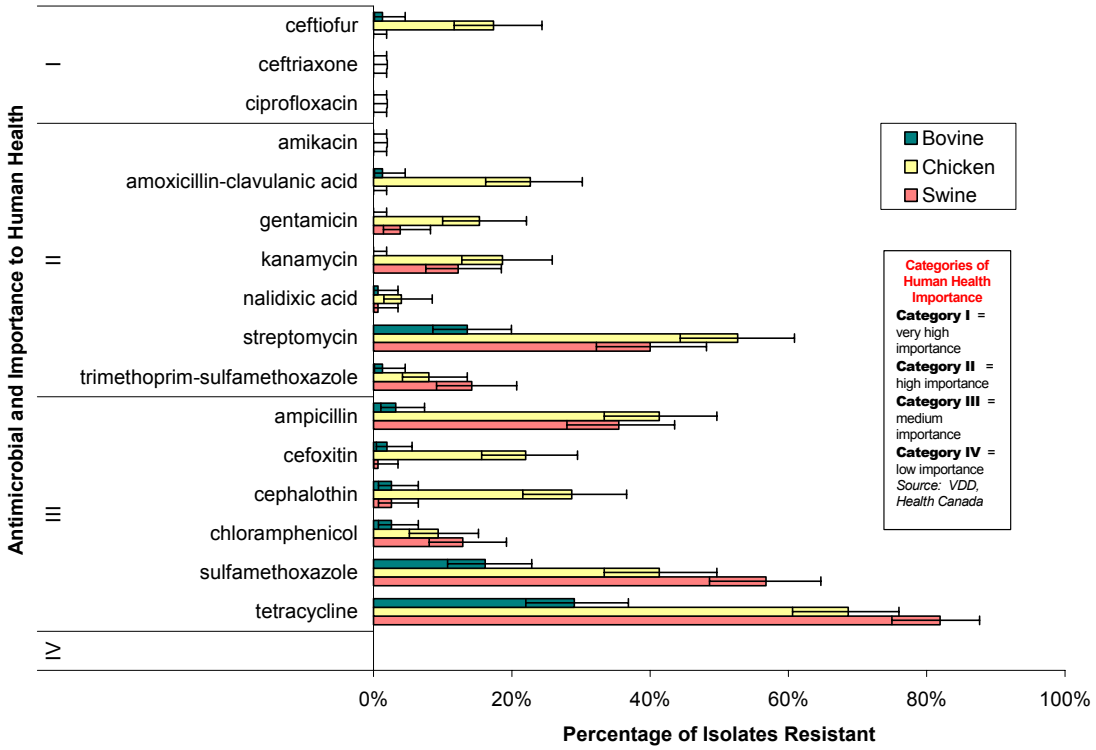

Figure 22. Individual antimicrobial drug resistance in *E. coli* from beef cattle (n=155), chicken (n=150), and swine (n=155) *abattoir* isolates, including confidence intervals.

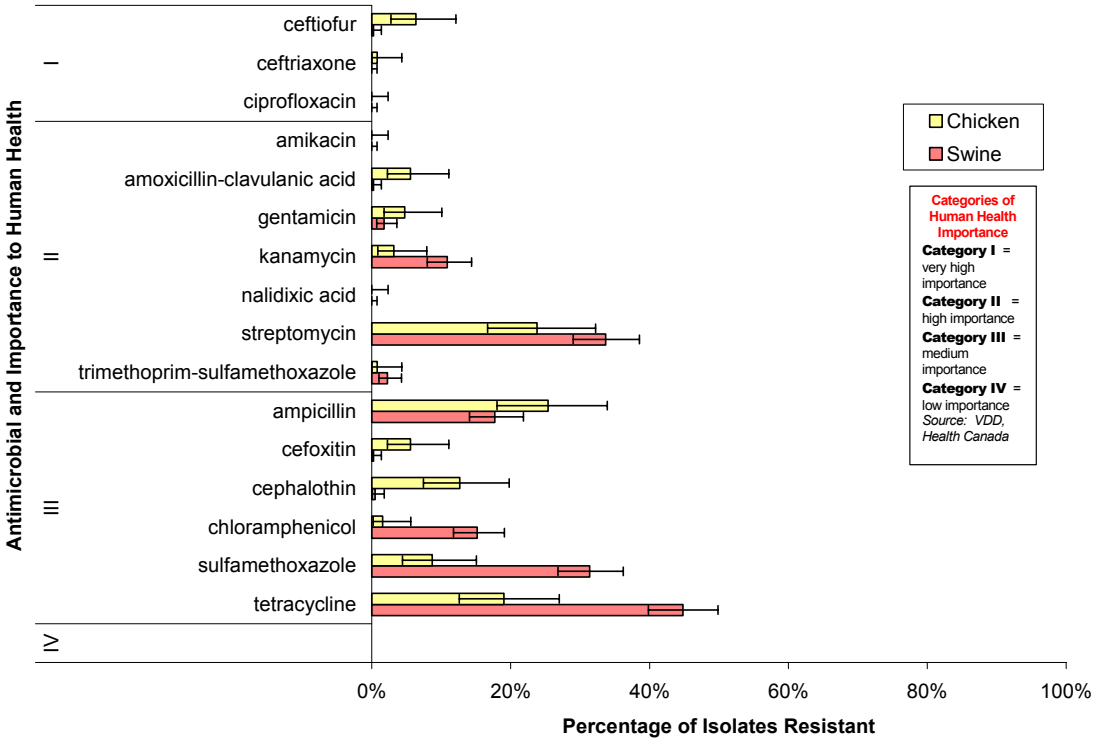

Figure 23. Individual antimicrobial drug resistance in *Salmonella* from chicken (n=126) and swine (n=395) *abattoir* isolates, including confidence intervals.

Resistance in Commensal and Pathogenic Bacteria

Antimicrobial resistance is a public health problem because of the risk of therapy failure when treating bacterial infections in humans. This problem is especially important if the resistant microorganism involved is highly pathogenic. Resistance among commensal enteric bacteria, such as *E. coli* or *Enteroccoccus* spp., also represents a public health problem because of the capacity of certain bacteria to exchange mobile genetic resistance elements. Hence, commensal bacteria can represent a potential reservoir of resistance for pathogenic enteric bacteria such as *Salmonella* or *Campylobacter* spp. In addition, some commensal bacteria can, in some situations, act themselves as opportunistic pathogens. Finally, the occurrence of antimicrobial resistance in common commensal bacteria can be used as an indication of the selection pressure on rarer or hard to recover bacteria including pathogens. Therefore, many antimicrobial resistance surveillance programs monitor resistance in commensal bacteria.

The *Retail Surveillance* component of CIPARS commenced in spring 2003. Since humans can be infected or colonized with enteric bacteria through consumption of contaminated animal-products, a comparison of the frequency of contamination of retail meat samples with resistant microorganisms was undertaken. Figure 24 compares the resistance level of generic *E. coli* isolates and *Salmonella*, and the prevalence of chicken samples contaminated with resistant bacteria (taking into account recovery rates among chicken samples of 97% for *E. coli* and 16% for *Salmonella*). This figure shows that the prevalence of resistance was either equivalent or higher for *E. coli* retail chicken isolates than for *Salmonella* isolates. When the prevalence of chicken samples contaminated with resistant *Salmonella* was compared to the prevalence of chicken samples contaminated with resistant *E. coli*, differences between these two microorganisms were even larger. Assuming that the sensitivity of laboratory recovery methods was similar between *Salmonella* and *E. coli*, the proportion of retail chicken samples contaminated with a resistant *E. coli* isolate was much higher than the proportion of retail chicken samples contaminated with a resistant isolate of *Salmonella*. This emphasizes the potential contribution of commensal bacteria to the spread of genetic elements from the bacteria of animals to the bacteria of humans. Therefore, although pathogen reduction programs can reduce considerably or even eliminate the risk of contamination with certain pathogenic bacteria, such programs may not address all aspects of antimicrobial resistance dissemination.

It is also interesting to note the differences between abattoir and retail recovery rates for both *E. coli* and *Salmonella* within each commodity (Table 19). These results highlight the impact of processing on the presence of microorganisms on retail meat. Although the *Salmonella* recovery rate from swine caecal samples was nearly 30%, the recovery rate from pork chops was below one percent. On the other hand, *Salmonella* recovery rates were similar between abattoir and retail samples for chicken. The recovery rates of *E. coli* from retail beef and pork samples were also lower than the rate obtained from chicken samples. These results may be partially the result of the sampling different cuts of meat. Chicken legs with skin on were used in order to obtain the highest recovery rates possible while reflecting normal consumption. The recovery rate from chicken breast or other type of cuts (without skin) would likely be lower. However, while the choice of cuts impacts recovery rates, it should not have a substantial impact on the AMR results. Another interesting observation is that *E. coli* recovery rates were $\geq$ 50% for all of the meat cuts surveyed, independent of processing type (ground beef) vs. portion skin-on (chicken) vs. portion skinless (pork). These observations reinforce the potential role that commensal bacteria may have in the spread of antimicrobial resistance and that such information needs to be taken into account when developing AMR control measures.

Note: *Salmonella recovery rates in beef and swine were $\leq$ 1%; resistance in Salmonella cultured from retail meat was not studied by CIPARS in 2003 for these two commodities and thus no comparisons between E. coli and Salmonella are presented.*

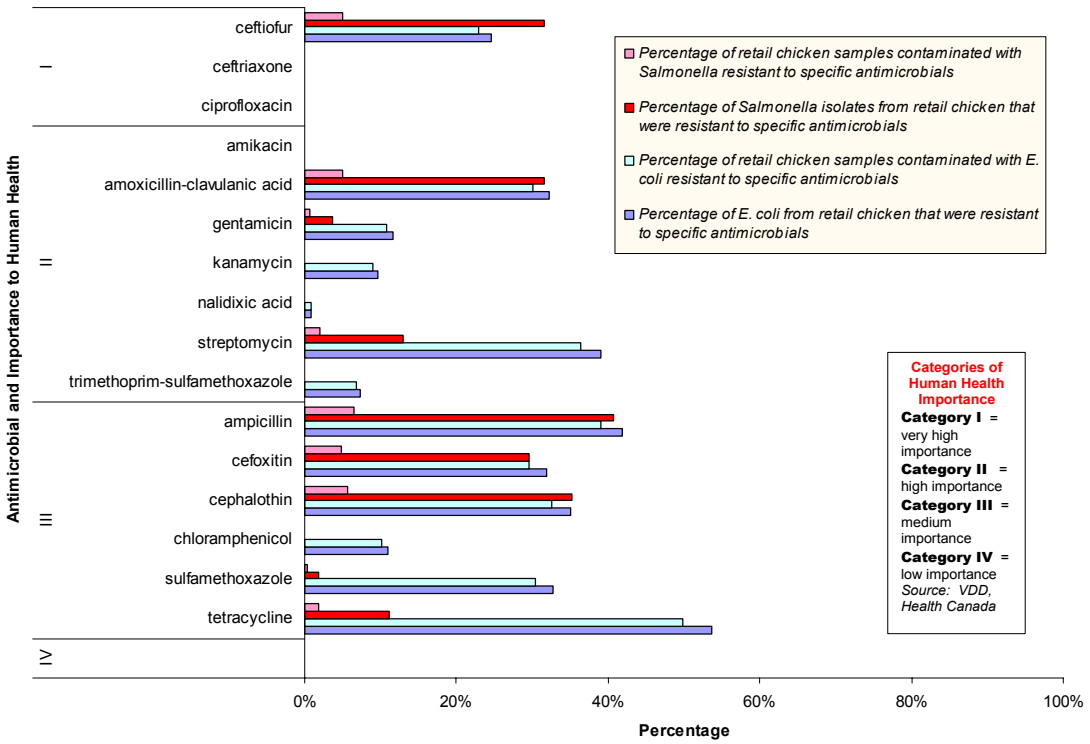

Figure 24. Individual antimicrobial drug resistance in *Salmonella* (n=54) and generic *E. coli* (n=248) from *retail* chicken isolates expressed as percentage of resistant isolates, and prevalence of *retail* chicken samples carrying a resistant isolate of *Salmonella* (n= 337) or *E. coli* (n= 270).

Table 19. Recovery rates and number of isolates from *Abattoir* and *Retail Surveillance.*

CIPARS Surveillance Component	*E. coli*		*Salmonella*		Campylobacter *spp.*	
	Recovery rate	n[1]	Recovery rate	n[1]	Recovery rate	n[1]
Abattoir Surveillance						
Beef Cattle	97%	155	<1%	0		
Chicken	97%	150	16%	126		
Swine	98%	155	28%	395		
***Retail Surveillance* (ON + QC)**						
Beef	63%	184	1%	0	1.7%	0
Chicken	93%	248	16%	54	51%	172
Pork	50%	152	<1%	0	2.6%	0

***Note**: 1= final number of isolates submitted for AMR testing. Shaded areas represent microorganisms and commodities where no AMR results were presented in 2003 for the Abattoir and Retail surveillance components.*

Comparisons of Resistance in Québec and in Ontario for *Salmonella* Heidelberg

As mentioned previously, the purpose of the *Retail Surveillance* component is to generate valid and representative estimates of the resistance observed in raw meat available for purchase by consumers in each sampled province. The intent is to compare results from *Retail Surveillance* to provincial estimates of resistance in humans. For 2003, the only bacterial species for which AMR results were available from humans was *Salmonella*. In addition, only two provinces, Ontario and Québec, were sampled through *Retail Surveillance*, and *Salmonella* results were only available for chicken. Since AMR patterns are generally linked to specific serovars, one

serovar frequently observed in both chicken and humans, *Salmonella* Heidelberg, was chosen to highlight differences and similarities of AMR results between isolates from raw chicken and isolates from human cases.

Salmonella Typhimurium were also frequently isolated from human cases in 2003. However, in animals, this serovar is more frequently cultured from bovine or swine samples, which are two commodities not investigated in *Retail Surveillance* for *Salmonella* in 2003. Since no provincial data from *Retail Surveillance* were available, comparisons of *S.* Typhimurium AMR results were made between national estimates obtained from *Abattoir Surveillance* in swine during the last four months of 2002 and all of 2003, and national results from *Enhanced Passive Surveillance* in humans. It was assumed that *S.* Typhimurium cultured from swine caecal samples could subsequently contaminate, albeit rarely, the meat product and that this process is random.

Note: *The AMR results from humans at the national scale were corrected for unequal submission schemes between provinces (Appendix B.2) and results for S. Typhimurium var Copenhagen were combined with results for S. Typhimurium.*

Resistance in *Salmonella* Heidelberg isolates: As highlighted in Figure 25, resistance levels for most cephalosporins and amoxicillin-clavulanic acid were overall higher in Québec compared to Ontario for isolates from both humans and chicken meat. In general, resistance to most cephalosporins and amoxicillin-clavulanic acid appeared higher in Québec chicken meat isolates than among human isolates, whereas in Ontario, results from chicken meat and from humans were very similar. In general, the prevalence of resistance to individual antimicrobial drugs tended to follow the same trend (antimicrobials showing high or low resistance level tended to be the same in both sources).

When AMR pattern and phagetype were compared, some similarities and some differences were noted between chicken meat and human isolates in Ontario and Québec. In Ontario, five different phagetype–resistance pattern combinations were detected in both chicken meat and humans. These phagetype–resistance pattern combinations represented 12/19 chicken Heidelberg isolates (63%) and 54/172 human *S*. Heidelberg isolates (31%). In Québec, there were 6 different phagetype–resistance pattern combinations common to both chicken meat and humans. These phagetype-resistance pattern combinations represented 15/20 chicken *S*. Heidelberg isolates (75%) and 45/167 human *S*. Heidelberg isolates (27%). In Ontario, the most common phagetype-resistance pattern combination in humans (42/172 isolates, 24%) and in chicken (4/19 isolates, 21%) was PT 19 with no resistance. This phagetype-resistance combination was not observed among the 20 chicken *S*. Heidelberg isolates from Québec. The most common phagetype-resistance pattern observed in Québec chicken (7/20 isolates, 35%), PT 29–pattern A3C-AMP, was the most common in human isolates in that province (26/167 isolates, 16%). Phagetype 29–pattern A3C-AMP was also observed in Ontario. It was the third most common in both human isolates (10/172 isolates, 6%) and chicken isolates (2/19 isolates, 11%). Phagetype 18–pattern AMP and PT 4–pattern A3C-AMP were both the second most common in chicken *S*. Heidelberg isolates from Québec. Phagetype 18-pattern AMP was not observed in human isolates in Québec, and PT 4-A3C-AMP was the fifth most common in human isolates in Québec (12/167 isolates, 7%).

It should be noted that only those human *S*. Heidelberg isolates cultured during the first half of each month were submitted to the NML while chicken retail sampling was year-round. Some phagetype-AMR pattern combinations could, therefore, be missing.

Resistance in *Salmonella* Typhimurium isolates: Figure 26 shows that resistance levels tended to be higher among swine isolates from *Abattoir Surveillance* than among human isolates from *Enhanced Passive Surveillance*. In general, resistance levels tended to follow the same trend in both animal and human sources.

There were 24 different phagetype–resistance pattern combinations common to both human (224/610 isolates, 37%) and swine (90/141 isolates, 64%) *S*. Typhimurium isolates. The most frequent was PT 104–ACSSuT pattern in both humans (101/610 isolates, 16%) and swine (20/141 isolates, 14%). The second most common combination in humans (PT 170–no resistance, 26/610 isolates, 4%) was only observed in four swine isolates (3%). The second most common combination in swine was PT 208–TCY (13/141 isolates, 9%). This pattern

was observed among 8 human isolates (1%). The PT 170–no resistance was the third most common combination for both human (26/610 isolates, 4%) and swine (12/141 isolates, 9%).

Limitations

The sampling plans of the *Abattoir* and the *Retail Surveillance* were designed to maximize external validity. However, there are several events between caecal sampling and retail meat sampling, and after retail meat sampling that could modify the proportion of serovars, phagetypes and AMR patterns present at each step along the food processing chain, and ultimately affect the rate of human exposure and subsequent rate of human illness. First, bacteria of intestinal origin may have different survival rates through processing steps to becoming a contaminant on retail meat. Second, careful and appropriate food preparation should prevent most of the transmission from food of animal origin to humans, but undercooking or cross-contamination of cooked and fresh products does occur and this process may not be random. Third, colonisation of the intestinal tract does not necessarily happen after ingestion of contaminated food. The age of the consumer, their immune status, and the pathogenicity of the ingested bacterial strain may influence the likelihood of developing salmonellosis. Bacterial pathogenicity, in particular, may contribute to the selection of certain strains more than others. Among those patients developing clinical signs of salmonellosis, the onset of the disease may occur only a few days after gastrointestinal colonisation but can also occur months later. Furthermore, there are several steps required before a *Salmonella* isolate is forwarded to the NML. These steps were described in CIPARS 2002 annual report. The more populated provinces (BC, AB, ON and QC) only forward a subsample of *Salmonella* isolates cultured or speciated by their provincial public health laboratories. Genetic modifications leading to changes in AMR patterns or other strain characteristics could occur at anytime during the farm-to-fork pathway. Finally, consumption of food of animal origin is only one of the various sources of infection for humans. All these considerations can lead to potentially important differences between the animal/food strain and the human clinical strain, and a clear increase in antimicrobial resistance in animal strains may not translate to an equivalent increase in human strains.

Nevertheless, the results described in this section identify similarities between animal and humans isolates at the phenotypic level. Molecular studies that highlight the level of genetic relatedness between both sources are required. Similarities between human and agri-food isolates could also be linked to similarities in antimicrobial use practices in both humans and animals. The current lack of animal antimicrobial use data precludes exploration of this possibility. An additional limitation is that representative data from *Retail Surveillance* are not available from each province, commodity and bacterial species. Furthermore, in the absence of a reliable food and animal tracking system, it is not possible to determine with precision the origin of meat purchased at the retail level.

At the moment, AMR results in humans are only available on clinical *Salmonella* isolates. Nationally representative AMR results from *Passive Surveillance* of other pathogens such as *Campylobacter* would be needed. The development of an *Active Surveillance component* of healthy humans would also be useful to allow comparison between AMR results from commensal bacteria and AMR results from the same bacteria in animals or food. In addition, epidemiological risk factor information such as travel, meat consumption, and prior antimicrobial treatment are currently unavailable for human *Salmonella* cases. These limitations have been recognized and CIPARS and its partners are actively working towards addressing these limitations wherever possible through additional surveillance activities and research.

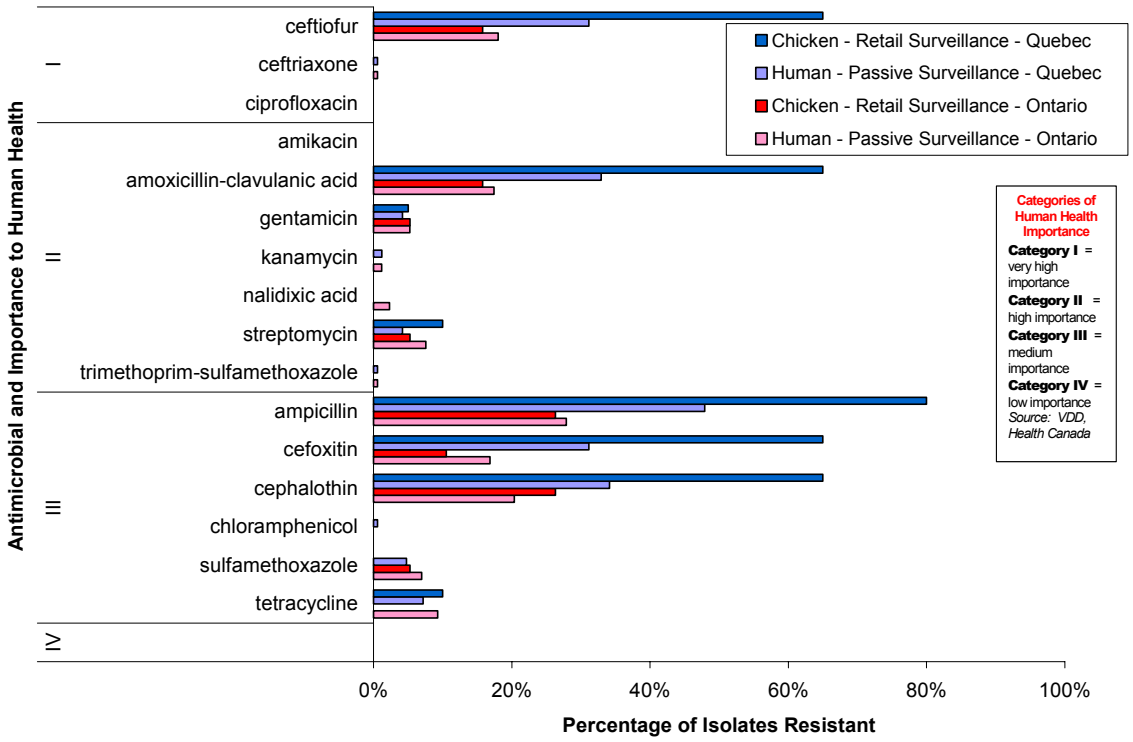

Figure 25. Individual antimicrobial drug resistance in *Salmonella* Heidelberg isolated from retail chicken (n=20) in Québec *(Retail Surveillance)*, human salmonellosis cases (n=167) in Québec *(Enhanced Passive Surveillance)*, retail chicken (n=19) in Ontario *(Retail Surveillance)* and human salmonellosis cases (n=172) in Ontario *(Enhanced Passive Surveillance)*.

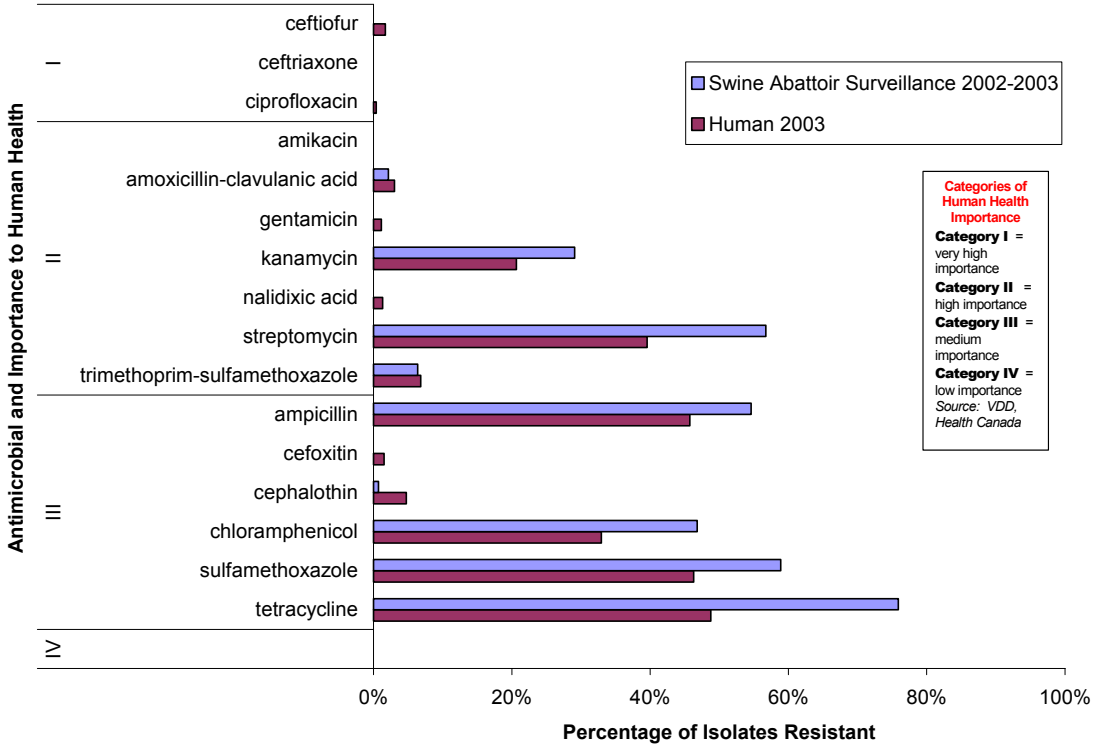

Figure 26. **Individual antimicrobial drug resistance of *Salmonella* Typhimurium isolated from swine caecal samples *(Abattoir surveillance)* (n=141) during 2002 and 2003 and from human cases (n=610) during 2003 (*Enhanced Passive Surveillance)*.**

Antimicrobial Resistance and Current Breakpoints

During the production of this report, three of the breakpoints used by CIPARS and NARMS were questioned by internal and external reviewers; two based on phenotypic expression of resistance as presented in this textbox and results published in scientific publications, and the third based on further genetic/molecular research as presented in the following text box.

Ceftiofur/ceftriaxone breakpoints: The only resistance breakpoint available from NCCLS for ceftiofur (≥8 μg/mL) is based upon document M31-A, and this breakpoint was derived for respiratory pathogens, not enteric bacteria. However, according to NCCLS, breakpoints for third generation cephalosporins for Gram-negative bacteria (including *E. coli* and *Salmonella*) used in human medicine are normally in the range of 32-64 μg/mL (NCCLS M2 and M7). CIPARS currently presents resistance findings for ceftriaxone (another 3rd generation cephalosporin) at ≥64 μg/mL (NCCLS M100-S14 M7). CIPARS data from human *Salmonella* shows that in-vitro ceftriaxone MICs are often lower than ceftiofur MICs by only one dilution. CIPARS data from abattoir and retail *E. coli* and from animal *Salmonella* isolates from all commodities tended to show an almost perfect relationship between TIO and CRO MICs in-vitro. When CIPARS data were reanalyzed using an ≥8 μg/mL breakpoint for both CRO and TIO, the prevalence of resistance to TIO and CRO was similar (see example below). It is important to note that clinical breakpoints may differ between two drugs even if in-vitro MICs show similar results because of differences in pharmacokinetic and pharmacodynamic properties. However, similar in-vitro MICs may suggest similar resistance mechanisms of the bacteria.

Surveillance Program/Bacterial Species/Animal Species	% 0f Isolates Resistant		
	Ceftiofur (≥8 μg/mL)	Ceftriaxone (≥64 μg/mL)	Ceftriaxone (≥8 μg/mL)
Abattoir/E. coli / chicken	17.3	0	19.3
Retail/E. coli / chicken	17.7	0	17.7

Ciprofloxacin breakpoint: It has been suggested that the ciprofloxacin breakpoint at ≥4 μg/mL (NCCLS M100-S14 M7) is too high (Aarestrup et al. 2003; Allen and Poppe, 2002; Crump et al. 2003), and it has been proposed that a breakpoint of ≥0.125 μg/mL would be more appropriate. In its M100-S14 guidelines, NCCLS states: "Fluoroquinolone-susceptible strains of Salmonella that test resistant to nalidixic acid may be associated with clinical failure or delayed response in fluoroquinolone-treated patients with extra-intestinal salmonellosis". Almost all CIPARS isolates resistant to NAL showed resistance to CIP at MICs equal or above 0.125 μg/ml. When CIPARS data were reanalyzed using a ≥0.125 μg/mL breakpoint for CIP and compared the results to NAL at a breakpoint of ≥32 μg/mL the prevalence of resistance to CIP and NAL becomes more similar (see example below).

Surveillance Program/Bacterial Species/Animal Species	% 0f Isolates Resistant		
	Nalidixic Acid (≥32 μg/mL)	Ciprofloxacin (≥4 μg/mL)	Ciprofloxacin (≥0.125 μg/mL)
Enhanced Passive Surveillance/ Salmonella Enteritidis/human	18.8	0	18.5
Abattoir/E. coli / chicken	4.0	0	2.6

For presentation of resistance data, CIPARS will use the internationally accepted breakpoints outlined in the NCCLS guidelines. CIPARS will also closely monitor correlations of prevalence of resistance based on MIC distributions to better understand Canadian surveillance data, trends over time and linkages with antimicrobial usage patterns.

Note: *CIPARS would like to thank VDD for input into above textbox. DANMAP is currently using the breakpoint ≥ 0.125 ug/mL for ciprofloxacin.*

Detection of streptomycin resistance in *E. coli* using the CMV7CNCD plates

Only two streptomycin dilutions (32 and 64μg/mL) are present on the CMV7CNCD plates used by CIPARS and NARMS. All the isolates with an MIC of 32μg/mL or below were considered susceptible to this antimicrobial. This short dilution series and the cut off value chosen for streptomycin make assessment of the frequency of streptomycin resistance difficult.

Two major genetic determinants are responsible for streptomycin resistance in *Enterobacteriaceae*. The first (*aadA*) provides simultaneous resistance to both streptomycin and spectinomycin, whereas the second (*strA/strB*) provides resistance to streptomycin only. Dr. Patrick Boerlin (Department of Pathobiology, University of Guelph) in collaboration with LFZ recently assessed the distribution of *aadA* and *strA/strB* genes, antimicrobial resistance to spectinomycin (disk diffusion), and antimicrobial resistance to streptomycin (NARMS plates; Sensititre™ System) using a collection of 150 faecal *E. coli* from pigs with diarrhea. The preliminary results of this study show good correlation between the presence of the *aadA* gene and reduced susceptibility to spectinomycin. A tri-modal distribution of inhibition diameters for spectinomycin was observed, suggesting that at least two different levels of *aadA* expression exist. However, of the 80 strains with reduced susceptibility to spectinomycin and carrying the *aadA* gene, less than a third were recognized as streptomycin resistant when using the NARMS micro-dilution system and the specific breakpoint used to date. These problematic strains are mainly those with the lowest level of spectinomycin resistance. The *aadA* genes of these low-level spectinomycin resistant strains are components of integrons that frequently carry other important resistance genes such as those for sulfonamides and trimethoprim. It may therefore be useful to detect them in the future to improve our global understanding of AMR epidemiology.

Note: *CIPARS would like to thank Dr. Boerlin (University of Guelph) for the above text box. No resistant breakpoints are available for streptomycin from NCCLS. DANMAP has used a breakpoint of ≥32 μg/mL to define resistance to streptomycin (DANMAP 2002).*

Section Two - Antimicrobial Use

Human Antimicrobial Use

The Public Health Agency of Canada (formerly part of Health Canada) has continued to use data from Intercontinental Medical Statistics (IMS) Health to quantify and describe human antimicrobial drug use across Canada. This report focuses on two IMS Health datasets: Canadian CompuScript (CCS) and Canadian Disease and Therapeutic Index (CDTI). For CCS, retail pharmacy dispensing data for systemic antibacterials are presented for calendar years 2001-2003 and for CDTI, diagnostic data associated with antimicrobial drug mentions[1] occurring during patient visits are presented for July 1, 2001-June 30, 2002 (Year One) and July 1, 2002-June 30, 2003 (Year Two). Additional information on IMS Health data collection and CIPARS analytic methodologies are described in Appendix B.3.

Currently, the World Health Organization (WHO) recommends measurement of antimicrobial use by DDDs (Defined Daily Doses[2]) per inhabitant-years (WHO Collaborating Centre for Drug Statistics Methodology http://www.whocc.no/atcddd/). In addition to adopting this standard, DDDs/1000 inhabitant-days are presented for retrospective national and international comparisons[3]. Furthermore, to provide the most comprehensive representation of antimicrobial drug use, systemic antibacterial use by volume of active ingredient (kg), number of prescriptions dispensed, and dollars spent (Tables 42 and 43, Appendix A.5) are presented.

[1] Product mentions are drugs prescribed or recommended for a specific diagnosis, including those started on the recorded visit and those previously ordered and continued.

[2] Defined Daily Dose: "is the assumed average maintenance dose per day for a drug used for its main indication in adults" [WHO Collaborating Centre for Drug Statistics Methodology (http://www.whocc.no/atcddd/)].

[3] To calculate the number of DDDs per unit of population-time, the division factor was determined by using the Canadian population estimates from Statistics Canada for a given year, example formula: number of days in calendar year x (population of Canada for given year/1,000 inhabitants).

Pharmacy Dispensing Data

The total number of DDDs of systemic antibacterials dispensed in Canada decreased from 208.9 million in 2001[4] to 202.0 million in 2002 then increased to 205.5 million in 2003 (Table 42, Appendix A.5). A similar trend was observed when use was measured by DDDs/inhabitant-years (DDDs/1000-inhabitant-days): 6.76 (18.51) in 2001, 6.46 (17.70) in 2002, and 6.52 (17.86) in 2003. The total number of systemic antibacterial prescriptions dispensed decreased from 22.5 million (0.728/inhabitant) in 2001 to 21.8 million (0.697/inhabitant) in 2002, and increased again to 22.1 million (0.701/inhabitant) in 2003 (Table 43, Appendix A.5). The total cost of these prescriptions decreased from $660.8 million ($21.37/inhabitant) in 2001 to $659.3 million ($21.09/inhabitant) in 2002 then increased to $695.5 million ($22.06/person) in 2003 (Table 17).

In 2003, the five most frequently dispensed systemic antibacterial drug classes, by proportion of total DDDs, were penicillins with extended spectrum (27%), macrolides (20%), tetracyclines (14%), fluoroquinolones (12%), and first- and second-generation cephalosporins (10%) (Table 42, Appendix A.5 or Figure 27; Figure 28 shows kg active ingredient, Figure 29 shows number of prescriptions).

Over time, the distribution of drug use by class appears to have changed. Use of penicillins with extended spectrum decreased from 29% of total DDDs in 2001 to 27% in 2003. At the same time, fluoroquinolones increased from 11% of total DDDs in 2001 to 12% in 2003. Human Health Importance Category I drugs represented a consistently increasing proportion of the total DDDs dispensed: 11.0% in 2001, 11.7% in 2003, and 12.1% in 2003.

For systemic antibacterials overall, per inhabitant-year, the highest number of prescriptions (1.04), dollars spent ($29.51),

[4] Pharmacy dispensing data presented in CIPARS 2002 encompassed one fiscal year, whereas in CIPARS 2003 data are presented by calendar year.

volume of active ingredient (0.0101 kg), and DDDs (9.99) were dispensed in Prince Edward Island and Newfoundland and Labrador. This difference from the other provinces may be due to sampling variations; however, it may reflect real differences in antimicrobial prescribing (Figure 30).

For 2001-2003, the number of DDDs dispensed/inhabitant-year was lowest June to August, began to increase in September, and peaked December to January (Figure 31).

Diagnostic Data

Note: *Year 1: 4155 female + 3295 male + 143 patients of undefined sex = 7593 total patient visits; Year 2: 3666 female + 2753 male + 137 patients of undefined sex = 6556 total patient visits.*

For Year One (n=7593 patient visits) and Year Two (n=6556 patient visits) combined, the five most common ICD-9 diagnostic classes associated with an antimicrobial drug mention during a patient visit were (Figure 32): *Diseases of the respiratory system* (5969/14149 visits; 42%), *Diseases of the genitourinary system* (2057/14149 visits; 15%), *Diseases of the nervous system and sense organs* (1849/14149 visits; 13%), *Diseases of skin and subcutaneous tissue* (1282/14149 visits; 9%), and *Infectious and parasitic diseases* (1177/14149 visits; 8%). Among these five most common diagnostic classes, the top diagnostic codes, respectively, were bronchitis (acute), urinary tract infection (site unspecified), unspecified otitis media, cellulitis and abscess (site unspecified), and streptococcal sore throat Figure 33. Overall, these diagnostic codes represented 29% of all patient visits in which antimicrobials were mentioned. From Year One to Year Two, among patient visits involving antimicrobial drug mentions, increases in the proportion of diagnoses for *Diseases of the respiratory system*, *the genitourinary system*, and *skin and subcutaneous tissues* were observed (Figure 32).

The relative ranking of the most common diagnostic classes differed by sex, with *Diseases of the genitourinary system* occurring more commonly among females than males (Figure 34).

For females, the age group[1] with the highest proportion of patient visits involving an antimicrobial drug mention (Figure 35) was 20-39 years (2339/7821 visits; 30%). Within this group, the most common diagnostic classes were *Diseases of the respiratory system* (881/2339 visits; 38%) followed by *Diseases of the genitourinary system* (659/2339 visits; 28%). In contrast, for males, the age group with the highest number of patient visits involving an antimicrobial drug mention was 40-59 years (1397/6048 visits; 23%). Similarly, the most common diagnostic class in this group was also *Diseases of the respiratory system* (593/1397visits; 42%).

Data Limitations

The information in this section is based on the best currently available data describing human antimicrobial use in Canada. However, potential limitations exist. Although *CCS* data are generally accurate, when analyzing extended units and prescription size alone, the information may be unreliable because of the methods pharmacists use to enter the number of units dispensed and the size of the prescription. Pharmacists enter the size of the prescription and the number of units dispensed. Pharmacists enter a number into the quantity field of the database that represents the number of drug units in the prescription. However, inconsistencies arise for pre-packaged products, such as vials, where the quantity field could represent either the number of vials dispensed or the number of millilitres per vial. There is no adjustment possible to account for these inconsistencies. To ensure a consistent approach, it was assumed that every formulation had the same quantity of units (Table 47, Appendix B.3).

Data from *CCS* measure systemic antibacterials dispensed by retail pharmacies; it was assumed that this information represented community use as opposed to hospital or health care facility use. However, these results may include drugs dispensed to health care facilities such as nursing homes. This is especially possible for products supplied in injectable forms, which represented 91,992 prescriptions and 4,877,332 units (i.e. vials or syringes) in these data for 2001-2003 (Table 44, Appendix A.5).

[1] Data as provided had unequal years in each age category.

For the diagnostic data from *CDTI*, it was not possible to limit analyses to systemic antibacterial drugs. Therefore, some of the drug mentions may be for topical preparations and/or antimicrobials not classified as J01. Furthermore, the diagnostic class system used by IMS Health in the *CDTI* dataset does not exactly follow the ICD-9 classification system. Therefore, some errors in interpretation may have occurred. Additionally, one cannot be certain about the true cause-effect relationship between diagnoses and anti-infective drug mention, as physicians may base treatment recommendations in advance of definitive diagnosis.

CIPARS would ideally like to link the quantities of antimicrobials used to their respective therapeutic purposes, however due to the nature of the different data collection structures of the two IMS databases, it is not possible to make this comparison.

In 2003, the human systemic antibacterial classes most frequently dispensed by retail pharmacies in Canada, as a proportion of total DDDs, were penicillins with extended spectrum (27%), macrolides (20%), tetracyclines (14%), fluoroquinolones (12%), and first and second-generation cephalosporins (10%). After controlling for population size, systemic antibacterial use appears to have increased between 2002 and 2003, evidenced by the higher number of DDDs, prescriptions, and dollars spent; however, use in both 2002 and 2003 was lower than that observed in 2001 (with the exception of the dollars spent per inhabitant for 2003). Nevertheless, Human Health Importance Category I drugs represented an increasing proportion of the total DDDs dispensed (primarily fluoroquinolones and glycopeptides): 11.0% in 2001, 11.7% in 2002, and 12.1% in 2003. In addition to annual variations, systemic antibacterial use appeared to differ by province, season, patient sex, and patient age. Of the total number of patient visits in which sampled physicians mentioned an antimicrobial therapy between July 1, 2002 and June 30, 2003, 43% of associated diagnoses were respiratory system diseases. Digestive system disease accounted for 6%.

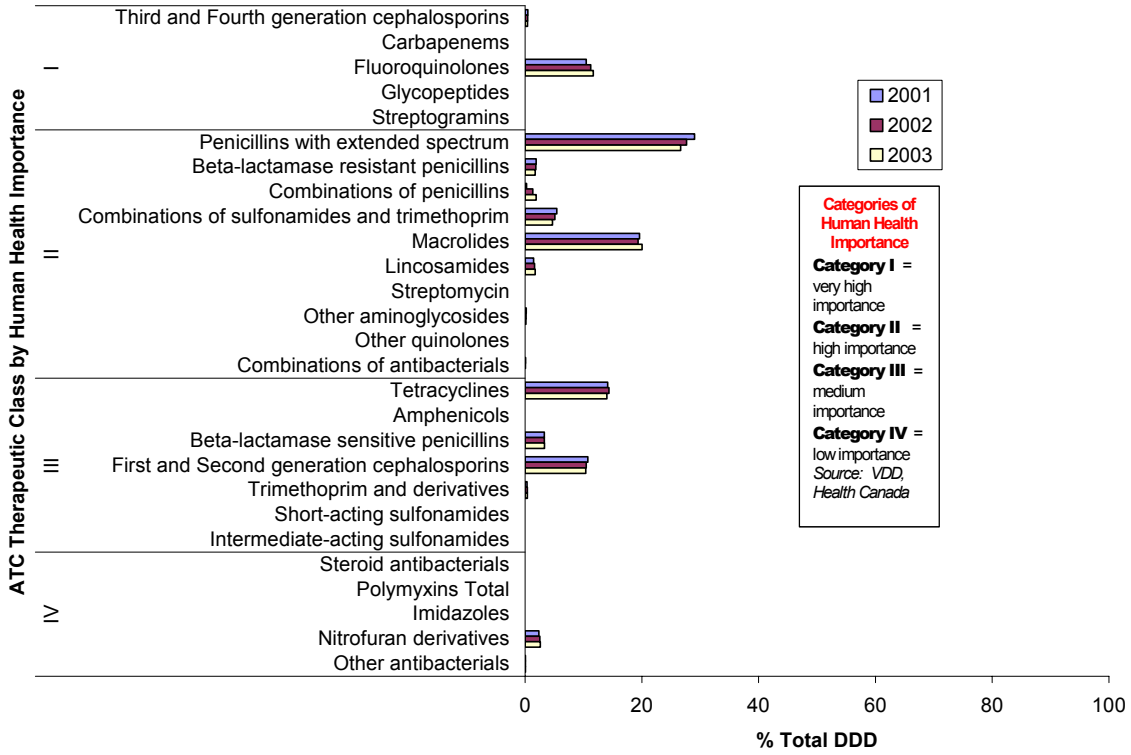

Figure 27. Defined Daily Doses (DDDs) of systemic antibacterials dispensed, by ATC code and year, 2001-2003.

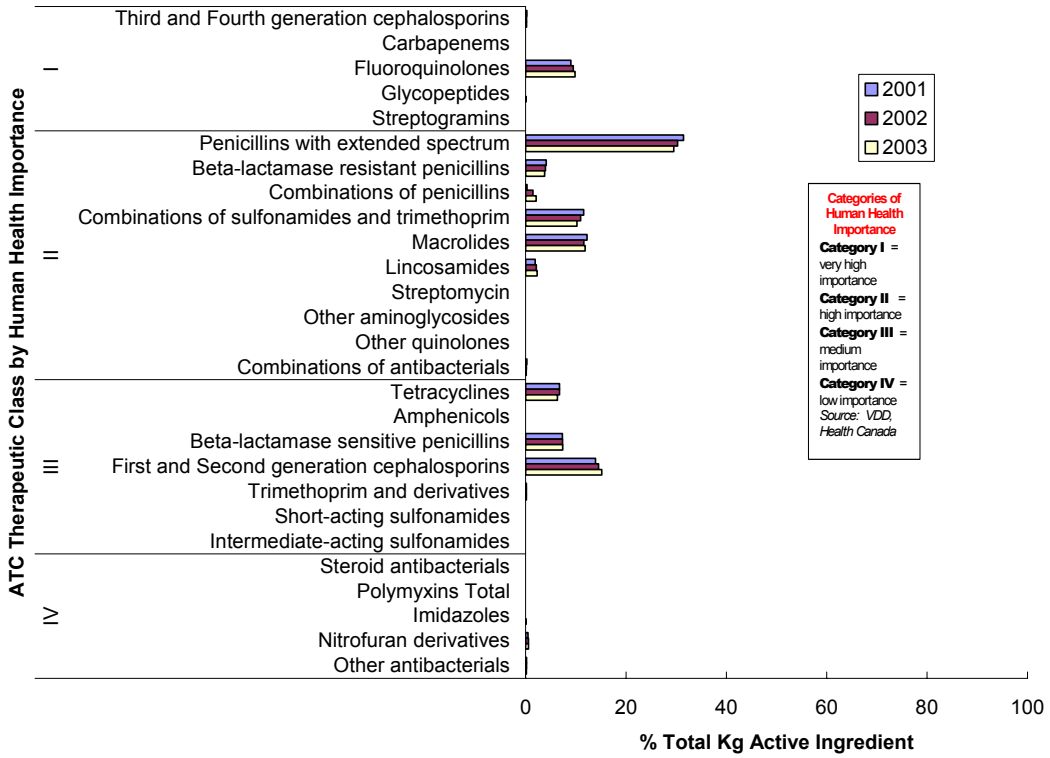

Figure 28. Volume (kg) of systemic antibacterials dispensed, by ATC code and year, for the period 2001-2003.

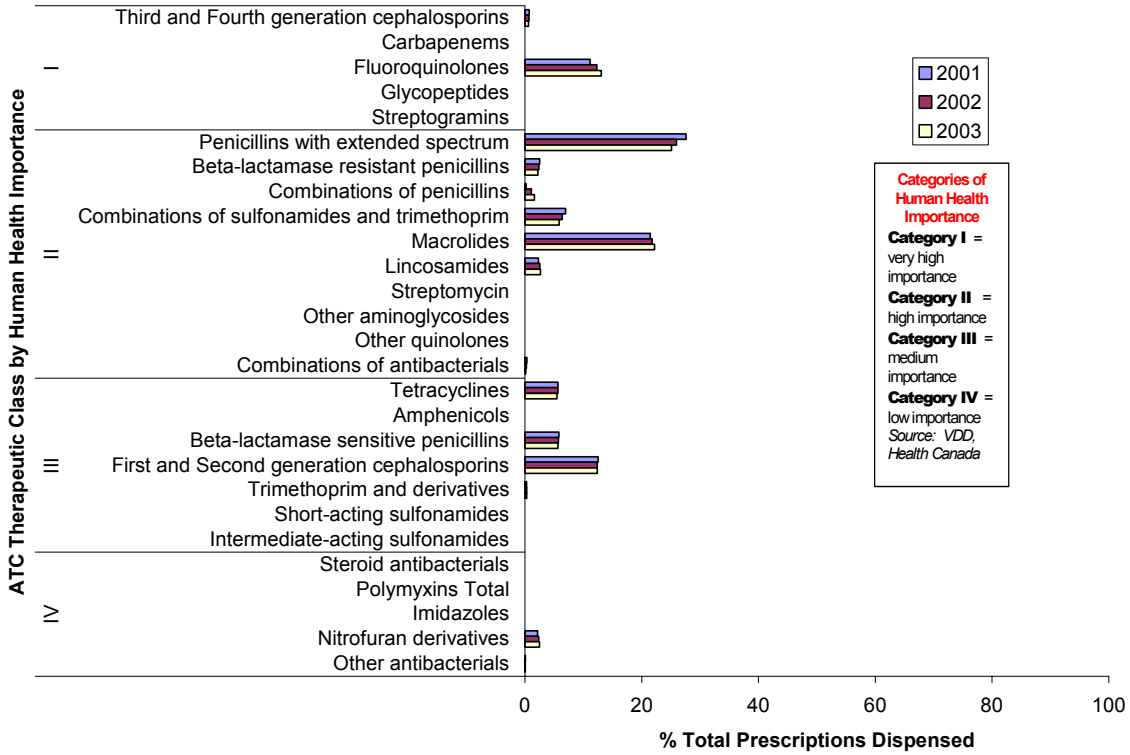

Figure 29. Prescriptions of systemic antibacterials dispensed, by ATC code and year, for the period 2001-2003.

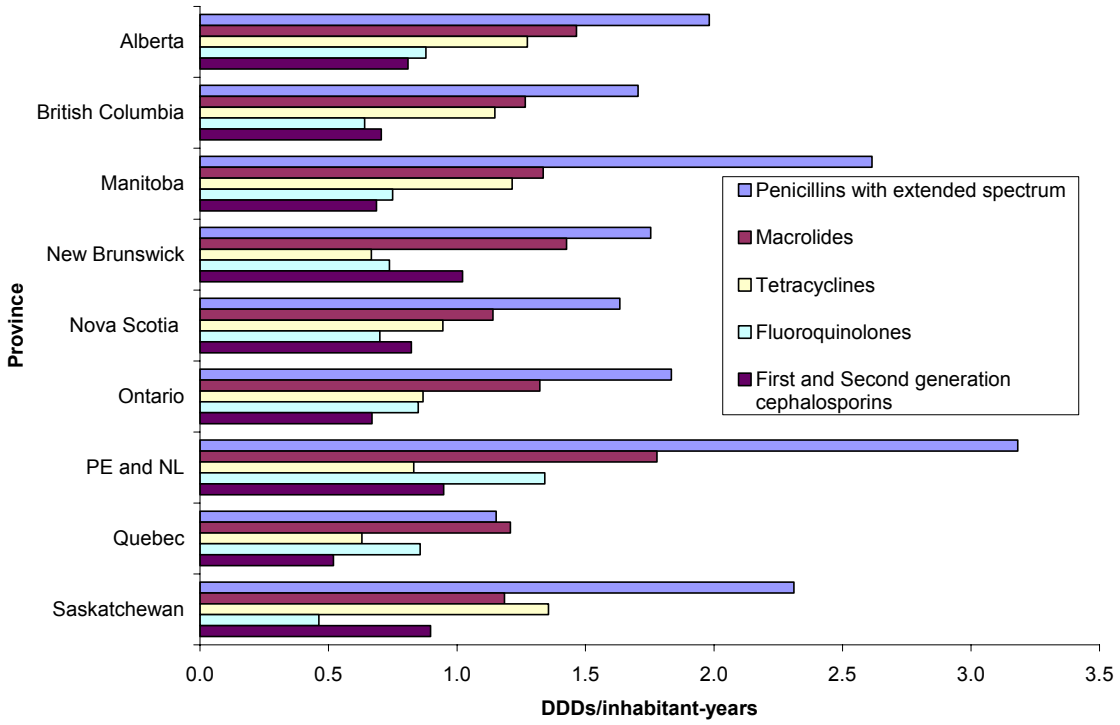

Figure 30. Top five most frequently dispensed ATC classes of systemic antibacterials, measured by DDD/inhabitant-years, by province, 2003.

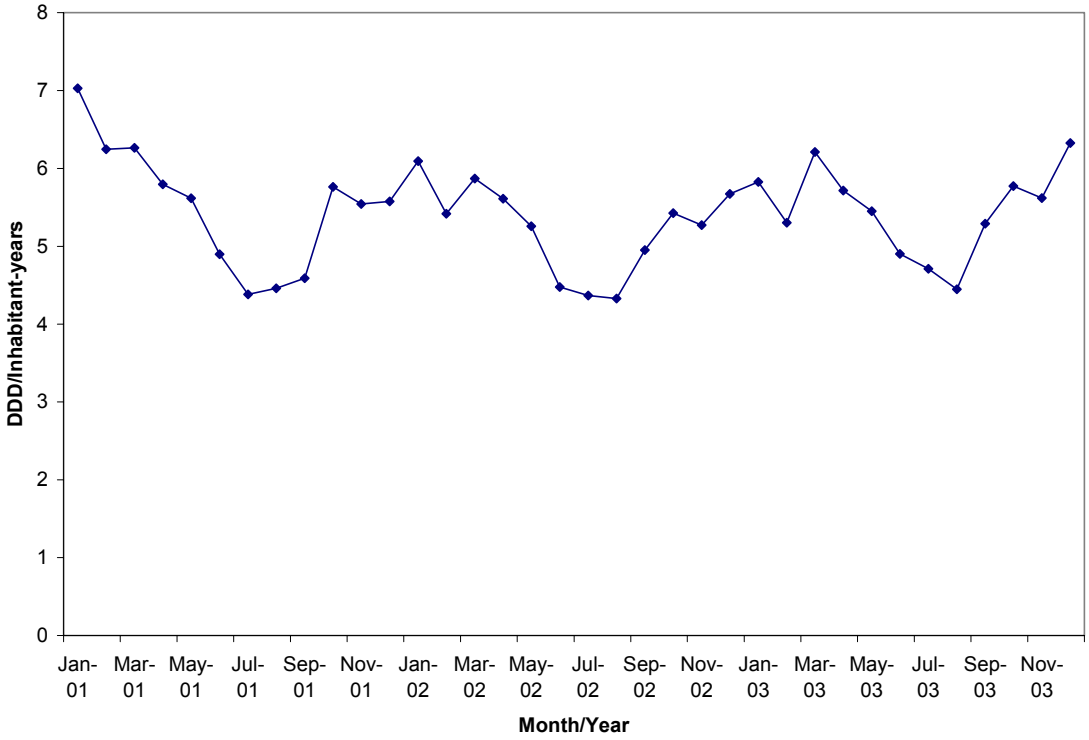

Figure 31. Systemic antibacterials dispensed, DDDs/inhabitant-years, by month and year, 2001-2003.

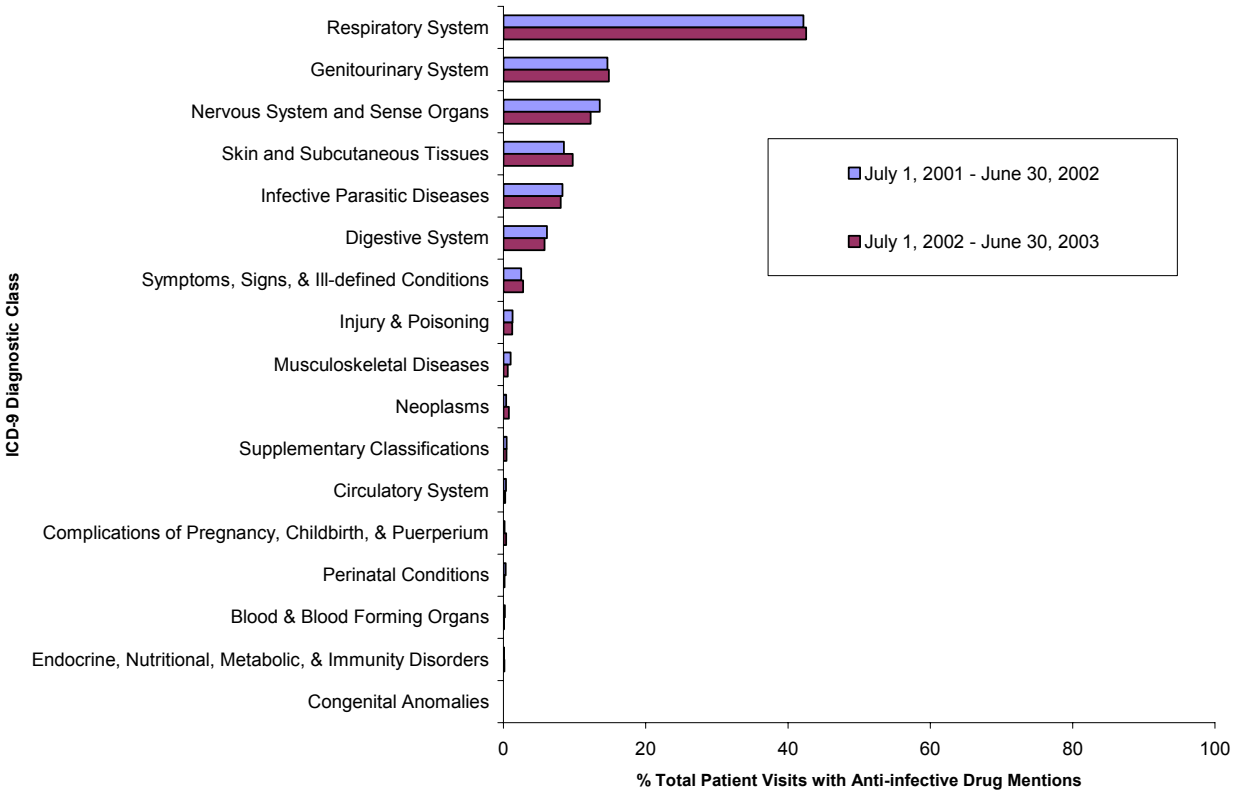

Figure 32. Patient visits to sampled physicians with mention of an antimicrobial therapy, by ICD-9 diagnostic class and yearly period.

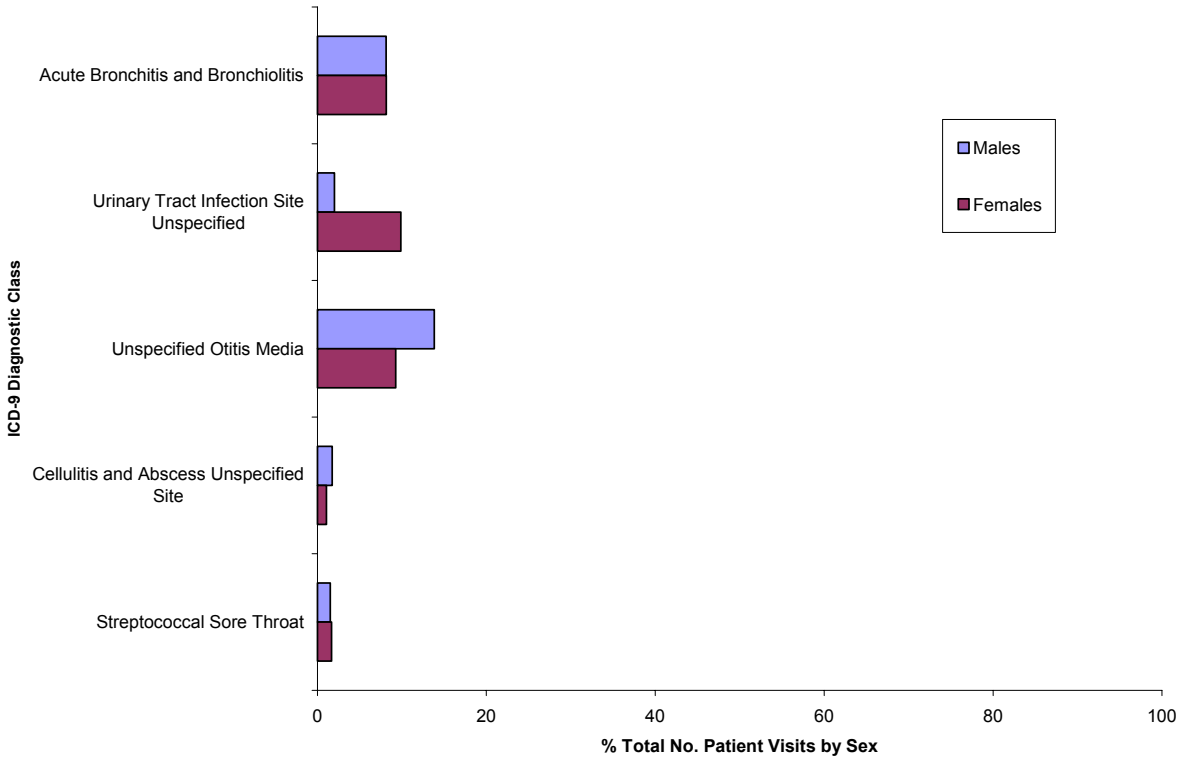

Figure 33. Top diagnostic codes among the top five ICD-9 diagnostic classes, by patient sex, July 1, 2001- June 30, 2003.

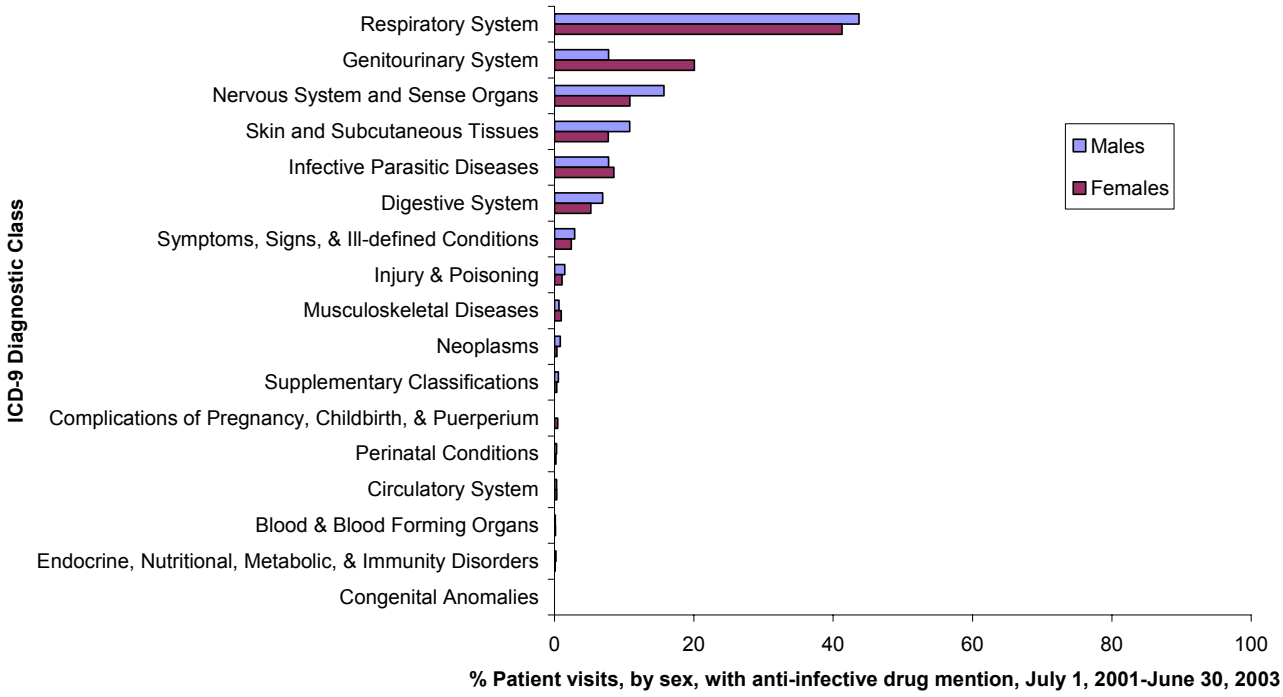

Figure 34. Patient visits to sampled physicians with mention of an antimicrobial therapy, by ICD-9 diagnostic class and patient sex.

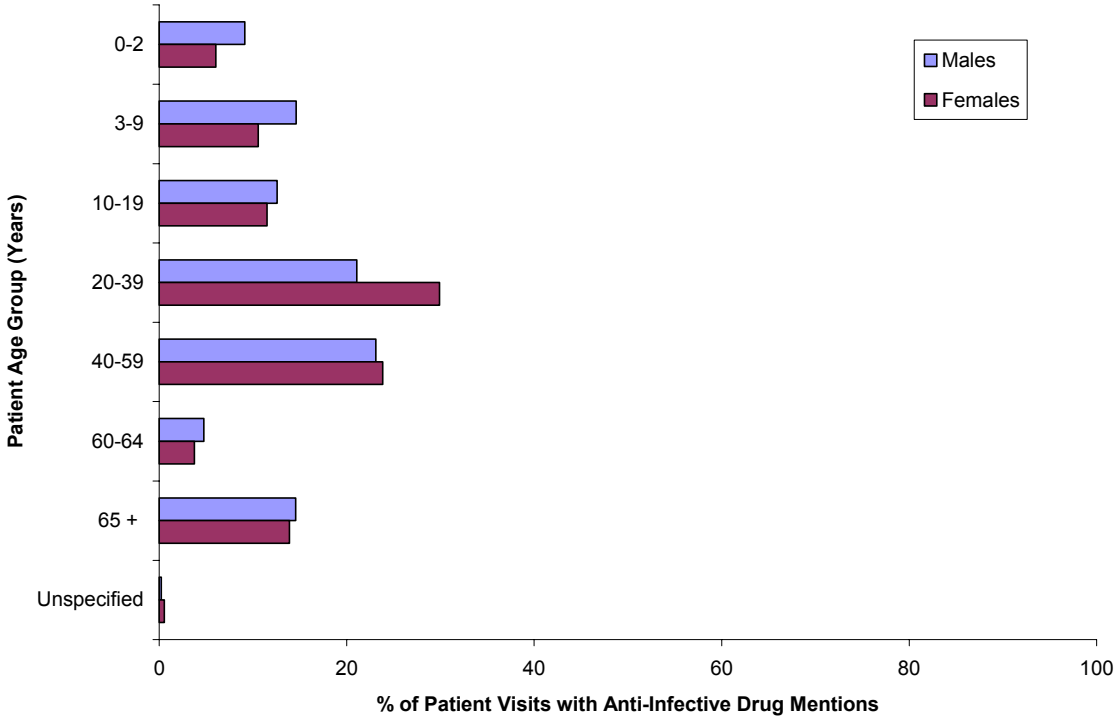

Figure 35. Patient visits to sampled physicians with mention of an antimicrobial therapy, by patient age group and patient sex, July 1, 2001- June 30, 2003.

Animal Antimicrobial Use

On-Farm Surveillance

The active *On-Farm Surveillance* program is the newest component of CIPARS and is currently in the development and early implementation stages. Based on a sentinel farm framework, the objectives are to provide estimates of group -level and individual animal-level antimicrobial use, while concurrently collecting faecal samples for bacterial isolation and antimicrobial susceptibility testing (see Appendix B.2).

Data collection commenced in January 2004 and analysis of Year One data will be presented in the 2004 CIPARS annual report. *On-Farm Surveillance* has been initiated in three core commodities: broiler chickens, grower/finisher pigs, and feedlot beef. In subsequent years, this program may be expanded to include additional animal commodities beyond the core sectors. Antimicrobial use information is being collected using forms adapted from existing on-farm food safety programs when available. Where necessary, new or modified forms were designed to capture additional use data. Collection of empty medication containers and feed tags may also be used to validate antimicrobial use information on-farm. Field workers and/or producers will be recording antimicrobial use data electronically using handheld Personal Digital Assistants (PDAs) in an attempt to protect data integrity and allow for more timely data analyses.

National Sales Data

The Canadian Animal Health Institute (CAHI) has been working towards providing CIPARS with data on the sales of veterinary antimicrobials for the calendar years 2001, 2002 and 2003. At the time of completion of this report the data validation was not yet complete. The data will be released in a later report once it is available.

Monitoring Antimicrobial Use in Animals

CIPARS is committed to the development of a national system for monitoring antimicrobial use in animals. The design is still being developed but will include data collected form a variety of sources. The 2004 CIPARS Annual Report will be one step closer to the implementation of the eventual operational system with the inclusion of national sales data and preliminary on-farm use data.

Appendix A: Additional Information

A.1 Drugs of Human Health Importance

Classification of Antimicrobial Products Based on Importance in Human Medicine

Excerpt from Veterinary Drugs Directorate's Draft Proposed Guidelines on the Microbiological Safety Studies for the Evaluation of Veterinary New Drug Submissions (September 2003)

Different classes of antimicrobials are used in human and animal medicine for the treatment and prevention of bacterial diseases. Some of these antimicrobials are last-line drugs for the treatment of serious life-threatening infections in humans. If these antimicrobials become ineffective due to the development of bacterial resistance, alternative antimicrobials are not available to treat human infections caused by the resistant bacteria. These and newer generation antimicrobials with unique mechanism of action and/or mechanism of resistance are of **V**ery **H**igh **I**mportance (**VHI**) in human medicine. Some antimicrobials that are considered of **H**igh **I**mportance (**HI**) in human medicine have limited alternatives. First-line or second-line antimicrobials may be classified as being of **M**edium **I**mportance (**MI**) or **L**ow **I**mportance (**LI**) in human medicine depending on their therapeutic usefulness.

Rationale for classification:
The criteria for classification of antimicrobials is based on the following factors:

- Spectrum of activity of antimicrobials;
- Mode of action;
- Mechanism of resistance;
- Availability of alternative antimicrobial therapy;
- Potential for transfer of resistance.

1. Category I: Very High Importance
These antimicrobial classes are of highest importance in human medicine and are used for the treatment of life-threatening bacterial infections. There may be no alternative antimicrobials in case of emergence of resistance to these agents. These agents are also considered "last-line" antimicrobials in human medicine. Examples include:

1.1 Fluoroquinolones
1.2 Glycopeptides
1.3 Carbapenems
1.4 3rd - Generation Cephalosporins
1.5 4th - Generation Cephalosporins
1.6 Streptogramins
1.7 Newer Generation Antimicrobial Drugs

2. Category II: High Importance
Antimicrobials classified as category II consist of those that can be used to treat infections caused by bacteria that are resistant to category III antimicrobials. Examples include:

2.1 Penicillins Group 1 (ß-lactamase resistant penicillins, extended spectrum penicillins)
2.2 Aminoglycosides
2.3 Macrolides
2.4 Lincosamides

3. Category III: Medium Importance
These antimicrobials are generally used as first-line drugs for treatment of bacterial infections. Bacteria that are resistant to these drugs can be treated by category II antimicrobials. Examples include:

3.1 1st - Generation Cephalosporins

3.2 2nd - Generation Cephalosporins
3.3 Penicillins Group 2 (natural penicillins, aminopenicillins)
3.4 Tetracyclines
3.5 Sulphonamides

4. Category IV: Low Importance

These antimicrobials are of limited use in human medicine. Some, such as the ionophores, are not used under any circumstances in human medicine. Examples include:

4.1 Zinc Bacitracin
4.2 Polymyxin B
4.3 Colistin
4.4 Quinoxalines
4.5 Flavophospholipols
4.6 Ionophores

***Note**:[1]The proposed classification of antimicrobial drugs is based only on the importance of each drug class to human health and does not reflect the extent of drug use or the degree to which resistance occurs in human bacterial pathogens. A proposed parallel classification based on risk of exposure is being developed and will be integrated with this classification system; for this report, the VDD suggested that products with a combination of antimicrobials be classified one category higher than the highest category of their individual constituents. For comments regarding the Proposed Drug Classification System, please contact the Veterinary Drugs Directorate, Health Canada.*

A.2 Demographic Information

The demographic section provides background information on Canadian population distributions and general health care availability. In addition, demographic data have been used to develop and refine statistically valid sampling strategies, and provide the necessary denominators for calculating rates of antimicrobial use and resistance.

Tables 20 to 22 outline human and livestock population demographics and general health care availability. As specific demographic data were not available for all categories in 2003, the most recent or most comparable data have been provided, accompanied by the year of data collection. It is important to recognize that Canada is a country with marked clusters of habitation and clusters of agricultural activity. The number of farms, number of animals, change in number of animals between 2002 and 2003, quantity of food produced, per capita consumption of the various commodities, imports and exports, and veterinary services are shown in Tables 21 to 23.

Human Demographic Information

Table 20 Human population demographics and health care availability.

	Post-Censal Population Estimates Jan 1, 2003[1]	Post-Censal Population Estimates Jan 1, 2002[2]	Percentage Change in 2003	Population Density Per Square Km (2003)	Health Care - Number of Approved Beds (1996-1997)[3]	[a]Number Of Physicians Per 100,000 Population (2002)[4]
Canada	31,475,999	31,240,487	0.75	3.49	352,334	189
British Columbia	4,127,454	4,120,891	0.16	4.45	44,571	199
Alberta	3,132,484	3,086,034	1.51	4.89	38,180	180
Manitoba	1,158,360	1,148,181	0.89	2.10	18,146	181
Saskatchewan	994,905	1,014,403	-1.92	1.70	18,411	155
Ontario	12,156,595	11,964,104	1.61	13.39	128,249	179
Québec	7,462,432	7,435,504	0.36	5.50	68,972	212
New Brunswick	750,439	755,391	-0.66	10.52	12,830	157
Nova Scotia	935,180	943,756	-0.91	17.67	12,547	206
Prince Edward Island	137,334	139,330	-1.43	24.16	2,507	136
Newfoundland and Labrador	519,560	533,305	-2.58	1.40	6,996	175
Yukon Territory	30,569	30,102	1.55	0.06	282	175
Northwest Territories	41,630	41,186	1.08	0.04	643	111
Nunavut	29,057	28,300	2.67	0.02	N/A	35

Note: Population density per square Km in 2003 was calculated based on the population Jan. 1, 2003 and the land area in square kilometres reported in Statistics Canada, Census of Population Products. http://www.12.statcan.ca/english/census01/products/standard/popdwell/Table-PR.cfm?T=2&S=9&O=A, Accessed Apr, 2004.

[1]Statistics Canada-The Daily. (2004). Demographic statistics - Canada's population. http://www.statcan.ca/Daily/English/040322/d040322e.htm. Accessed Mar. 2004.

[2]Statistics Canada-The Daily. (2003). http://www.statcan.ca/Daily/English/030326/d030326c.htm. Accessed Apr. 2004.

[3]Statistics Canada, Canadian Institute for Health Information. http://www.statcan.ca/english/Pgdb/health32a.htm, Accessed Feb 2003.

[4]Canadian Institute for Health Information. http://secure.cihi.ca/cihiweb/en/AR14_2002_tab5_e.html. Accessed June 2004.

[a]Ontario data does not reflect four of twelve monthly updates (September-December, 2002) from the College of Physicians and Surgeons of Ontario.

Animal Demographic Information

Table 21 Canadian livestock–demographics, production, and per-capita consumption

Farmed Species	Number of Farms 2001	Number of Animals Jan. 1, 2002	Number of Animals Jan 1, 2003	Percentage change in 2003 [(2003-2002)/2002] *100	Product Produced Metric Tonnes 2002	Per-Capita Consumption Kg/Person 2002[12]
Cattle	[1]122,066	[6]13,761,500	[6] 3,487,600	-1.99	[6]cattle total cold dressed weight[b] = 1,238,387 [6]calves total cold dressed weight[b] = 33,556	beef = 13.31 veal = 0.48
Beef cows	[1]90,066	[6] 4,636,000	[6] 4,752,100	2.50		
Dairy cows	[1]21,911	[6] 1,083,900	[6] 1,065,300	-1.72	[9]kilolitres milk and cream = 7,400,000	fluid milk = 62.34 (litres/person) [13]cream = 5.3 (litres/person) cheese = 8.75
Heifers	[1]83,914					
Beef Replacement		[6] 653,700	[6] 648,300	-0.83		
Dairy Replacements		[6] 507,500	[6] 512,000	0.89		
Steers (≥1 year)	[1]32,884	[6] 1,205,100	[6] 1,178,300	-2.22		
Calves (<1 year)	[1]110,397	[6] 4,573,700	[6] 4,311,900	-5.72		
Bulls (≥1year)	[1]78,816	[6] 237,000	[6] 239,700	1.14		
Swine	[2]15,472	[7]14,367,100	[7]14,671,900	2.12	[7]total cold trimmed weight = 1,854,082[b]	pork = 12.22
Sows and Bred gilts	[2]8,542	[7]1,468,000	[7] 1,536,700	4.68		
Boars	[2]7,615	[7]44,400[a]	[7] 41,700[a]	-6.08		
Pigs < 20Kg		[7]4,236,000	[7] 4,341,800	2.50		
Pigs 20-60Kg		[7]4,338,400	[7] 4,427,800	2.06		
Pigs > 60Kg		[7]4,280,300	[7] 4,323,900	1.02		
Poultry					[10]poultry meat = 1,100,000 [10]eggs 575,800,000 dozen	poultry meat = 13.62 eggs 12.82 dozen/person
Hens and Chickens	[3]26,484		[3] *2001 data* 126,159,529			
Broilers, Roasters, and Cornish hens	[3]10,875		[3]*2001 data* 87,437,798			chicken meat = 10.80 stewing hens = 0.59
Turkeys	[3]4,176		[3]*2001 data* 8,115,942		[10]turkey meat = 146,400, 000 Kg	turkey meat = 2.23
Ovine	[4]13,232	[8]993,600	[8]975,600	-1.81	[8]total cold dressed weight = 14,502[b]	mutton/lamb meat = 0.42
Ewes	[4]12,510	[8]615,400	[8] 612,800	-0.42		
Rams		[8]29,000	[8] 28,800	-0.69		
Replacement Lambs		[8]110,400	[8] 96,000	-13.04		
Market lambs		[8]238,800	[8] 238,000	-0.34		

Farmed Species	Number of Farms 2001	Number of Animals Jan. 1, 2002	Number of Animals Jan 1, 2003	Percentage change in 2003 [(2003-2002)/2002] *100	Product Produced Metric Tonnes 2002	Per-Capita Consumption Kg/Person 2002[12]
Fish						fish meat = 7.17
Salmon Trout Steelhead	*2001 data* salmon =300[5] trout =900[5]				[11]salmon = 132,021[c] [11]trout = 7,080[c] [11]steelhead = 2,034[c] [11]all shellfish = 34,040[c]	fresh and frozen seafish = 2.79 freshwater = 0.29 processed seafish = 2.71 shellfish = 1.38

Note: These data represent food available for consumption in Canada, and not actual quantities of food consumed; totals represent net availability and account for imports as well exports.

[1]*Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/Pgdb/econ105a.htm. Accessed May 2004.*

[2]*Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/Pgdb/econ106a.htm. Accessed May, 2004.*

[3]*Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/Pgdb/econ109a.htm. Accessed May, 2004.*

[4]*Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/Pgdb/econ107a.htm. Accessed May, 2004.*

[5]*Veterinary Drugs Directorate, Health Canada. 2002. Uses of antimicrobials in food animals in Canada: Impact on resistance and human health. Report of the Advisory Committee on Animal Uses of Antimicrobials and Impact on Resistance and Human Health.*

[6]*Statistics Canada, Census of Agriculture- Cat. No. 23-012-XIE. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2003002.pdf. Accessed May. 2004.*

[7]*Statistics Canada, Census of Agriculture- Cat. No. 23-010-XIE. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2004001.pdf. Accessed May 2004.*

[8]*Statistics Canada, Census of Agriculture- Cat. No. 23-011-XIE. http://www.statcan.ca/english/freepup/23-011-XIE/23-011-XIE2003002.pdf. Accessed May 2004.*

[9]*Statistics Canada, The Daily- Dairy Statistics. http://www.statcan.ca/Daily/English/030213/d030213c.htm. Accessed May 2004.*

[10]*Statistics Canada, The Daily- Production of Poultry and Eggs. http://www.statcan.ca/Daily/English/030516/d030516d.htm. Accessed May 2004.*

[11]*Statistics Canada, Aquaculture Statistics- Cat. No. 23-222-XIE. http://www.statcan.ca:80/english/freepub/23-222-XIE/23-222-XIE02000.pdf. Accessed May, 2004.*

[12]*Statistics Canada , Food Statistics- Cat. No. 21-020-XIE. http://statcan.ca/english/freepub/21-020-XIE/21-020-XIE02002.pdf. Accessed May 2004.*

[13]*Statistics Canada, Food Consumption in Canada 2002. http://www.statcan.ca/english/ads /23F0001XCB/highlight.htm. Accessed May 2004.*

[a]*Boars* ≥6months.

[b]*Not including edible offal.*

[c]*Excludes confidential data.*

Table 22. The number of births, slaughtered animals, international imports and exports, and on farm deaths of Canadian cattle, swine and ovine in 2003.

	Cattle[1]	Swine[2]	Ovine[3]
Births	5,772,600	3,1309,200	938,000
Slaughter	3,514,300	2,2465,900	721,500
% change of slaughter in 2003[a]	-8.40%	1.41%	3.80%
International imports	57,600	4,800	400
% change of imports in 2003 [a]	-65.80%	-65.20%	-63.60%
International exports	508,700	7,356,200	68,800
% change of exports in 2003 [a]	-69.90%	28.20%	-50.60%
Deaths and condemnations	634,800	1555,800	126,700
% change of deaths and condemnations 2003/2002 [a]	-1.00%	6.60%	1.00%

Note: Due to a single reported case of bovine spongiform encephalopathy (BSE) on May 20, 2003, the number of domestic cattle slaughtered, international imports and international exports plummeted in the weeks and months that followed. [1]Statistics Canada, Census of Agriculture- Cat. No. 23-012-XIE. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2003002.pdf. Accessed May. 2004; [2]Statistics Canada, Census of Agriculture- Cat. No. 23-010-XIE. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2004001.pdf. Accessed May 2004; [3]tatistics Canada, Census of Agriculture- Cat. No. 23-011-XIE. http://www.statcan.ca/english/freepup/23-011-XIE/23-011-XIE2003002.pdf. Accessed May 2004.
[a]Percent change was calculated by **[(2003-2002)/2002] *100.**

Table 23. Veterinary services in Canada, 2003.

Province	Total # Veterinary Practices	Total # Large Animal Practices
Ontario	1181	239
Québec	599	163
Alberta	373	203
Nova Scotia	81	26
Newfoundland and Labrador	19	5
Manitoba	118	55
New Brunswick	71	23
Prince Edward Island	13	8

Note: Large animal practices included any practices that had a large animal component. Data from British Columbia and Saskatchewan were not available.
Sources: College of Veterinarians of Ontario, http://www.cvo.org/regulat-acc-practices-details.cfm. Accessed May, 2004; Ordre des Medicins Veterinaires du Québec, http://www.omvq.qc.ca/regionsetliens.html. Accessed May 2004; Alberta Veterinary Medical Association, http://www.avma.ab.ca/directory/frame.htm. Accessed May 2004; Nova Scotia Veterinary Medical Association, http://www3.ns.sympatico.ca/nsvma/. Accessed May, 2004; Email correspondence, June, 2004, with Newfoundland & Labrador Veterinary Medical Association; Manitoba Veterinary Medical Association; New Brunswick Veterinary Medical Association; Prince Edward Island Veterinary Medical Association.

The demographic information provided in this section highlights the need for more current statistics on human health care availability, animal health care availability data across all provinces, and consideration of the spatial clustering of human and livestock populations for future epidemiological analysis of antimicrobial use and resistance.

A.3 Human Antimicrobial Resistance

Table 24. Details regarding human *Salmonella* isolates from *Enhanced Passive Surveillance* for 2003 (N=3056).

Specimen type n(%)	Gender n(%)	Age distribution n(%)	Province n(%)
Feces: 2000/3056 (65%) Blood: 152/3056 (5%) Urine: 3% (86) Other known source: 10/3056 (<1%) Unknown source: 807/3056 (26%)	Female: 1452/3056 (48%) Male: 1399/3056 (46%) Unknown: 172/3056 (6%)	Less than 5 years: 773/3056 (25%) 5 to 12 years: 329/3056 (11%) 13 to 17 years: 140/3056 (5%) 18 to 29 years: 481/3056 (16%) 30 to 49 years: 727/3056 (24%) 50 to 69years: 433/3056 (14%) 70 + years: 173/3056 (6%)	British Columbia: 395/3056 (13%) Alberta: 382/3056 (12%) Saskatchewan: 118/3056 (4%) Manitoba: 183/3056 (6%) Ontario: 1150/3056 (38%) Québec: 508/3056 (17%) New Brunswick: 135/3056 (4%) Nova Scotia: 127/3056 (4%) Prince Edward Island: 21/3056 (1%) Newfoundland and Labrador: 33/3056 (1%) Yukon: 1/3056 (<1%) Northwest Territories: 3/3056 (<1%)

Note: *For all the following MIC tables - * Roman numerals I-IV indicate the ranking of human health importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold font are the number of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of the antimicrobial. Red font indicates percentage of isolates resistant.*

Table 25. Distribution of MICs and resistance in *Salmonella* recovered from humans, *Enhanced Passive Surveillance* 2003.

*	Antimicrobial	Serovar	N	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	Enteritidis	352	0.5	1				0.3		59.9	38.1	0.6	0.6	0.3	**0.3**						>=8
	Ceftiofur	Heidelberg	613	0.5	1					0.2	73.7	3.1		0.7	0.7	**21.7**						>=8
	Ceftiofur	Newport	175	0.5	0.5					0.6	83.4	6.3				**9.7**						>=8
	Ceftiofur	Typhi	127	0.5	0.5				1.6	15.7	79.5	2.4				**0.8**						>=8
	Ceftiofur	Typhimurium	610	0.5	1				0.2		71.5	24.8	1.5	0.5		**1.6**						>=8
	Ceftiofur	Other serovars	1179	0.5	1					0.7	69.1	28.0	0.3	0.2	0.2	**1.5**						>=8
	Ceftriaxone	Enteritidis	352	<=0.25	<=0.25					99.1	0.6			0.3								>=64
	Ceftriaxone	Heidelberg	613	<=0.25	<=0.25					76.7	0.5		0.2	0.8	13.1	7.0	1.3	0.3	**0.2**			>=64
	Ceftriaxone	Newport	175	<=0.25	<=0.25					90.3					2.9	5.1	1.7					>=64
	Ceftriaxone	Typhi	127	<=0.25	<=0.25					99.2					0.8							>=64
	Ceftriaxone	Typhimurium	610	<=0.25	<=0.25					97.0	0.7		0.5	0.2	0.8	0.7	0.2					>=64
	Ceftriaxone	Other serovars	1179	<=0.25	<=0.25					97.7	0.3		0.1	0.2	1.4	0.3	0.1					>=64
	Ciprofloxacin	Enteritidis	352	<=0.015	<=0.015	79.8	1.1	0.6	15.9	2.6												>=4
	Ciprofloxacin	Heidelberg	613	<=0.015	<=0.015	97.4	1.3	0.2	0.7	0.5												>=4
	Ciprofloxacin	Newport	175	<=0.015	<=0.015	96.0			2.9	1.1												>=4
	Ciprofloxacin	Typhi	127	0.06	0.25	45.7		4.7	19.7	27.6	2.4											>=4
	Ciprofloxacin	Typhimurium	610	<=0.015	<=0.015	95.6	3.1	0.3	0.5			0.2			**0.3**							>=4
	Ciprofloxacin	Other serovars	1179	<=0.015	<=0.015	91.3	2.4	0.7	1.8	2.0	1.8	0.2										>=4
II	Amikacin	Enteritidis	352	1	1						32.7	61.1	5.1	1.1								>=64
	Amikacin	Heidelberg	613	1	1						10.9	75.9	11.9	1.3								>=64
	Amikacin	Newport	175	1	1						6.9	80.6	10.3	2.3								>=64
	Amikacin	Typhi	127	1	1						18.9	75.6	5.5									>=64
	Amikacin	Typhimurium	610	1	1						0.3	76.9	19.3	3.4								>=64
	Amikacin	Other serovars	1179	1	1						5.6	76.6	16.3	1.5								>=64
	Amoxicillin-Clavulanic Acid	Enteritidis	352	<=1	<=1							92.9	4.0	0.9	1.7		0.6					>=32/16
	Amoxicillin-Clavulanic Acid	Heidelberg	613	<=1	16							62.3	2.6	1.0	4.6	6.7	3.9	**18.9**				>=32/16
	Amoxicillin-Clavulanic Acid	Newport	175	<=1	<=1							86.9	0.6	1.1		1.7	1.1	**8.6**				>=32/16
	Amoxicillin-Clavulanic Acid	Typhi	127	<=1	<=1							84.3	3.9	6.3	4.7			**0.8**				>=32/16
	Amoxicillin-Clavulanic Acid	Typhimurium	610	<=1	16							53.1	3.1	0.8	8.7	31.5	1.0	**1.8**				>=32/16
	Amoxicillin-Clavulanic Acid	Other serovars	1179	<=1	<=1							87.8	4.6	0.9	2.6	2.1	0.6	**1.4**				>=32/16
	Gentamicin	Enteritidis	352	<=0.25	<=0.25					88.1	8.2	2.8	0.3	0.3		0.3						>=16
	Gentamicin	Heidelberg	613	<=0.25	0.5					74.6	11.6	8.0	0.3	0.2	1.1	2.8	**1.5**					>=16

*	Antimicrobial	Serovar	N	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
	Gentamicin	Newport	175	<=0.25	<=0.25					81.1	12.0	5.7			0.6	0.6						>=16
	Gentamicin	Typhi	127	<=0.25	<=0.25					96.9	2.4	0.8										>=16
	Gentamicin	Typhimurium	610	<=0.25	0.5					63.1	26.6	9.2				0.3	**0.8**					>=16
	Gentamicin	Other serovars	1179	<=0.25	0.5					71.1	18.3	8.4	0.1	0.2	0.2	0.8	**1.0**					>=16
	Kanamycin	Enteritidis	352	<=8	<=8										98.6			0.3	**1.1**			>=64
	Kanamycin	Heidelberg	613	<=8	<=8										95.9	0.5	0.2	0.3	**3.1**			>=64
	Kanamycin	Newport	175	<=8	<=8										94.3	0.6			**5.1**			>=64
	Kanamycin	Typhi	127	<=8	<=8										100							>=64
	Kanamycin	Typhimurium	610	<=8	<=8										80.3	0.5	0.2		**19.0**			>=64
	Kanamycin	Other serovars	1179	<=8	<=8										97.3	0.6		0.3	**1.9**			>=64
	Nalidixic Acid	Enteritidis	352	4	8							0.3	0.3	68.2	11.9	0.6		**18.8**				>=32
	Nalidixic Acid	Heidelberg	613	4	4									85.0	13.7	0.2		**1.1**				>=32
	Nalidixic Acid	Newport	175	4	4								1.1	91.4	4.0			**3.4**				>=32
	Nalidixic Acid	Typhi	127	8	>32								18.9	27.6	8.7	0.8		**44.1**				>=32
	Nalidixic Acid	Typhimurium	610	4	4								1.6	89.3	7.2	0.7		**1.1**				>=32
	Nalidixic Acid	Other serovars	1179	4	4								2.2	84.6	6.7	0.9	0.3	**5.3**				>=32
	Streptomycin	Enteritidis	352	<=32	<=32												98.6	0.3	**1.1**			>=64
II	Streptomycin	Heidelberg	613	<=32	<=32												87.9	5.4	**6.7**			>=64
	Streptomycin	Newport	175	<=32	<=32												90.3		**9.7**			>=64
	Streptomycin	Typhi	127	<=32	<=32												89.8	0.8	**9.4**			>=64
	Streptomycin	Typhimurium	610	<=32	64												61.5	25.9	**12.6**			>=64
	Streptomycin	Other serovars	1179	<=32	<=32												88.9	7.5	**3.6**			>=64
	Trimethoprim-Sulfamethoxazole	Enteritidis	352	<=0.12	<=0.12				92.3	6.3					**1.4**							>=4/76
	Trimethoprim-Sulfamethoxazole	Heidelberg	613	<=0.12	<=0.12				94.0	4.9		0.2		0.2	**0.8**							>=4/76
	Trimethoprim-Sulfamethoxazole	Newport	175	<=0.12	<=0.12				90.9	6.9	1.1				**1.1**							>=4/76
	Trimethoprim-Sulfamethoxazole	Typhi	127	<=0.12	<=0.12				86.6	3.1		0.8			**9.4**							>=4/76
	Trimethoprim-Sulfamethoxazole	Typhimurium	609	<=0.12	0.25				56.8	33.2	2.8	0.8	0.2	0.2	**6.1**							>=4/76
	Trimethoprim-Sulfamethoxazole	Other serovars	1179	<=0.12	<=0.12				89.5	5.3	1.0	0.1	0.1	0.3	**3.7**							>=4/76

*	Antimicrobial	Serovar	N	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
	Ampicillin	Enteritidis	352	2	2							45.5	49.7	2.0	0.6			2.3					>=32
	Ampicillin	Heidelberg	613	2	>32							47.0	16.6	1.0			0.2	35.2					>=32
	Ampicillin	Newport	175	<=1	2							73.7	12.6	0.6	0.6			12.6					>=32
	Ampicillin	Typhi	127	<=1	<=1							83.5	6.3					10.2					>=32
	Ampicillin	Typhimurium	610	2	>32							37.0	16.2	2.1	0.3		0.5	43.8					>=32
	Ampicillin	Other serovars	1179	<=1	2							73.1	17.6	2.0	0.2	0.1	0.1	7.0					>=32
	Cefoxitin	Enteritidis	352	2	2							4.3	88.6	6.0	0.9		0.3						>=32
	Cefoxitin	Heidelberg	613	2	4							33.4	41.4	2.9	0.5	0.5	21.2						>=32
	Cefoxitin	Newport	175	2	2							11.4	75.4	2.9	0.6		9.7						>=32
	Cefoxitin	Typhi	127	2	4						0.8	45.7	6.3	32.3	14.2		0.8						>=32
	Cefoxitin	Typhimurium	610	2	2							4.9	82.6	8.5	2.1	0.3	1.5						>=32
	Cefoxitin	Other serovars	1179	2	4							9.1	54.5	31.6	2.8	0.6	1.5						>=32
	Cephalothin	Enteritidis	352	<=2	<=2								78.1	17.9	3.1	0.3	0.3	0.3					>=32
	Cephalothin	Heidelberg	613	<=2	32								58.2	8.0	3.4	5.1	1.5	23.8					>=32
	Cephalothin	Newport	175	<=2	<=2								82.3	6.3	1.1		0.6	9.7					>=32
	Cephalothin	Typhi	127	<=2	<=2								81.1	14.2	3.9			0.8					>=32
	Cephalothin	Typhimurium	610	4	4								48.5	36.9	8.0	2.3	1.8	2.5					>=32
	Cephalothin	Other serovars	1179	<=2	4								66.8	26.2	3.5	1.2	0.4	2.0					>=32
III	Chloramphenicol	Enteritidis	352	4	8								0.3	57.1	41.8	0.3	0.3	0.3					>=32
	Chloramphenicol	Heidelberg	613	8	8									30.3	65.6	1.1	0.2	2.8					>=32
	Chloramphenicol	Newport	175	4	4								0.6	78.3	10.3	0.6		10.3					>=32
	Chloramphenicol	Typhi	127	4	4								2.4	78.7	7.9	0.8		10.2					>=32
	Chloramphenicol	Typhimurium	610	8	>32								1.0	41.1	24.3	1.6		32.0					>=32
	Chloramphenicol	Other serovars	1179	4	8								1.4	49.2	44.6	1.3	0.4	3.1					>=32
	Streptomycin	Enteritidis	352	<=16	<=16											88.4	9.4					2.3	>=512
	Streptomycin	Heidelberg	613	<=16	<=16											90.5	1.6				0.5	7.3	>=512
	Streptomycin	Newport	175	<=16	<=16											77.7	9.7		0.6			12.0	>=512
	Streptomycin	Typhi	127	<=16	<=16											89.0	1.6				2.4	7.1	>=512
	Streptomycin	Typhimurium	610	<=16	>512											52.8	2.5			0.2	1.3	43.3	>=512
	Streptomycin	Other serovars	1179	<=16	<=16											77.3	12.5	0.3		0.2	0.4	9.3	>=512
	Tetracycline	Enteritidis	352	4	4									96.6	0.3	0.6		2.6					>=16
	Tetracycline	Heidelberg	613	4	4									83.7	0.7	0.3	0.5	14.8					>=16
	Tetracycline	Newport	175	4	4									86.9	0.6		2.3	10.3					>=16
	Tetracycline	Typhi	127	4	4									90.6	0.8	0.8		7.9					>=16
	Tetracycline	Typhimurium	610	4	32									52.3	1.0	20.3	7.2	19.2					>=16
	Tetracycline	Other serovars	1179	4	4									80.0	0.7	1.4	7.4	10.5					>=16
IV																							

Table 26. Details regarding 'Other Serovars' by province for human *Salmonella* isolates.

Province	Serovar	n (%)
British Columbia	Hadar	13/169 (7.7%)
	Agona	12/169 (7.2%)
	Infantis	11/169 (6.6%)
	Paratyphi A	11/169 (6.6%)
	Saintpaul	11/169 (6.6%)
	Stanley	11/169 (6.6%)
	Anatum	6/169 (3.6%)
	Javiana	6/169 (3.6%)
	Oranienburg	6/169 (3.6%)
	ssp. 4,5,12:b:-	5/169 (3%)
	Braenderup	5/169 (3%)
	Mbandaka	5/169 (3%)
	Virchow	5/169 (3%)
	ssp. 4,5,12:i:-	4/169 (2.4%)
	Paratyphi B var. Java	4/169 (2.4%)
	Thompson	4/169 (2.4%)
	Uganda	4/169 (2.4%)
	"Less Common Serovars"	46/169 (27.2%)
Alberta	Hadar	14/107 (13.1%)
	Saintpaul	14/107 (13.1%)
	Agona	8/107 (7.5%)
	Infantis	7/107 (6.6%)
	Rubislaw	6/107 (5.7%)
	Javiana	5/107 (4.7)
	Schwarzengrund	4/107 (3.8%)
	Thompson	4/107 (3.8%)
	ssp. 4,5,12:i:-	3/107 (2.9%)
	Blockley	3/107 (2.9%)
	Oranienburg	3/107 (2.9%)
	Muenchen	2/107 (1.9%)

Province	Serovar	n (%)
Saskatchewan	Pomona	2/63 (3.2%)
	Schwarzengrund	2/63 (3.2%)
	"Less Common Serovars"	13/63 (20.6%)
Manitoba	ssp. 4,5,12:i:-	7/75 (9.4%)
	Agona	6/75 (8%)
	Saintpaul	5/75 (6.7%)
	Virchow	5/75 (6.7%)
	Mbandaka	4/75 (5.4%)
	Schwarzengrund	4/75 (5.4%)
	Thompson	4/75 (5.4%)
	Paratyphi B var. Java	3/75 (4%)
	ssp. 4,5,12:b:-	2/75 (2.7%)
	Bovismorbificans	2/75 (2.7%)
	Braenderup	2/75 (2.7%)
	Hadar	2/75 (2.7%)
	Kiambu	2/75 (2.7%)
	Montevideo	2/75 (2.7%)
	Muenchen	2/75 (2.7%)
	Oranienburg	2/75 (2.7%)
	Worthington	2/75 (2.7%)
	"Less Common Serovars"	19/75 (25.3%)
Ontario	Hadar	34/446 (7.7%)
	Thompson	34/446 (7.7%)
	Agona	30/446 (6.8%)
	Infantis	28/446 (6.3%)
	Muenchen	22/446 (5%)
	Braenderup	20/446 (4.5%)
	ssp. 4,5,12:b:-	18/446 (4.1%)
	Berta	14/446 (3.2%)

Province	Serovar	n (%)
	Paratyphi A	2/107 (1.9%)
	Stanley	2/107 (1.9%)
	ssp. IV 44:z4,z23:-	2/107 (1.9%)
	“Less Common Serovars”	28/107 (26.2%)
Saskatchewan	Hadar	15/63 (23.9%)
	Saintpaul	10/63 (15.9%)
	Agona	4/63 (6.4%)
	Muenchen	4/63 (6.4%)
	Infantis	3/63 (4.8%)
	Javiana	3/63 (4.8%)
	Oranienburg	3/63 (4.8%)
	ssp. 4,5,12:i:-	2/63 (3.2%)
	Braenderup	2/63 (3.2%)
Québec	Thompson	20/167 (12%)
	Hadar	18/167 (10.8%)
	Agona	13/167 (7.8%)
	Agona	13/167 (7.8%)
	Paratyphi B var. Java	12/167 (7.2%)
	Saintpaul	10/167 (6%)
	Infantis	9/167 (5.4%)
	ssp. 4,5,12:i:-	7/167 (4.2%)
	Braenderup	6/167 (3.6%)
	Hartford	5/167 (3%)
	Javiana	5/167 (3%)
	Muenchen	5/167 (3%)
	“Less Common Serovars”	57/167 (34.1%)
New Brunswick	Agona	9/50 (18%)
	Minnesota	9/50 (16%)
	Havana	6/50 (12%)
	Javiana	13/446 (3%)
	Anatum	11/446 (2.5%)
	ssp. 4,5,12:i:-	10/446 (2.3%)
	Oranienburg	10/446 (2.3%)
	Virchow	10/446 (2.3%)
	Mbandaka	9/446 (2.1%)
	Paratyphi A	9/446 (2.1%)
	Paratyphi B var. Java	9/446 (2.1%)
	“Less Common Serovars”	165/446 (37%)
Nova Scotia	Oranienburg	42/81 (51.9%)
	Thompson	16/81 (19.8%)
	ssp. 4,5,12:i:-	2/81 (2.5%)
	Brandenburg	2/81 (2.5%)
	Hadar	2/81 (2.5%)
	Javiana	2/81 (2.5%)
	“Less Common Serovars”	15/81 (18.5)
Prince Edward Island	Braenderup	2/10 (20%)
	Group B	2/10 (20%)
	ssp. 4,5,12:i:-	1/10 (10%)
	Infantis	1/10 (10%)
	Oranienburg	1/10 (10%)
	Paratyphi B var. Java	1/10 (10%)
	Saintpaul	1/10 (10%)
	Senftenberg	1/10 (10%)

Province	Serovar	n (%)
	Braenderup	3/50 (6%)
	Schwarzengrund	3/50 (6%)
	Thompson	3/50 (6%)
	Hadar	2/50 (4%)
	Miami	2/50 (4%)
	Uganda	2/50 (4%)
	ssp. 4,5,12:b:-	1/50 (2%)
	ssp. 4,5,12:i:-	1/50 (2%)
	Anatum	1/50 (2%)
	Bardo	1/50 (2%)
	Istanbul	1/50 (2%)
	Mississippi	1/50 (2%)
	Montevideo	1/50 (2%)
	Muenchen	1/50 (2%)
	Oranienburg	1/50 (2%)
	Paratyphi A	1/50 (2%)
	Paratyphi B var. Java	1/50 (2%)
	ssp IV 48:g,z51:-	1/50 (2%)
Newfoundland and Labrador	Agona	1/8 (12.5%)
	Brandenburg	1/8 (12.5%)
	Haardt	1/8 (12.5%)
	Hadar	1/8 (12.5%)
	Infantis	1/8 (12.5%)
	Montevideo	1/8 (12.5%)
	Paratyphi B var. Java	1/8 (12.5%)
	Sandiego	1/8 (12.5%)
Northwest Territories	Durban	1/3 (33.4%)
	Infantis	1/3 (33.4%)
	Thompson	1/3 (33.4%)

Note: *[a] Serovars with greater than 2% prevalence within a province are presented; serovars with less than 2% prevalence are categorized as "Less Common Serovars".*

A.4 Agri-Food Antimicrobial Resistance

Note: *For all the following MIC tables - * Roman numerals I-IV indicate the ranking of human health importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold font are the number of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of the antimicrobial. Red font indicates percentage of isolates resistant.*

Table 27. Distribution of MICs and resistance in generic *E. coli* recovered from beef cattle; *Abattoir Surveillance*.

*	Antimicrobial	n	MIC Percentiles 2002 Median	MIC Percentiles 2002 75th	MIC Percentiles 2003 Median	MIC Percentiles 2003 75th	Distribution (%) of MICs <=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	Resistance Breakpoint (µg/mL)
I	Ceftiofur	150	0.25	0.25	0.25	0.25				16.7	67.3	14.7				0.7	**0.7**							>=8
I	Ceftriaxone	150	<=0.25	<=0.25	<=0.25	<=0.25					98.7					0.7	0.7							>=64
I	Ciprofloxacin	150	<=0.015	<=0.015	<=0.015	<=0.015	100.0																	>=4
II	Amikacin	150	2	2	2	2						1.3	46.7	46.0	6.0									>=64
II	Amoxicillin-Clavulanic Acid	150	4	4	2	4							11.3	42.0	44.7	0.7		0.7	**0.7**					>=32/16
II	Gentamicin	150	1	1	0.5	1					18.7	46.0	32.0	2.0	0.7	0.7								>=16
II	Kanamycin	150	<=8	<=8	<=8	<=8										99.3	0.7							>=64
II	Nalidixic Acid	150	4	4	2	4						0.7	2.7	65.3	30.7	0.7								>=32
II	Streptomycin	150	<=32	<=32	<=32	<=32												88.0	8.0	**4.0**				>=64
II	Trimethoprim-Sulfamethoxazole	150	<=0.12	<=0.12	<=0.12	<=0.12				90.0	8.0	0.7				**1.3**								>=4/76
III	Ampicillin	150	2	4	2	4							13.3	40.7	40.7	1.3	0.7		**3.3**					>=32
III	Cefoxitin	150	4	8	4	4							0.7	29.3	52.7	14.7	0.7	**2.0**						>=32
III	Cephalothin	150	8	8	8	8								6.7	25.3	50.0	15.3	1.3	**1.3**					>=32
III	Chloramphenicol	150	4	8	4	8								6.0	53.3	38.0	0.7		**2.0**					>=32
III	Sulfamethoxazole	150	<=16	<=16	<=16	<=16											79.3	4.0	2.0			0.7	**14.0**	>=512
III	Tetracycline	150	<=4	8	<=4	16									66.7	5.3	4.0	2.0	**22.0**					>=16
IV																								

Table 28. Distribution of MICs and resistance in generic *E. coli* recovered from swine; *Abattoir Surveillance*.

	Antimicrobial	n	MIC Percentiles 2002 Median	MIC Percentiles 2002 75th	MIC Percentiles 2003 Median	MIC Percentiles 2003 75th	Distribution (%) of MICs <=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	Resistance Breakpoint (µg/mL)
	Ceftiofur	155	0.25	0.25	0.25	0.25				12.3	67.7	18.7	1.3											>=8
I	Ceftriaxone	155	<=0.25	<=0.25	<=0.25	<=0.25					100.0													>=64
	Ciprofloxacin	155	<=0.015	<=0.015	<=0.015	<=0.015	97.4	1.9			0.6													>=4
	Amikacin	155	2	2	2	2						3.2	41.3	49.7	5.8									>=64
	Amoxicillin-Clavulanic Acid	155	4	8	4	4							0.6	31.0	45.2	22.6	0.6							>=32/16
	Gentamicin	155	0.5	1	0.5	1					23.2	40.0	31.0	1.9			1.9	1.9						>=16
II	Kanamycin	155	<=8	<=8	<=8	<=8										84.5	3.2			12.3				>=64
	Nalidixic Acid	155	4	4	2	4							3.9	52.3	43.2				0.6					>=32
	Streptomycin	155	<=32	64	<=32	64												60.0	22.6	17.4				>=64
	Trimethoprim-Sulfamethoxazole	155	<=0.12	0.25	0.25	0.5				49.0	21.3	11.0	4.5			14.2								>=4/76
	Ampicillin	155	4	>32	4	>32							4.5	28.4	27.1	3.9	0.6	1.3	34.2					>=32
	Cefoxitin	155	4	4	4	4								29.0	48.4	21.3	0.6	0.6						>=32
	Cephalothin	155	8	8	8	16								1.3	27.1	41.3	27.7	1.9	0.6					>=32
III	Chloramphenicol	155	4	8	8	8								3.2	41.9	36.1	5.8	11.6	1.3					>=32
	Sulfamethoxazole	155	<=16	>512	>512	>512											40.0	1.9	0.6	0.6		1.3	55.5	>=512
	Tetracycline	155	>32	>32	>32	>32									16.8	1.3	1.3	7.1	73.5					>=16
IV																								

Table 29. Distribution of MICs and resistance in *Salmonella* recovered from swine; *Abattoir Surveillance*.

*	Antimicrobial	n	MIC Percentiles 2002 Median	MIC Percentiles 2002 75th	MIC Percentiles 2003 Median	MIC Percentiles 2003 75th	Distribution (%) of MICs <=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	Resistance Breakpoint (µg/mL)
I	Ceftiofur	395	0.5	1	0.5	1					0.5	61.0	35.4	2.8			0.3							>=8
	Ceftriaxone	395	<=0.25	<=0.25	<=0.25	<=0.25					99.7						0.3							>=64
	Ciprofloxacin	395	<=0.015	0.3	<=0.015	<=0.015	75.9	21.5	2.5															>=4
II	Amikacin	395	1	2	1	2						11.9	61.0	23.8	3.3									>=64
	Amoxicillin-Clavulanic Acid	395	<=1	2	<=1	<=1							79.2	3.3	1.8	9.9	5.6	0.3						>=32/16
	Gentamicin	395	<=0.25	0.5	<=0.25	0.5					61.5	17.0	19.7					1.8						>=16
	Kanamycin	395	<=8	<=8	<=8	<=8										89.1			0.8	10.1				>=64
	Nalidixic Acid	395	8	8	4	4								2.5	72.9	22.8	1.8							>=32
	Streptomycin	395	<=32	64	<=32	64												66.3	11.4	22.3				>=64
	Trimethoprim-Sulfamethoxazole	395	<=0.12	0.25	<=0.12	0.25				65.3	18.5	10.4	3.5			2.3								>=4/76
III	Ampicillin	395	2	4	<=1	2							65.1	14.2	2.5	0.5		0.3	17.5					>=32
	Cefoxitin	395	4	4	4	4							3.0	41.0	45.1	9.1	1.5	0.3						>=32
	Cephalothin	395	4	4	4	4								44.3	45.8	6.8	2.5	0.3	0.3					>=32
	Chloramphenicol	395	8	8	8	8									27.1	53.9	3.8		15.2					>=32
	Sulfamethoxazole	395	32	>512	<=16	>512											52.9	14.2	1.5		0.5	1.3	29.6	>=512
	Tetracycline	395	<=4	<=4	<=4	>32									55.2		7.1	4.8	32.9					>=16
IV																								

Table 30. Distribution of MICs and resistance in generic *E. coli* recovered from broiler chickens; *Abattoir Surveillance*.

*	Antimicrobial	n	MIC Percentiles 2002 Median	MIC Percentiles 2002 75th	MIC Percentiles 2003 Median	MIC Percentiles 2003 75th	Distribution (%) of MICs <=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	Resistance Breakpoint (µg/mL)
I	Ceftiofur	150	0.25	0.5	0.25	0.5				5.3	48.7	22.0	3.3		3.3	9.3	**8.0**							>=8
	Ceftriaxone	150	<=0.25	<=0.25	<=0.25	<=0.25					76.0	2.7	0.7		1.3	10.7	7.3	1.3						>=64
	Ciprofloxacin	150	<=0.015	<=0.015	<=0.015	<=0.015	94.7	1.3	1.3	1.3	1.3													>=4
II	Amikacin	150	2	2	2	2						2.7	38.0	49.3	10.0									>=64
	Amoxicillin-Clavulanic Acid	150	4	8	4	16							2.7	30.0	26.7	14.7	3.3	15.3	**7.3**					>=32/16
	Gentamicin	150	1	8	1	1					10.7	29.3	40.0	0.7	2.0	2.0	8.7	**6.7**						>=16
	Kanamycin	150	<=8	4	<=8	<=8										78.0	3.3		1.3	**17.3**				>=64
	Nalidixic Acid	150	>=4	>=4	2	4							3.3	62.0	28.0	2.7			**4.0**					>=32
	Streptomycin	150	64	>64	64	>64												47.3	22.0	**30.7**				>=64
	Trimethoprim-Sulfamethoxazole	150	<=0.12	0.25	<=0.12	0.25				66.7	16.7	8.7				**8.0**								>=4/76
III	Ampicillin	150	4	>32	4	>32							5.3	28.0	20.0	4.7	0.7	0.7	**40.7**					>=32
	Cefoxitin	150	8	16	4	8							0.7	13.3	40.0	23.3	0.7	**22.0**						>=32
	Cephalothin	150	8	16	16	32								2.0	16.0	31.3	22.0	4.0	**24.7**					>=32
	Chloramphenicol	150	4	8	4	8								4.0	59.3	26.7	0.7		**9.3**					>=32
	Sulfamethoxazole	150	<=16	>512	<=16	>512											54.0	2.7	2.0			4.0	**37.3**	>=512
	Tetracycline	150	>32	>32	>32	>32									31.3		2.0	2.7	**64.0**					>=16
IV																								

Table 31. Distribution of MICs and resistance in *Salmonella* recovered from broiler chickens; *Abattoir Surveillance.*

*	Antimicrobial	n	MIC Percentiles 2002 Median	MIC Percentiles 2002 75th	MIC Percentiles 2003 Median	MIC Percentiles 2003 75th	Distribution (%) of MICs <=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	Resistance Breakpoint (µg/mL)
	Ceftiofur	126	0.5	0.5	0.5	0.5					2.4	77.8	13.5				6.3							>=8
I	Ceftriaxone	126	<=0.25	<=0.25	<=0.25	<=0.25					92.9	0.8				0.8	3.2	1.6	0.8					>=64
	Ciprofloxacin	126	<=0.015	<=0.015	<=0.015	<=0.015	75.4	24.6																>=4
	Amikacin	126	1	1	1	1						20.6	55.6	20.6	3.2									>=64
	Amoxicillin-Clavulanic Acid	126	<=1	16	<=1	8							74.6			7.9	11.9	1.6	4.0					>=32/16
	Gentamicin	126	<=0.25	0.5	<=0.25	0.5					65.9	16.7	11.9	0.8			3.2	1.6						>=16
II	Kanamycin	126	<=8	<=8	<=8	<=8										96.0	0.8			3.2				>=64
	Nalidixic Acid	126	8	8	4	4								0.8	75.4	23.8								>=32
	Streptomycin	126	<=32	<=32	<=32	<=32												76.2	12.7	11.1				>=64
	Trimethoprim-Sulfamethoxazole	126	<=0.12	<=0.12	<=0.12	<=0.12				91.3	5.6	2.4				0.8								>=4/76
	Ampicillin	126	2	>32	<=1	4							61.9	11.9	0.8				25.4					>=32
	Cefoxitin	126	2	4	2	2							13.5	69.0	10.3	1.6		5.6						>=32
	Cephalothin	126	<=2	16	<=2	4								61.9	15.9	2.4	7.1	4.0	8.7					>=32
III	Chloramphenicol	126	8	8	8	8								4.8	40.5	52.4	0.8		1.6					>=32
	Sulfamethoxazole	126	<=16	<=16	<=16	<=16											77.8	12.7	0.8			0.8	7.9	>=512
	Tetracycline	126	<=4	<=4	<=4	<=4									81.0		1.6	11.9	5.6					>=16
IV																								

Table 32. Distribution of MICs and resistance in generic *E. coli* recovered from ground beef in Ontario and Québec; *Retail Surveillance*.

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
	Ceftiofur	ON	100	0.25	0.5				7.0	63.0	25.0	2.0		1.0	2.0								>=8
	Ceftiofur	QC	84	0.25	0.25				15.5	71.4	9.5	2.4	1.2										>=8
I	Ceftriaxone	ON	100	<=0.25	<=0.25					98.0				1.0	1.0								>=64
	Ceftriaxone	QC	84	<=0.25	<=0.25					98.8			1.2										>=64
	Ciprofloxacin	ON	100	<=0.015	<=0.015	99.0	1.0																>=4
	Ciprofloxacin	QC	84	<=0.015	<=0.015	97.6	1.2		1.2														>=4
	Amikacin	ON	100	2	2						1.0	41.0	47.0	11.0									>=64
	Amikacin	QC	84	2	2							41.7	51.2	6.0	1.2								>=64
	Amoxicillin-Clavulanic Acid	ON	100	4	4							3.0	39.0	51.0	3.0	1.0	2.0	1.0					>=32/16
	Amoxicillin-Clavulanic Acid	QC	84	4	4							6.0	31.0	52.4	9.5		1.2						>=32/16
	Gentamicin	ON	100	0.5	0.5					16.0	68.0	15.0	1.0										>=16
II	Gentamicin	QC	84	0.5	1					8.3	65.5	23.8	1.2			1.2							>=16
	Kanamycin	ON	100	<=8	<=8										98.0				2.0				>=64
	Kanamycin	QC	84	<=8	<=8										97.6				2.4				>=64
	Nalidixic Acid	ON	100	2	4							4.0	60.0	35.0	1.0								>=32
	Nalidixic Acid	QC	84	2	4						1.2	4.8	64.3	27.4	1.2			1.2					>=32
	Streptomycin	ON	100	<=32	<=32												89.0	5.0	6.0				>=64
	Streptomycin	QC	84	<=32	<=32												92.9	4.8	2.4				>=64
	Trimethoprim-Sulfamethoxazole	ON	100	<=0.12	<=0.12				79.0	18.0	1.0				2.0								>=4/76
	Trimethoprim-Sulfamethoxazole	QC	84	<=0.12	<=0.12				89.3	8.3	1.2				1.2								>=4/76
	Ampicillin	ON	100	4	4							6.0	43.0	35.0	7.0	1.0		8.0					>=32
	Ampicillin	QC	84	2	4							9.5	42.9	35.7	4.8			7.1					>=32
	Cefoxitin	ON	100	4	4							2.0	17.0	69.0	8.0	1.0	3.0						>=32
	Cefoxitin	QC	84	4	4							2.4	23.8	63.1	8.3	2.4							>=32
	Cephalothin	ON	100	8	8								1.0	26.0	54.0	15.0	1.0	3.0					>=32
III	Cephalothin	QC	84	8	8								1.2	16.7	59.5	20.2	2.4						>=32
	Chloramphenicol	ON	100	4	8								4.0	51.0	40.0	2.0	1.0	2.0					>=32
	Chloramphenicol	QC	84	4	8								9.5	53.6	34.5	1.2		1.2					>=32
	Sulfamethoxazole	ON	100	<=16	<=16											84.0	2.0					14.0	>=512
	Sulfamethoxazole	QC	84	<=16	<=16											88.1	2.4			2.4		7.1	>=512
	Tetracycline	ON	100	<=4	8									70.0	7.0	6.0	3.0	14.0					>=16
	Tetracycline	QC	84	<=4	<=4									78.6	2.4	2.4	2.4	14.3					>=16
IV																							

Table 33 Distribution of MICs and resistance in generic *E. coli* recovered from pork in Ontario and Québec; *Retail Surveillance*.

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	ON	91	0.25	0.25				14.3	64.8	15.4	3.3		1.1	1.1								>=8
	Ceftiofur	QC	61	0.25	0.5				9.8	59.0	26.2	3.3		1.6									>=8
	Ceftriaxone	ON	91	<=0.25	<=0.25					96.7	1.1				2.2								>=64
	Ceftriaxone	QC	61	<=0.25	<=0.25					95.1		1.6		1.6		1.6							>=64
	Ciprofloxacin	ON	91	<=0.015	<=0.015	95.6	4.4																>=4
	Ciprofloxacin	QC	61	<=0.015	<=0.015	90.2	9.8																>=4
II	Amikacin	ON	91	1	2						1.1	50.5	36.3	12.1									>=64
	Amikacin	QC	61	2	2							29.5	57.4	11.5	**1.6**								>=64
	Amoxicillin-Clavulanic Acid	ON	91	4	4							3.3	33.0	44.0	12.1	1.1	4.4	**2.2**					>=32/16
	Amoxicillin-Clavulanic Acid	QC	61	4	4							4.9	42.6	31.1	16.4	3.3		**1.6**					>=32/16
	Gentamicin	ON	91	0.5	1					25.3	44.0	27.5	1.1		1.1	1.1							>=16
	Gentamicin	QC	61	0.5	1					11.5	59.0	21.3	6.6			1.6							>=16
	Kanamycin	ON	91	<=8	<=8										92.3	1.1	1.1	1.1	**4.4**				>=64
	Kanamycin	QC	61	<=8	<=8										95.1	1.6		1.6	**1.6**				>=64
	Nalidixic Acid	ON	91	2	4						1.1	5.5	57.1	34.1	2.2								>=32
	Nalidixic Acid	QC	61	2	4							4.9	62.3	24.6	8.2								>=32
	Streptomycin	ON	91	<=32	<=32												83.5	6.6	**9.9**				>=64
	Streptomycin	QC	61	<=32	64												72.1	11.5	**16.4**				>=64
	Trimethoprim-Sulfamethoxazole	ON	91	<=0.12	0.25				64.8	17.6	12.1		1.1		**4.4**								>=4/76
	Trimethoprim-Sulfamethoxazole	QC	61	<=0.12	0.25				70.5	11.5	8.2				**9.8**								>=4/76
III	Ampicillin	ON	91	4	8							8.8	38.5	26.4	3.3	3.3	1.1	**18.7**					>=32
	Ampicillin	QC	61	2	8							6.6	45.9	18.0	8.2	1.6		**19.7**					>=32
	Cefoxitin	ON	91	4	4							1.1	33.0	50.5	8.8	3.3	**3.3**						>=32
	Cefoxitin	QC	61	4	4								29.5	45.9	14.8	3.3	**6.6**						>=32
	Cephalothin	ON	91	8	8								3.3	23.1	53.8	12.1	1.1	**6.6**					>=32
	Cephalothin	QC	61	8	16								1.6	27.9	37.7	23.0	6.6	**3.3**					>=32
	Chloramphenicol	ON	91	4	8								8.8	50.5	29.7	3.3	7.7						>=32
	Chloramphenicol	QC	61	4	8								6.6	54.1	19.7	9.8	8.2	**1.6**					>=32
	Sulfamethoxazole	ON	91	<=16	>512											68.1	2.2				1.1	**28.6**	>=512
	Sulfamethoxazole	QC	61	<=16	>512											63.9		4.9			1.6	**29.5**	>=512
	Tetracycline	ON	91	32	>32									44.0	1.1	3.3	9.9	**41.8**					>=16
	Tetracycline	QC	61	8	>32									49.2	3.3		4.9	**42.6**					>=16
IV																							

Table 34 Distribution of MICs and resistance in generic *E. coli* recovered from chicken in Ontario and Québec; *Retail Surveillance*.

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs															Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
	Ceftiofur	ON	136	0.25	0.5				5.1	50.0	20.6	2.9	1.5	2.2	9.6	8.1						>=8
	Ceftiofur	QC	112	0.5	8				5.4	35.7	13.4	2.7	0.9	8.9	25.0	8.0						>=8
I	Ceftriaxone	ON	136	<=0.25	<=0.25					77.2	0.7	2.2		2.2	9.6	8.1						>=64
	Ceftriaxone	QC	112	<=0.25	8					53.6	1.8	2.7	1.8	7.1	23.2	9.8						>=64
	Ciprofloxacin	ON	136	<=0.015	<=0.015	98.7	0.7			1.5												>=4
	Ciprofloxacin	QC	112	<=0.015	<=0.015	96.4	1.8	1.8														>=4
	Amikacin	ON	136	2	2						0.7	34.6	55.1	9.6								>=64
	Amikacin	QC	112	2	2						1.8	32.1	56.3	9.8								>=64
	Amoxicillin-Clavulanic Acid	ON	136	4	8							6.6	27.2	33.8	7.4	0.7	13.2	11.0				>=32/16
	Amoxicillin-Clavulanic Acid	QC	112	4	32							4.5	22.3	25.0	5.4	0.9	23.2	18.8				>=32/16
	Gentamicin	ON	136	0.5	1					15.4	55.1	20.6	0.7		1.5	3.7	2.9					>=16
II	Gentamicin	QC	112	0.5	1					12.5	45.5	19.6	1.8	0.9	1.8	4.5	13.4					>=16
	Kanamycin	ON	136	<=8	<=8										91.2			1.5	7.4			>=64
	Kanamycin	QC	112	<=8	<=8										84.8	4.5		1.8	8.9			>=64
	Nalidixic Acid	ON	136	2	4							3.7	65.4	27.9	1.5			1.5				>=32
	Nalidixic Acid	QC	112	2	4						0.9	4.5	61.6	29.5	2.7	0.9						>=32
	Streptomycin	ON	136	<=32	>64												68.4	12.5	19.1			>=64
	Streptomycin	QC	112	<=32	>64												51.8	18.8	29.5			>=64
	Trimethoprim-Sulfamethoxazole	ON	136	<=0.12	0.25				72.1	15.4	7.4	0.7	0.7		3.7							>=4/76
	Trimethoprim-Sulfamethoxazole	QC	112	<=0.12	0.25				52.7	24.1	8.0	2.7	0.9	0.9	10.7							>=4/76
	Ampicillin	ON	136	4	>32							8.8	27.2	24.3	4.4			35.3				>=32
	Ampicillin	QC	112	8	>32							8.9	19.6	18.8	2.7			50.0				>=32
	Cefoxitin	ON	136	4	8							0.7	14.0	53.7	8.1	1.5	22.1					>=32
	Cefoxitin	QC	112	6	>16							0.9	11.6	37.5	6.3		43.8					>=32
	Cephalothin	ON	136	8	32								0.7	17.6	37.5	18.4	1.5	24.3				>=32
III	Cephalothin	QC	112	16	>32								0.9	10.7	30.4	11.6	1.8	44.6				>=32
	Chloramphenicol	ON	136	4	8								4.4	62.5	27.2	0.7		5.1				>=32
	Chloramphenicol	QC	112	6	8								3.6	46.4	28.6	3.6	1.8	16.1				>=32
	Sulfamethoxazole	ON	136	<=16	32											72.8	2.2	0.7			24.3	>=512
	Sulfamethoxazole	QC	112	<=16	>512											56.3	0.9				41.1	>=512
	Tetracycline	ON	136	16	>32									47.1	2.2	2.2	11.0	37.5				>=16
	Tetracycline	QC	112	32	>32									41.1	1.8	3.6	16.1	37.5				>=16
IV																						

Table 35 Distribution of MICs and resistance in *Salmonella* recovered from chicken in Ontario and Québec; *Retail Surveillance.*

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	ON	26	0.5	0.5						76.9	11.5			3.8	7.7							>=8
	Ceftiofur	QC	28	1	16					3.6	39.3	7.1				50.0							>=8
	Ceftriaxone	ON	26	<=0.25	<=0.25					88.5					3.8	7.7							>=64
	Ceftriaxone	QC	28	0.5	16					46.4	3.6				3.6	32.1	14.3						>=64
	Ciprofloxacin	ON	26	<=0.015	0.03	61.5	38.5																>=4
	Ciprofloxacin	QC	28	<=0.015	0.03	64.3	32.1	3.6															>=4
II	Amikacin	ON	26	1	1							84.6	11.5	3.8									>=64
	Amikacin	QC	28	1	2							53.6	42.9	3.6									>=64
	Amoxicillin-Clavulanic Acid	ON	26	<=1	<=1							80.8			7.7		3.8	7.7					>=32/16
	Amoxicillin-Clavulanic Acid	QC	28	32	>32							39.3			10.7		14.3	35.7					>=32/16
	Gentamicin	ON	26	<=0.25	0.5					57.7	30.8	7.7					3.8						>=16
	Gentamicin	QC	28	0.5	1					25.0	46.4	25.0					3.6						>=16
	Kanamycin	ON	26	<=8	<=8										96.2	3.8							>=64
	Kanamycin	QC	28	<=8	<=8										100.0								>=64
	Nalidixic Acid	ON	26	4	8									57.7	42.3								>=32
	Nalidixic Acid	QC	28	4	8								7.1	50.0	42.9								>=32
	Streptomycin	ON	26	<=32	<=32												96.2		3.8				>=64
	Streptomycin	QC	28	<=32	<=32												78.6	3.6	17.9				>=64
	Trimethoprim-Sulfamethoxazole	ON	26	<=0.12	<=0.12				96.2	3.8													>=4/76
	Trimethoprim-Sulfamethoxazole	QC	28	<=0.12	<=0.12				89.3	10.7													>=4/76
III	Ampicillin	ON	26	<=1	2							73.1	7.7					19.2					>=32
	Ampicillin	QC	28	>32	>32							32.1	7.1					60.7					>=32
	Cefoxitin	ON	26	2	4							7.7	65.4	15.4		3.8	7.7						>=32
	Cefoxitin	QC	28	4	>16							3.6	42.9	3.6			50.0						>=32
	Cephalothin	ON	26	<=2	4								57.7	23.1			3.8	15.4					>=32
	Cephalothin	QC	28	16	>32								32.1	7.1		10.7		50.0					>=32
	Chloramphenicol	ON	26	4	8									57.7	42.3								>=32
	Chloramphenicol	QC	28	8	8								7.1	35.7	57.1								>=32
	Sulfamethoxazole	ON	26	<=16	<=16											92.3	3.8					3.8	>=512
	Sulfamethoxazole	QC	28	<=16	<=16											96.4	3.6						>=512
	Tetracycline	ON	26	<=4	<=4									100.0									>=16
	Tetracycline	QC	28	<=4	<=4									75.0	3.6	3.6	7.1	10.7					>=16
IV																							

Table 36 Distribution of MICs and resistance in *Campylobacter* spp. recovered from chicken in Ontario and Québec; *Retail Surveillance.*

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
				Median	75th	<=0.012	0.016	0.024	0.032	0.047	0.064	0.094	0.125	0.19	0.25	0.38	0.5	0.75	1	1.5	2	3	
I	Ciprofloxacin	ON	78	0.047	0.064	3.8	3.8	16.7	23.1	20.5	9.0	5.1	9.0	1.3	3.8								>=4
	Ciprofloxacin	QC	94	0.032	0.064	1.1	6.4	12.8	35.1	12.8	9.6	3.2	4.3	6.4	2.2	2.2		1.1					>=4
II	Azithromycin	ON	78	0.064	0.125		1.3	2.6	20.5	15.4	17.9	12.8	5.1	6.4	1.3		1.3	3.8		1.3		1.3	>=2
	Azithromycin	QC	94	0.064	1			5.3	17.0	12.8	18.1	9.6	4.3	1.1	3.2		1.1	2.1	2.1			1.1	>=2
	Clindamycin	ON	78	0.125	0.25		1.3	1.3	3.8	11.5	10.3	7.7	21.8	9.0	9.0	5.1	5.1	3.8	1.3		1.3		>=4
	Clindamycin	QC	94	0.19	1			1.1	2.1	8.5	13.8	13.8	6.4	9.6	6.4	4.3	3.2	3.2	4.3	1.1	2.1	1.1	>=4
	Erythromycin	ON	78	0.5	0.75						1.3		3.8	12.8	10.3	20.5	17.9	10.3	7.7	5.1			>=8
	Erythromycin	QC	94	0.5	2								2.1	8.5	20.2	16.0	9.6	8.5	4.3	3.2	3.2	1.1	>=8
	Gentamicin	ON	78	0.38	0.5			1.3				1.3	5.1	15.4	25.6	23.1	11.5	7.7	2.6	1.3	2.6		>=16
	Gentamicin	QC	94	0.25	0.5						2.1		5.3	12.8	30.9	23.4	13.8	3.2	2.1	1.1	1.1	1.1	>=16
	Nalidixic Acid	ON	78	1.5	3						2.6					1.3	1.3	11.5	23.1	16.7	16.7	5.1	>=32
	Nalidixic Acid	QC	94	1.5	3		1.1						1.1				2.1	3.2	21.3	34.0	11.7	7.4	>=32
III	Chloramphenicol	ON	78	0.75	1							3.8		3.8	9.0	14.1	15.4	21.8	11.5	6.4	9.0		>=32
	Chloramphenicol	QC	94	0.75	1.5							1.1	3.2	4.3	2.1	9.6	16.0	22.3	14.9	11.7	7.4	2.1	>=32
	Tetracycline	ON	78	>256	>256				2.6	5.1	7.7	6.4	6.4	3.8	6.4			2.6				1.3	>=16
	Tetracycline	QC	94	>256	>256			1.1	1.1	5.3	5.3	1.1	6.4		3.2	1.1	3.2			2.1			>=16
IV																							

*	Antimicrobial	Province	n	MIC Percentiles		Distribution (%) of MICs											Resistance Breakpoint (µg/mL)
				Median	75th	4	6	8	12	16	24	32	48	64	128	256	>256	
I	Ciprofloxacin	ON	78	0.047	0.064	1.3	1.3							1.3				>=4
	Ciprofloxacin	QC	94	0.032	0.064							1.1					2.1	>=4
II	Azithromycin	ON	78	0.064	0.125							1.3					7.7	>=2
	Azithromycin	QC	94	0.064	1												22.3	>=2
	Clindamycin	ON	78	0.125	0.25					2.6	1.3		1.3	1.3			1.3	>=4
	Clindamycin	QC	94	0.19	1	1.1	1.1	3.2	1.1	1.1	2.1	2.1	2.1		1.1		4.3	>=4
	Erythromycin	ON	78	0.5	0.75		1.3										9.0	>=8
	Erythromycin	QC	94	0.5	2		1.1										22.3	>=8
	Gentamicin	ON	78	0.38	0.5	1.3		1.3										>=16
	Gentamicin	QC	94	0.25	0.5	1.1		1.1									1.1	>=16
	Nalidixic Acid	ON	78	1.5	3	1.3	3.8	2.6	3.8				1.3				9.0	>=32
	Nalidixic Acid	QC	94	1.5	3	3.2	1.1	4.3	2.1	2.1							5.3	>=32
III	Chloramphenicol	ON	78	0.75	1	1.3	1.3	1.3					1.3					>=32
	Chloramphenicol	QC	94	0.75	1.5		1.1	3.2	1.1									>=32
	Tetracycline	ON	78	>256	>256				1.3		1.3					1.3	53.8	>=16
	Tetracycline	QC	94	>256	>256							2.1	1.1	3.2	1.1		62.8	>=16
IV																		

Note : *Results falling between serial twofold dilutions should be rounded up to the next highest concentration (NCCLS M100-S14).*

Table 37 Details regarding the data obtained from the *Passive Surveillance* of clinical *Salmonella* in animals.

Zoological species n (%)	Specimen source n (%)	Province n (%)
Cattle: 234/409 (57%)	Organs: 27/409 (7%)	Alberta: 8/409 (2%)
Swine: 107/409 (26%)	Intestine, intestinal contents, feces : 328/409 (80%)	Manitoba: 60/409 (15%)
Chicken: 32/409 (8%)	Other: 41/409 (10%)	Ontario: 323/409 (79%)
Turkey: 36/409 (9%)	Unknown or Missing: 13/409 (3%)	New Brunswick: 4/409 (1%)
		Nova Scotia: 10/409 (2%)
		Prince Edward Island: 2/409 (0.5%)
		Missing: 2/409 (0.5%)

Table 38 Distribution of MICs and resistance in *Salmonella* recovered from cattle; *Passive Surveillance.*

*	Antimicrobial	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
			Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	234	1	16					0.4	44.4	12.0	0.4		1.3	41.5							>=8
	Ceftriaxone	234	<=0.25	16					57.3					2.1	29.5	10.3	0.9					>=64
	Ciprofloxacin	234	<=0.015	<=0.015	98.7	0.9	0.4															>=4
II	Amikacin	234	1	2						8.5	65.0	22.6	3.8									>=64
	Amoxicillin-Clavulanic Acid	234	16	>32							34.6			6.0	16.7		42.7					>=32/16
	Gentamicin	234	<=0.25	0.5					50.9	25.2	15.4	0.9			4.3	3.4						>=16
	Kanamycin	234	<=8	>64										56.0				44.0				>=64
	Nalidixic Acid	234	4	4								3.8	89.7	6.0	0.4							>=32
	Streptomycin	234	>64	>64												35.5	14.1	50.4				>=64
	Trimethoprim-Sulfamethoxazole	234	0.25	0.25				32.1	45.3	7.3				15.4								>=4/76
III	Ampicillin	234	>32	>32							30.3	4.3					65.4					>=32
	Cefoxitin	234	4	>16							1.7	41.9	9.4	3.8	1.7	41.5						>=32
	Cephalothin	234	8	>32								26.9	20.5	6.8	0.9	0.9	44.0					>=32
	Chloramphenicol	234	>32	>32								3.8	17.9	17.5			60.7					>=32
	Sulfamethoxazole	234	>512	>512											25.2	8.1				0.4	66.2	>=512
	Tetracycline	234	>32	>32									31.6		3.8	11.5	53.0					>=16
IV																						

Table 39 Distribution of MICs and resistance in *Salmonella* recovered from swine; *Passive Surveillance.*

*	Antimicrobial	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (ug/mL)
			Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	107	0.5	1						57.0	38.3	2.8			1.9							>=8
	Ceftriaxone	107	<=0.25	<=0.25					98.1					0.9	0.9							>=64
	Ciprofloxacin	107	<=0.015	<=0.015	94.4	3.7	1.9															>=4
II	Amikacin	107	1	2						1.9	65.4	29.0	3.7									>=64
	Amoxicillin-Clavulanic Acid	107	4	16							43.9	4.7	2.8	13.1	32.7	0.9	1.9					>=32/16
	Gentamicin	107	0.5	1					42.1	30.8	23.4			0.9	1.9	0.9						>=16
	Kanamycin	107	<=8	<=8										86.0				14.0				>=64
	Nalidixic Acid	107	4	4								4.7	86.9	8.4								>=32
	Streptomycin	107	64	64												42.1	34.6	23.4				>=64
	Trimethoprim-Sulfamethoxazole	107	0.25	0.25				31.8	47.7	12.1	1.9			6.5								>=4/76
III	Ampicillin	107	>32	>32							35.5	9.3	1.9			0.9	52.3					>=32
	Cefoxitin	107	2	4								71.0	21.5	4.7	0.9	1.9						>=32
	Cephalothin	107	4	4								31.8	53.3	10.3	2.8		1.9					>=32
	Chloramphenicol	107	8	>32									7.5	48.6	2.8		41.1					>=32
	Sulfamethoxazole	107	>512	>512											26.2	10.3				0.9	62.6	>=512
	Tetracycline	107	32	>32									33.6		7.5	26.2	32.7					>=16
IV																						

Table 40 Distribution of MICs and resistance in *Salmonella* recovered from chickens; *Passive Surveillance.*

*	Antimicrobial	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
			Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	32	0.5	0.5						78.1	12.5				9.4							>=8
	Ceftriaxone	32	<=0.25	<=0.25					90.6					6.3	3.1							>=64
	Ciprofloxacin	32	<=0.015	<=0.015	93.8	6.3																>=4
II	Amikacin	32	1	1						25.0	50.0	25.0										>=64
	Amoxicillin-Clavulanic Acid	32	<=1	8							65.6			9.4	15.6		9.4					>=32/16
	Gentamicin	32	<=0.25	0.5					65.6	18.8	9.4	3.1				3.1						>=16
	Kanamycin	32	<=8	<=8										93.8		3.1		3.1				>=64
	Nalidixic Acid	32	4	4								3.1	84.4	12.5								>=32
	Streptomycin	32	<=32	<=32												75.0	25.0					>=64
	Trimethoprim-Sulfamethoxazole	32	<=0.12	<=0.12				84.4	12.5	3.1												>=4/76
III	Ampicillin	32	2	>32							46.9	18.8					34.4					>=32
	Cefoxitin	32	2	2							9.4	71.9	9.4			9.4						>=32
	Cephalothin	32	2	16								50.0	15.6	6.3	9.4	6.3	12.5					>=32
	Chloramphenicol	32	8	8									31.3	65.6			3.1					>=32
	Sulfamethoxazole	32	<=16	<=16											87.5	3.1					9.4	>=512
	Tetracycline	32	<=4	<=4									87.5		3.1	6.3	3.1					>=16
IV																						

Table 41 Distribution of MICs and resistance in *Salmonella* recovered from turkeys; *Passive Surveillance*.

*	Antimicrobial	n	MIC Percentiles		Distribution (%) of MICs																Resistance Breakpoint (µg/mL)
			Median	75th	<=0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512	
I	Ceftiofur	36	0.5	1						50.0	33.3				16.7							>=8
	Ceftriaxone	36	<=0.25	<=0.25					83.3						13.9	2.8						>=64
	Ciprofloxacin	36	<=0.015	<=0.015	97.2			2.8														>=4
II	Amikacin	36	1	2						5.6	55.6	33.3	5.6									>=64
	Amoxicillin-Clavulanic Acid	36	<=1	16							52.8				30.6		16.7					>=32/16
	Gentamicin	36	8	>16					22.2	8.3	8.3	5.6		5.6	5.6	44.4						>=16
	Kanamycin	36	<=8	64										52.8		13.9	11.1	22.2				>=64
	Nalidixic Acid	36	4	4									91.7	2.8	5.6							>=32
	Streptomycin	36	<=32	>64												52.8	16.7	30.6				>=64
	Trimethoprim-Sulfamethoxazole	36	<=0.12	<=0.12				75.0	19.4	5.6												>=4/76
III	Ampicillin	36	>32	>32							44.4	8.3					47.2					>=32
	Cefoxitin	36	4	4							8.3	27.8	47.2			16.7						>=32
	Cephalothin	36	4	32								36.1	16.7			30.6	16.7					>=32
	Chloramphenicol	36	4	8									50.0	50.0								>=32
	Sulfamethoxazole	36	<=16	32											72.2	5.6				2.8	19.4	>=512
	Tetracycline	36	<=4	>32									55.6	2.8			41.7					>=16
IV																						

A.5. Antimicrobial Use - Human

Table 42 Defined daily doses of systemic antimicrobials dispensed, 2001-2003.

Human Health Importance	ATC Class		Total DDD (%)						DDDs/inhabitant-years			DDDs/1000 inhabitant-days		
			2001		2002		2003		2001	2002	2003	2001	2002	2003
I	J01DA	Third and Fourth generation cephalosporins	1,040,733.05	0.5	940,586.25	0.5	821,732.88	0.4	0.034	0.030	0.026	0.092	0.082	0.071
	J01DH	Carbapenems	836.25	0.0	484.50	0.0	1,091.00	0.0	0.000	0.000	0.000	0.000	0.000	0.000
	J01MA	Fluoroquinolones	21,900,694.90	10.48	22,698,794.90	11.2	24,030,135.20	11.70	0.708	0.726	0.762	1.940	1.989	2.088
	J01XA	Glycopeptides	19,838.13	0.0	23,817.81	0.0	58,744.69	0.0	0.001	0.001	0.002	0.002	0.002	0.005
	J01FG	Streptogramins	-	0.0	4.33	0.0	-	0.0	0.000	0.000	0.000	0.000	0.000	0.000
II	J01CA	Penicillins with extended spectrum	60,636,610.76	29.0	55,871,945.33	27.7	54,745,562.99	26.6	1.961	1.787	1.736	5.372	4.897	4.757
	J01CF	ß-lactamase resistant penicillins	4,008,083.61	1.9	3,689,784.56	1.8	3,573,099.00	1.7	0.130	0.118	0.113	0.355	0.323	0.311
	J01CR	Combinations of penicillins	512,427.34	0.25	2,686,238.78	1.33	3,932,213.11	1.91	0.017	0.086	0.125	0.045	0.235	0.342
	J01EE	Combinations of sulfonamides and trimethoprim	11,351,069.58	5.4	10,292,153.48	5.1	9,635,441.52	4.7	0.367	0.329	0.306	1.006	0.902	0.837
	J01FA	Macrolides	40,943,717.46	19.6	39,077,937.87	19.3	41,189,259.84	20.0	1.324	1.250	1.306	3.628	3.425	3.579
	J01FF	Lincosamides	3,042,903.06	1.5	3,296,770.66	1.6	3,596,427.24	1.8	0.098	0.105	0.114	0.270	0.289	0.313
	J01GA	Streptomycin	218.00	0.0	95.00	0.0	338.00	0.0	0.000	0.000	0.000	0.000	0.000	0.000
	J01GB	Other aminoglycosides	431,884.80	0.2	375,409.99	0.2	316,793.68	0.2	0.014	0.012	0.010	0.038	0.033	0.028
	J01MB	Other quinolones	15,548.50	0.0	13,030.50	0.0	11,338.38	0.0	0.001	0.000	0.000	0.001	0.001	0.001
	J01RA	Combinations of antibacterials	238,787.37	0.1	156,411.96	0.1	105,394.33	0.1	0.008	0.005	0.003	0.021	0.014	0.009
III	J01AA	Tetracyclines	29,543,962.13	14.1	29,046,391.98	14.4	28,801,051.38	14.0	0.955	0.929	0.914	2.618	2.546	2.503
	J01B	Amphenicols	419.58	0.0	94.67	0.0	75.33	0.0	0.000	0.000	0.000	0.000	0.000	0.000
	J01CE	ß-lactamase sensitive penicillins	6,903,452.28	3.3	6,652,056.74	3.3	6,810,972.05	3.3	0.223	0.213	0.216	0.612	0.583	0.592
	J01DA	First and Second generation cephalosporins	22,454,813.95	10.7	21,136,824.35	10.5	21,408,660.12	10.4	0.726	0.676	0.679	1.990	1.852	1.860
	J01EA	Trimethoprim and derivatives	743,221.50	0.4	775,842.25	0.4	768,348.75	0.4	0.024	0.025	0.024	0.066	0.068	0.067
	J01EB	Short-acting sulfonamides	10,756.88	0.0	805.25	0.0	257.50	0.0	0.000	0.000	0.000	0.001	0.000	0.000

Human Health Importance	ATC Class		Total DDD (%)						DDDs/inhabitant-years			DDDs/1000 inhabitant-days		
			2001		2002		2003		2001	2002	2003	2001	2002	2003
	J01EC	Intermediate-acting sulfonamides	7,232.25	0.0	7,206.57	0.0	8,763.75	0.0	0.000	0.000	0.000	0.001	0.001	0.001
IV	J01XB	Polymyxins Total	-	0.0	3,988.50	0.0	40,806.00	0.0	0.000	0.000	0.001	0.000	0.000	0.004
	J01XC	Steroid antibacterials	26,040.74	0.0	23,694.16	0.0	24,846.30	0.0	0.001	0.001	0.001	0.002	0.002	0.002
	J01XD	Imidazoles	22,810.33	0.0	39,604.33	0.0	104,320.00	0.1	0.001	0.001	0.003	0.002	0.003	0.009
	J01XE	Nitrofuran derivatives	4,909,864.05	2.4	5,097,555.60	2.5	5,365,926.88	2.6	0.159	0.163	0.170	0.435	0.447	0.466
	J01XX	Other antibacterials	137,585.35	0.1	135,647.80	0.1	119,717.90	0.1	0.004	0.004	0.004	0.012	0.012	0.010
	J01	**Total antibacterial drugs**	**208,903,511.84**	**100.0**	**202,043,178.11**	**100.0**	**205,471,317.79**	**100.0**	**6.756**	**6.463**	**6.517**	**18.509**	**17.707**	**17.855**

Note: To calculate the number of DDDs per unit of population time, the division factor was determined by using the Canadian population estimates from Statistics Canada for a given year, example formula: number of days in calendar year x (population of Canada for given year/1,000 inhabitants).
Source: IMS Health Compuscript audit.

Table 43 Prescriptions and cost of systemic antimicrobials dispensed, 2001-2003.

Human Health Importance	ATC Class		Total No. Prescriptions (%)						Total Dollars (%)					
			2001		2002		2003		2001		2002		2003	
I	J01DA	Third and Fourth generation cephalosporins	166,471	0.7	154,431	0.7	137,426	0.6	$ 6,677,960	1.0	$ 6,177,122	0.9	$ 5,754,533	0.8
	J01DH	Carbapenems	120	0.0	76	0.0	181	0.0	$ 61,261	0.0	$ 60,036	0.0	$ 143,298	0.0
	J01MA	Fluoroquinolones	2,505,706	11.2	2,680,944	12.3	2,895,333	13.1	$ 140,935,557	21.3	$ 148,831,405	22.6	$ 160,322,199	23.1
	J01XA	Glycopeptides	4,990	0.0	5,756	0.0	7,730	0.0	$ 1,930,305	0.3	$ 2,277,245	0.3	$ 3,026,038	0.4
	J01FG	Streptogramins	-	0.0	1	0.0	-	0.0	$ -	0.0	$ 1,299	0.0	$ -	0.0
II	J01CA	Penicillins with extended spectrum	6,199,951	27.6	5,658,216	26.0	5,557,468	25.1	$ 100,610,082	15.2	$ 87,819,789	13.3	$ 85,624,291	12.3
	J01CF	ß-lactamase resistant penicillins	568,620	2.5	524,851	2.4	493,030	2.2	$ 8,444,459	1.3	$ 7,873,381	1.2	$ 7,657,389	1.1
	J01CR	Combinations of penicillins	45,389	0.2	239,963	1.1	360,940	1.6	$ 1,562,341	0.2	$ 7,973,062	1.2	$ 12,026,614	1.7
	J01EE	Combinations of sulfonamides and trimethoprim	1,565,429	7.0	1,393,594	6.4	1,295,644	5.9	$ 17,658,860	2.7	$ 15,981,290	2.4	$ 15,183,883	2.2
	J01FA	Macrolides	4,819,935	21.5	4,747,617	21.8	4,914,966	22.2	$ 193,351,539	29.3	$ 196,985,191	29.9	$ 212,300,994	30.5
	J01FF	Lincosamides	524,728	2.3	557,969	2.6	589,776	2.7	$ 20,700,378	3.1	$ 21,771,722	3.3	$ 22,712,945	3.3
	J01GA	Streptomycin	7	0.0	8	0.0	33	0.0	$ 943	0.0	$ 2,626	0.0	$ 7,773	0.0
	J01GB	Other aminoglycosides	10,893	0.0	10,861	0.0	10,398	0.0	$ 5,488,950	0.8	$ 6,181,571	0.9	$ 6,839,413	1.0
	J01MB	Other quinolones	1,952	0.0	1,593	0.0	1,395	0.0	$ 93,224	0.0	$ 79,016	0.0	$ 71,718	0.0
	J01RA	Combinations of antibacterials	75,296	0.3	49,365	0.2	33,114	0.15	$ 2,052,985	0.3	$ 1,359,710	0.2	$ 927,548	0.1
III	J01AA	Tetracyclines	1,272,883	5.7	1,229,246	5.6	1,212,394	5.5	$ 44,893,782	6.8	$ 46,468,449	7.0	$ 48,139,828	6.9
	J01B	Amphenicols	91	0.0	19	0.0	19	0.0	$ 3,206	0.0	$ 800	0.0	$ 1,476	0.0
	J01CE	ß-lactamase sensitive penicillins	1,304,812	5.8	1,247,841	5.7	1,251,072	5.7	$ 14,528,966	2.2	$ 14,197,039	2.2	$ 14,646,964	2.1
	J01DA	First and Second generation cephalosporins	2,808,789	12.5	2,698,785	12.4	2,739,895	12.4	$ 89,678,047	13.6	$ 82,195,028	12.5	$ 84,664,353	12.2
	J01EA	Trimethoprim and derivatives	65,477	0.3	66,640	0.3	68,291	0.3	$ 1,350,704	0.2	$ 1,305,693	0.2	$ 1,250,379	0.2
	J01EB	Short-acting sulfonamides	362	0.0	25	0.0	16	0.0	$ 10,836	0.0	$ 818	0.0	$ 280	0.0
	J01EC	Intermediate-acting sulfonamides	145	0.0	103	0.0	172	0.0	$ 12,231	0.0	$ 10,050	0.0	$ 15,000	0.0

Human Health Importance	ATC Class		Total No. Prescriptions (%)						Total Dollars (%)					
			2001		2002		2003		2001		2002		2003	
IV	J01XB	Polymyxins Total	-	0.0	37	0.0	684	0.0	$ -	0.0	$ 18,550	0.0	$ 602,846	0.1
	J01XC	Steroid antibacterials	1,785	0.0	1,704	0.0	1,722	0.0	$ 208,481	0.0	$ 188,968	0.0	$ 198,902	0.0
	J01XD	Imidazoles	211	0.0	245	0.0	1,159	0.0	$ 7,741	0.0	$ 8,520	0.0	$ 70,762	0.0
	J01XE	Nitrofuran derivatives	487,213	2.2	513,131	2.4	551,725	2.5	$ 9,657,990	1.5	$ 10,408,137	1.6	$ 11,516,536	1.7
	J01XX	Other antibacterials	23,337	0.1	18,712	0.1	16,150	0.1	$ 918,113	0.1	$ 1,158,975	0.2	$ 1,827,807	0.3
	J01	**Total antibacterial drugs**	**22,454,592**	**100.0**	**21,801,733**	**100.0**	**22,140,733**	**100.0**	**$ 660,838,941**	**100.0**	**$ 659,335,492**	**100.0**	**$ 695,533,769**	**100.0**

Source: IMS Health Compuscript audit.

Table 44 Summary of quantities and dollars spent on dispensed injectable antimicrobials.

Year	Number of Prescriptions	Kg active ingredient	DDDs	Dollars
2001	31,745.00	474.00	667,066.06	6,633,869.00
2002	29,101.00	399.56	526,990.96	6,124,383.00
2003	31,146.00	671.92	715,041.28	7,453,370.00

Source: IMS Health Compuscript audit.

Appendix B - Methods

B.1. Human Antimicrobial Resistance

Antimicrobial Resistance Sample and Data Collection

Human *Salmonella* isolates are usually cultured by hospital or private laboratories. Although laboratory notification of reportable diseases is mandatory and captured in the National Notifiable Disease Surveillance program, forwarding *Salmonella* isolates to the provincial reference laboratory is voluntary and passive in nature. The proportion of *Salmonella* isolates forwarded to a Provincial Public Health Laboratories (PPHLs) is unknown and likely varies between laboratories. Most isolates forwarded to a PPHL originate in community laboratories, which are legally required to report *Salmonella* cases to provincial notifiable disease surveillance programs. Isolates may also be sent to PPHLs on a voluntary basis for further testing. A *National Studies on Acute Gastrointestinal Illness* survey compared provincial laboratory isolate counts to notifiable disease reports and concluded that *Salmonella* isolates received by a PPHL were "...*highly representative of those isolated by community laboratories*" (NSAGI summary report, June 2001).

In the past, PPHLs have forwarded a certain number of *Salmonella* isolates to the National Microbiology Laboratory (NML) (previously known as the National Laboratory for Enteric Pathogens) for serotyping or phagetyping. At the end of year 2002, a letter of agreement by which provinces agreed to forward all or a sample of their *Salmonella* isolates to CIPARS was signed between the NML, the Laboratory for Foodborne Zoonoses (LFZ), the Centre for Infectious Disease Prevention and Control (CIDPC), and the PPHLs. This signature officially launched the *Enhanced Passive Human Component of CIPARS.*

The objective of this component was to implement and evaluate a prospective, representative, and methodologically unified approach to monitor trends in the development of antimicrobial resistance in *Salmonella* from human sources and allow the integration of this information with AMR information from the CIPARS agri-food components. Consequently, during 2003, less populated provinces (New Brunswick, Newfoundland, Nova Scotia, Manitoba, Prince Edward Island, and Saskatchewan) forwarded all human *Salmonella* isolates (outbreak and non-outbreak) received passively by their PPHL to the NML. In order to reduce the work load and the cost in more populated provinces (Alberta, British Columbia, Ontario, and Québec), it was agreed that only those human *Salmonella* isolates (outbreak and non-outbreak related) received passively by the PPHL from the first to the fifteenth of each month would be evaluated. However, all human *S*. Newport and *S*. Typhi received throughout the year were forwarded to the NML in these more populated provinces because of concern of emerging multidrug resistance and clinical importance, respectively.

The PPHLs from each province were also asked to provide additional information with each forwarded isolate such as the serovar, the date received, the outbreak ID when applicable, the patient age and/or date of birth, the patient gender, and the province of residence. Additional variables such as travel history, antimicrobial use, hospitalization status of the patient at the time of specimen collection, date of isolation, and date of onset were optional information, not usually provided to the NML in 2003.

Outbreaks are identified by the provinces. Some outbreaks can be identified after the isolates have been forwarded to the NML.

Bacterial Isolation Methods

Hospital-based and private laboratories isolated *Salmonella* according to their standard procedures, which likely varied from one laboratory to another. Nevertheless, most methods for examining specimens for the presence of *Salmonella* are similar in principle and involve pre-enrichment, selective enrichment, differential and selective plating,

and biochemical and serological confirmation of the selected isolates.

Serotyping and Phagetyping

The NML Identification/Serotyping Phagetyping and Antimicrobial Testing Laboratories have actively participated in WHO GSS EQAS proficiency program for *Salmonella* in 2001, 2002, 2003 & 2004. In addition, NML has been a strategic planning member of WHO GSS since 2002. NML have participated in the EnterNet (European Surveillance Network) proficiency program for *Salmonella* in 2000, 2002, 2003 and 2004. NML has had a proficiency panel strain exchange with LFZ (*Salmonella* and *E. coli*) in 2002, 2003, and 2004.

The NML Identification/Serotyping, Phagetyping and Antimicrobial Testing Laboratories are in the final stages of preparation of ISO 15189 accreditation.

Serotyping: In general, hospital-based and private laboratories forwarded their *Salmonella* isolates to their PPHL for serotyping. Isolates received at the NML with a *Salmonella* (lacking serotyping information) or *Salmonella* (Group B) designation were serotyped by the NML. If problems arose during phagetyping on a designated *Salmonella* serotype, then the serotype was confirmed by the NML.

Phagetyping: All *Salmonella* were phagetyped at the NML. *Salmonella* isolates were maintained at room temperature until tested. For testing, isolates were plated on nutrient agar plates and incubated at 37^{o}C for 18 hours. A single smooth colony was inoculated into 4.5 mL of Difco Phage Broth (DPB) (pH 6.8) and incubated for 1.5 to 2 hours in a shaking water bath at 37^{o}C to attain a bacterial growth turbidity equivalent to 0.5 McFarland Standard. The Difco Phage Agar (DPA) plates were flooded with 2 mL of culture and excess liquid was removed using a Pasteur pipette. Seeded plates were allowed to dry for 15 minutes at room temperature and approximately 20μl of each of the serovar specific typing phages were inoculated onto the bacterial lawn using a multiple inoculating syringe method (Farmer, Hickman and Sikes, 1956). The plates were incubated at 37°C overnight and lytic patterns were observed (Anderson and Williams, 1975).

Antimicrobial Susceptibility Testing Methods

See section B.2.

Data Analysis

See section B.2.

B.2. Agri-Food Antimicrobial Resistance

Sampling Design and Data Collection

Abattoir Surveillance

The principal objective of CIPARS *Active Abattoir Surveillance* is to provide nationally representative and valid annual antimicrobial susceptibility data from bacteria isolated from animals entering the food chain. Initially, the program targeted generic *E. coli* and *Salmonella* from beef cattle, swine, and broiler chicken. Program refinement since 2002 has included the discontinuation of *Salmonella* isolation from beef cattle due to low prevalence of infection/contamination. The unit of concern is the bacterial isolate tested for antimicrobial susceptibility to a panel of 16 antimicrobials. The bacteria of interest are sampled from the caecal contents of slaughtered food-producing animals, as caecal contents most closely represent the farm environment.

The expected number of isolates to be yielded by the sampling is set at 150 per targeted bacterial species, for each of the three commodities, across Canada, over a 12-month period. This number is a trade-off between acceptable statistical precision and affordability (Ravel, 2001). The actual number of specimens to be collected is derived for each commodity according to the expected caecal prevalence of the bacteria for this commodity, e.g. 1500 specimens have to be collected and submitted for bacterial isolation if the bacteria prevalence in the population is expected to be 10%.

The sampling design is based on an annual two-stage sampling of food animals in slaughterhouses, each commodity being handled separately. The first stage is a random selection of federally inspected slaughterhouses - the probability for an abattoir to be selected is proportional to its annual slaughter volume. Federally inspected abattoirs slaughter over 90% of all food-producing animals in Canada. The second stage is a systematic selection of animals on the slaughter line. The number of caecal specimens collected yearly, by each selected abattoir, is proportional to its slaughter volume amongst all participating slaughterhouses. In order for each abattoir to minimize shipping costs and to maintain efficiency, the annual total number of samples to be collected is divided by five (for swine, divided by 10), leading to a given number of collection periods. Collection periods are uniformly distributed over the year, leading to an abattoir-specific schedule for collecting caecal contents. For a sampling week, the five caecal samples are collected within 12 to 36 hours, at the slaughterhouse's convenience, provided the five animals come from different lots. Sampling from different lots is important to maximize diversity and avoid bias due to over-representation of particular producers. The uniform distribution of the collection periods over a 12-month course avoids any potential seasonal bias in bacteria prevalence and in the susceptibility test results.

Forty-nine federally inspected slaughter plants (21 poultry plants, 19 swine plants, and 9 beef plants[1]), randomly selected from across Canada, participated in the 2003 CIPARS abattoir component. As stated above, the number of samples required was based on the requirement for 150 *Salmonella* and 150 generic *E. coli* isolates per commodity and the expected prevalence of *Salmonella* and generic *E. coli* in each commodity. The sample size for beef was based only on generating 150 *E. coli*. Beef cattle samples were taken from cattle slaughtered for beef – the vast majority of these are beef cattle but a small proportion of dairy cattle slaughtered for beef may be included. Calves slaughtered for veal were excluded. Samples were taken according to a pre-determined protocol, with modifications to accommodate various line configurations in the different plants. Protocols were designed in order to avoid conflict with current inspection methodology, plant specific HACCP/Food Safety Enhancement Program, Health and Safety requirements, and industry's ability to salvage viscera. They were also designed to avoid situations of potential cross-contamination. The samples were collected by industry personnel under the guidance of the CFIA Veterinarian-in-Charge.

[1] There were a total of 35 cattle, 46 swine and 62 poultry federally inspected slaughter plants in January 2003. The numbers were of 29 cattle, 42 swine and 58 poultry plants in January 2004.

Retail Surveillance

Human exposure to commensal bacteria, zoonotic pathogens and their associated genetic determinants of antimicrobial resistance from animals can occur by direct contact, environmental contamination or through the food production system. Retail food represents a logical sampling node for antimicrobial resistance surveillance, as it is the endpoint of the food pathway, i.e. the point of consumer exposure prior to the kitchen. The objective of CIPARS *Active Retail Surveillance* is to examine antimicrobial resistance patterns of bacteria found in food at retail.

The unit of concern is the bacterial isolate cultured from one of the commodities of interest and tested for susceptibility to a standard panel of antimicrobials. The commodities of interest are meat products commonly consumed by Canadians and mirror those commodities sampled in CIPARS *Active Abattoir Surveillance* and the developing *On-Farm Surveillance* program. They are poultry (chicken legs or wings), pork (shoulder chops) and beef (ground beef). The type of meat cuts chosen were based on the prevalence of targeted bacteria and cost of purchase (Ravel, 2002). For ground beef in 2003, only lean ground beef was selected, but in Year Two this will be changed to a systematic selection of extra lean, lean and regular ground beef to reflect the heterogeneity of this product in terms of the commodity combinations of fed beef and cull dairy, and the domestic vs. imported meat content.

The bacteria of interest in poultry are *Campylobacter* spp., *Salmonella, Enterococcus* spp., and generic *E. coli.* In pork and beef only generic *E. coli* are cultured, given the low prevalence of *Campylobacter* spp. and *Salmonella* at retail in these commodities as determined during the early phase of the program.

The target population are Canadian consumers of retail meat. The sampling protocol involves continuous weekly sample submissions from randomly selected census divisions, weighted by population, in each of the participating provinces. In the developmental phase (Year 1: May 2003-April 2004) two provinces were included, Québec and Ontario (only data from May – Dec. 2003 were presented in this report). Using Statistics Canada data, 17 census divisions were selected in each province by stratified random selection. The strata were formed by the cumulative population quartiles from a list of divisions in a province sorted by population in ascending order. There are 20 sampling days per strata per year:

Strata One - 10 divisions selected with two sampling days per division per year;

Strata Two - four divisions selected, with five sampling days per division per year;

Strata Three - two divisions selected with 10 sampling days per division per year;

Strata Four - one division, 20 sampling days per year.

Field workers in each participating province conduct one sampling day per week. Samples are collected on Monday or Tuesday for submission to the LFZ, Saint-Hyacinthe, Québec by Wednesday. Samples submitted from outside Québec are sent via 24-hour courier. In each province one or two divisions are sampled on each sampling day. In each division a slate of four stores is selected based on *Store Type*. Generally, three chain stores and one independent market or butcher shop are selected for sampling. An exception to this protocol is made in densely populated urban divisions, e.g. Toronto and Montreal, where two chain stores and two independent markets or butcher shops are sampled to reflect the shopping behaviour of that sub-population. From each *Store Type* one sample of each commodity of interest is collected, providing 12 meat samples per division per sampling day. If possible, specific store locations are to be sampled only once per sampling year. Using prevalence estimates, sampling protocols are optimized to yield 100 isolates per commodity per province per year (anticipated), plus 20% for lost or damaged samples.

In Year One, a paper SAMPLE SUBMISSION FORM was used to capture the following store and sample data:

- Type of store
- Number of cash registers – a surrogate measure of store volume
- Sell-by or packaging date
- Product Origin: Canada / USA / Other
- Federal Inspection stamp: Y / N
- “May Contain Previously Frozen Meat” label: Y / N
- Final Processing in store: Y / N
- Price/kg

Individual samples are packaged in Zip-Loc™ bags (S.C. Johnson & Son, Ltd, Brantford, ON, Canada) and placed in hard plastic 16 litre coolers for transport. The ambient temperature determines the number of ice packs placed in each cooler. Temperature data recording instruments (Ertco Data Logger, West Patterson, NJ, USA) are used to monitor the temperature experience of samples in one or two coolers per sampling day. This data is used to determine whether or not samples were frozen during transport, which could affect the isolate yield.

Passive Surveillance

The *Salmonella* Typing Laboratory at LFZ received the veterinary diagnostic Salmonella isolates included in the passive veterinary component. These isolates came from veterinary diagnostic laboratories from across the country (although primarily from Ontario) and the isolation methodology may vary for each laboratory. Since the samples were submitted for diagnostic purposes, private practitioners and/or producers carry out the sample collection. Therefore, the sample collection methodology varies both between and within laboratories. Other *Salmonella* isolates were also received from various other sources such as inspection agencies or private laboratories, which also use different sampling techniques and isolation methods.

Developing Program Component: On-Farm Surveillance

The active *On-Farm Surveillance* program is the newest component of CIPARS and is currently in the development and early implementation stages. Based on a sentinel farm framework, one main objective is to provide group-level and/or individual animal-level faecal samples for bacterial isolation and antimicrobial susceptibility testing. *On-Farm Surveillance* has been initiated in three core commodities: broiler chickens, grower/finisher pigs and feedlot beef. Data collection commenced in January 2004 and analysis of Year One data will be presented in the 2004 CIPARS annual report. Isolates from *On-Farm Surveillance* will be characterized and antimicrobial resistance profiles will be determined. Microorganisms of interest include zoonotic bacteria (*Campylobacter* spp., *Salmonella*) and commensal bacteria (generic *E. coli* and *Enterococcus* spp.). No data were available at the time of printing.

Bacterial Isolation Methods

Active Surveillance
(Abattoir, Retail)

Primary isolation of *E. coli, Salmonella*, *Campylobacter* spp., and *Enterococcus* spp., and antimicrobial susceptibility testing for *E. coli, Enterococcus* spp., and *Campylobacter* spp. were conducted at LFZ, Saint-Hyacinthe, Québec. *Salmonella* isolates were sent to the LFZ, Guelph, Ontario for testing as follows: serotyping and phagetyping were performed by the *Salmonella* Typing Laboratory (STL) and antimicrobial susceptibility testing was performed by the CIPARS Guelph Laboratory. Both laboratories are ISO/IEC 17025 accredited by the Standards Council of Canada. The STL is also designated as an OIÉ Reference Laboratory for salmonellosis. STL has been a member of the WHO Global *Salmonella* Surveillance network (Global Salm-Surv) since 2000. STL is listed on the Global Salm-Surv web page (http://www.who.int/salmsurv/en) and provides yearly *Salmonella* summary data (http://www.who.int/salmsurv/en). The STL successfully participates in a yearly External Quality Assurance System for *Salmonella* serotyping (EQAS) among Global Salm-Surv member labs, as well as yearly inter-laboratory exchange programs with the Ontario Ministry of Health, Toronto, Ontario, and NML, Winnipeg, Manitoba. STL began external proficiency testing for phagetyping in 2003 and successfully completed a phagetyping proficiency panel provided by NML originating from the Central Public Health Laboratory, Colindale, England.

Abattoir Surveillance (*Salmonella*)

A modification of the MFLP-75 method of the *Compendium of Analytical Methods, Health Protection Branch, Methods of Microbiological Analysis of Food, Government of Canada* was used. This method isolated motile and viable *Salmonella* from caecal content of broilers, swine and beef samples. The method was based on the capacity of *Salmonella* to multiply and be motile in Modified Semi-Solid Rappaport

Vassiliadis (MSRV) media at a temperature of 42°C.

Porcine and bovine samples were mixed with a non-selective pre-enrichment broth; 10 g of caecal contents were mixed with 90 mL of buffered peptone water (BPW). In the same manner, avian caecal contents were weighed and BPW was added in a proportion of 1:10. The samples were incubated at 35°C for 24 hours. Then a MSRV plate was inoculated with 0.1 mL of the pre-enrichment broth and was incubated at 42°C for 24 to 72 hours. Suspect colonies were screened for purity and inoculated on Triple Sugar Iron (TSI) and urea agar slants. Presumptive *Salmonella* isolates were verified by slide agglutination using Poly A-I & Vi *Salmonella* antiserum.

Abattoir Surveillance (*E. coli*)

E. coli were isolated from the caecal contents of broilers, swine and beef cattle. A drop of BPW aliquot prepared for the *Salmonella* isolation was inoculated on a MacConkey (MAC) agar and incubated at 35°C for 18 to 24 hours. Suspect lactose fermenting colonies were screened for purity and transferred onto Luria-Bertani (LB) agar. Presumptive colonies were identified using Simmons citrate and indole test. All bacterial isolates from food animals were stored at -70°C for potential future study.

Retail Surveillance (*Salmonella*)

Chicken legs or wings were mixed with 225mL of BPW. Fifty mL of this peptone rinse were incubated at 35°C for 24 hours. Further description of bacterial isolation methods are described in the CIPARS *Abattoir Surveillance* section.

Retail Surveillance (*E. coli*)

Chicken legs or wings, pork shoulder chops and ground beef were mixed with 225 mL of BPW. Fifty mL of this peptone rinse were mixed with 50 mL of double strength EC Broth and incubated at 45°C for 24 hours. A loopful from the incubated mix was streaked on Eosin Methylene Blue (EMB) Agar and incubated at 35°C for 24 hours. Suspect colonies were screened for purity and transferred onto Trypticase Soy Agar with 5% sheep blood (TSA-B). Presumptive colonies were identified using the Simmons citrate and indole tests.

Retail Surveillance (*Campylobacter* spp.)

Chicken legs or wings were mixed with 225 mL of BPW. Fifty mL of this peptone rinse was mixed with 50 mL of double Bolton Broth and incubated in a microaerophilic atmosphere at 42°C for 48 hours. The incubated broth was then streaked on modified cefoperazone charcoal deoxycholate agar (mCCDA) and incubated in a microaerophilic atmosphere at 42°C for 24 hours. Suspect colonies were streaked on another mCCDA plate and on Mueller Hinton Agar supplemented with 5% sheep blood (MHB). The plates were incubated in a microaerophilic atmosphere at 42°C for 48 to 72 hours. Several tests were performed on presumptive colonies: Gram stain, oxidase, catalase, growth at 25°C, nalidixic acid and cephalothin resistance, and hippurate and indoxyl acetate hydrolysis.

Retail Surveillance (*Enterococci* spp.)

Chicken legs or wings were mixed with 225 mL of BPW. Fifty mL of this peptone rinse were mixed with 50 mL of double strength Enterococcosel Broth and incubated at 35°C for 24 hours. A loopful from the incubated broth was then streaked on an Enterococcosel Agar and incubated at 35°C for 24 hours. Suspect colonies were screen for purity on Columbia Agar with 5% sheep blood (CBA). Presumptive colonies were transferred on Slaneth and Bartley Agar and inoculated in three tubes of Phenol Red Base Broth containing 0.25% L-arabinose, 1% mannitol and 1% alpha-methyl-D-glucoside respectively. The plate and tubes were incubated at 35° for 24 hours. No data were available at the time of printing.

Passive Surveillance (*Salmonella*)

Submitting laboratories isolated *Salmonella* according to their standard procedures, which varied from one laboratory to another. Nevertheless, most methods for examining

products for the presence of *Salmonella* are similar in principle and involve pre-enrichment, selective enrichment, differential and selective plating, isolation, and biochemical and serological confirmation of the selected isolates.

Serotyping, Phagetyping, and Antimicrobial Susceptibility Testing Methods

For serotyping: the O or somatic antigens of the *Salmonella* isolates were determined by slide agglutination (Ewing 1986). The H or flagellar antigens were identified using a microtechnique (Shipp and Rowe 1980) that employs microtitre plates. The antigenic formulae of Le Minor and Popoff (1992) were used to name the serovars.

For phagetyping: The standard phagetyping technique described by Anderson and Williams (1956) was followed. *Salmonella* Enteritidis strains were phagetyped with typing phages obtained from the International Centre for Enteric Phage Typing (ICEPT), Central Public Health Laboratory, Colindale, United Kingdom (Ward et al. 1987) via NML, Winnipeg, Manitoba. The phagetyping scheme and phages for *Salmonella* Typhimurium, developed by Callow (1959) and further extended by Anderson (1964) and Anderson and colleagues (1977), were obtained from the ICEPT via NML. The *Salmonella* Heidelberg phagetyping scheme and phages were supplied by NML (Demczuk *et al*, 2003). Isolates that reacted with the phages but did not conform to any recognized phagetype were considered atypical (AT). Strains which did not react with any of the typing phages were considered untypable (UT).

Antimicrobial Susceptibility Testing: *Salmonella*, *E. coli*, and *Enterococcus*

Salmonella of human origin were tested by the NML while isolates from agri-food samples were processed at the LFZ-Guelph. *E. coli*, *Enterococcus* and *Campylobacter* isolated were tested by LFZ-Saint-Hyacinthe.

MIC values for *Salmonella*, *E. coli* and *Enterococcus* were determined by the broth microdilution method (Methods for Dilution Antimicrobial Susceptibility tests for Bacteria That Grow Aerobically; Approved Standard-Fifth Edition. NCCLS document M7-A5, Wayne Pennsylvania 19087-1898).

Broth microdilution method was performed using the Sensititre™ ARIS Automated Microbiology System (Trek™ Diagnostic Systems Ltd) for antimicrobial resistance testing. Sensititre™ is a commercially available microbroth dilution technique using dehydrated antimicrobials in microtitre wells. NARMS susceptibility panels CMV7CNCD (Sensititre™) were used for *E. coli* and *Salmonella* while the CMV5ACDC plates were used for *Enterococci*. The specimens were streaked onto a Mueller Hinton Agar (or Columbia Blood Agar or Mueller Hinton Blood Agar) plate to obtain isolated single colonies and incubated inverted at 37°C ± 0.5°C (NML, LFZ-Guelph) or 35° ± 1°C (LFZ-St-Hyacinthe) for 18 to 24 hours. A 0.5 McFarland suspension of bacterial growth was prepared by transferring colonies to 5.0 mL sterile water and suspended by vortexing the tube for at least 10 seconds. A volume of 10µl of the water-bacterial suspension was transferred to a Mueller-Hinton broth tube containing one fluorophor subtrate strip (*Salmonella* and *E. coli* only) and mixed by using a vortex mixer for 10 seconds. The Mueller Hinton broth suspension was dispensed into plates at a rate of 50 µl per well. The plates were sealed with adhesive plastic sheets and incubated for 18 hours. Detection of possible vancomycin-resistant *Enterococc*i required 6 more hours of incubation for a total of 24 hours. After incubation, the CMV7CNCD plates were read and interpreted using the ARIS system, whereas the CMV5ACDC plates were read by the Sensititre Sensitouch™. *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Enterococcus faecalis* ATCC 29212 were used for quality assurance purposes to ensure validity and integrity of the MIC values of the susceptibility CMV7CNCD panels as outlined in the NCCLS (NCCLS. Performance Standards for Antimicrobial Susceptibility testing; Twelfth Informational Supplement. NCCLS document M100-S12, Wayne, Pennsylvania 19087-1898). *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, and *Enterococcus*

faecalis ATCC 51299 were used as quality controls for *Enterococcus* susceptibility testing.

Additional amikacin susceptibility testing for *Salmonella* and *E. coli* were performed by the agar dilution method (LFZ-Saint-Hyacinthe), as described in Methods for Dilution Antimicrobial Susceptibility tests for Bacteria That Grow Aerobically; Approved Standard-Fifth Edition. NCCLS document M7-A6, Wayne Pennsylvania 19087-1898.

Antimicrobial Susceptibility Testing: *Campylobacter*

Antimicrobial susceptibility testing of *Campylobacter* isolates was performed by the disk diffusion method using the ETest® methodology (AB Biodisk, Solna, Sweden). The colonies were streaked on Mueller Hinton Agar plates with 5% laked horse blood and incubated in a microaerophilic atmosphere at 42°C ± 0.5°C for 48 hours. A 0.5 McFarland suspension of bacterial growth in prepared by transferring colonies to Mueller Hinton broth and suspended by vortexing tube at least 10 seconds. A sterile swab was dipped into the inoculum suspension and the excess fluid was removed. The swab was then used to inoculate a Mueller Hinton Agar plate with 5% laked horse blood. Antimicrobial strips were applied firmly onto the agar surface. Plates were incubated aerobically at 35°C ± 1°C for 48 hours. *Campylobacter jejuni* ATCC 33560, *Staphylococcus aureus* ATCC 29213, and *Escherichia coli* ATCC 25922 were used as quality controls. *Staphylococcus aureus* ATCC 29213, and *Escherichia coli* ATCC 25922 were incubated aerobically at 35°C ± 1°C for 18 hours and *Campylobacter jejuni* ATCC 33560 were incubated in a microaerophilic atmosphere at 35°C ± 1°C for 48 hours. MIC values were compared to NCCLS standards (NCCLS. Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals; Approved Standard- Second Edition. NCCLS document M31-A2, Wayne Pennsylvania 19087-1898).

Data Analysis, Validation, and Review

All recovery and susceptibility data from animal and human sources were analysed by LFZ. Susceptibility data from *Human Salmonella Enhanced Passive Surveillance* were provided by NML (Winnipeg, Manitoba). Susceptibility data from all animal *Salmonella* isolates (*Passive, Active Abattoir* and *Active Retail Surveillance*) were provided by LFZ (Guelph, Ontario). Susceptibility data on *E. coli* (*Abattoir* and *Retail Surveillance*) and *Campylobacter* (*Retail Surveillance*) isolates and all recovery data from *Abattoir* and *Retail Surveillance* were obtained from LFZ (Saint-Hyacinthe, Québec).

All initial datasets were checked for data validity. The bovine abattoir *E. coli* dataset had five isolates removed as they were identified as being from veal. The agri-food *Salmonella* dataset was also cleaned of duplicate isolates and 16 isolates from *Passive Surveillance,* three isolates from *Retail Surveillance* and 22 isolates from *Abattoir Surveillance* were deleted. All *Passive Salmonella Surveillance* submissions from outside the country were also excluded from analysis. Outbreak related isolates were not excluded from data analysis but these were noted in the text when they occurred.

The breakpoints used for the interpretation of susceptibility results are listed in Table Appendix 45 and 46, Appendix B.2. In 2003, the range tested for amikacin with CMV7CNCD *Sensititre* plate for Enterobacteriaceae did not include the breakpoint. Therefore, all isolates with an MIC value for amikacin equal to "> 4 μg/mL " were retested using the Agar Dilution Method from 0.5 to 128 μg/mL. Results from this last method were used for the final identification of resistant isolates. For the interpretation of E-Test results on *Campylobacter* where dilutions between usual concentrations were tested, results falling between serial twofold dilutions were rounded up to the next highest concentration as recommended by NCCLS (NCCLS, M100-S14).

Data were analyzed using SAS™ V8.0 (SAS Institute Inc., Cary, NC, USA), Stata 8 (Stata Corp., College Station, TX, USA) and Excel notebook software (Excel 2000, Microsoft Corp., Redmond, WA, USA). All figures were generated with Microsoft® Excel 2000. Subsets of the data were additionally validated using two different analysis packages to compare statistical output. Exact confidence intervals were computed using SAS BINOMIAL statement in PROC FREQ and an alpha level of 0.05. When prevalences were equal to zero, an alpha level of 0.10 was used.

The *Individual Antimicrobial Drug Resistance* percentage was the number of isolates resistant divided by the total number of isolates tested for each individual antimicrobial.

The *Number of Antimicrobials in Resistance Pattern* was calculated by adding the number of resistant results across all antimicrobials tested for each isolate. This number was used to generate the multiple drug resistance figures. Isolates with missing information for one or more antimicrobials within the panel tested were not included in figures.

For the *Abattoir* and *Retail Surveillance* components, the *Recovery Rate* was the number of samples where the target organism was detected divided by the total number of samples processed. The *Percentage of Samples Carrying a Resistant Isolate* for a given microorganism and antimicrobial was calculated by multiplying the *Recovery Rate* for this particular microorganism by the *Individual Antimicrobial Drug Resistance* for each antimicrobial tested.

For the human data, the number of *Salmonella cases per 100,000 inhabitant-year* in each province was calculated by dividing the total number of cases reported to the NESP database in each province by that province population (Stat. Can. Post-censal population estimates Jan, 1, 2003),
multiplied by 100 000. The national estimates of the *Individual Antimicrobial Drug Resistance* for the most important *Salmonella* serovars were calculated as followed: only one isolate per outbreak was kept; in provinces submitting isolate during the first 15 days of the month, the number of resistant isolates and the total number of submitted isolates were multiplied by two each month; the number of resistant isolates (estimated in larger province or actual number in smaller provinces) were added; the total number of isolates submitted (estimated in larger province or actual numbers in smaller provinces) were added; the total estimated number of resistant isolates was divided by the total estimated number of submissions for each antimicrobial tested to obtain a national estimate of resistance for each antimicrobial for each *Salmonella* serovar.

CIPARS members were invited to review and critique the report during a five-week review period. Four external reviewers were chosen based on their academic qualifications in this area to provide their expertise on the data analysis and interpretations.

Table 45 *Salmonella* and *E. coli* breakpoints.

Antimicrobial	Range tested in 2003 µg/mL	Susceptible range µg/mL	Intermediate range µg/mL	Resistant range µg/mL
amikacin	0.5-4	≤ 16	32	≥ 64
amoxicillin-clavulanic acid	1.0/0.5 - 32/16	≤ 8/4	16/8	≥ 32/16
ampicillin	1-32	≤ 8	16	≥ 32
cefoxitin	0.5-16	≤ 8	16	≥ 32
ceftiofur	0.12-8	≤ 2	4	≥ 8
ceftriaxone	0.25-64	≤ 8	16-32	≥ 64
cephalothin	2-32	≤ 8	16	≥ 32
chloramphenicol	2-32	≤ 8	16	≥ 32
ciprofloxacin	0.015-4	≤ 1	2	≥ 4
gentamicin	0.25-16	≤ 4	8	≥ 16
kanamycin	8-64	≤ 16	32	≥ 64
nalidixic acid	0.5-32	≤ 16	-	≥ 32
streptomycin	32-64	≤ 32	-	≥ 64
sulfamethoxazole	16-512	≤ 256	-	≥ 512
tetracycline	4-32	≤ 4	8	≥ 16
trimethoprim-sulfamethoxazole	0.12/2.38-4/76	≤ 2/38	-	≥ 4/76

***Note**: All breakpoints are from NCCLS M100-S14 Table 2A, M7-A6-MIC Testing section except breakpoints for Ceftiofur (NCCLS M31-A2, Table 2.) and Streptomycin (NARMS 2001 Annual report).*

Table 46 *Campylobacter* spp. breakpoints.

Antimicrobial	Range tested in 2003 µg/mL	Susceptible range µg/mL	Intermediate range µg/mL	Resistant range µg/mL
Azithromycin	0.016-256	≤ 0.25	0.5-1	≥ 2
Chloramphenicol	0.016-256	≤ 8	16	≥ 32
Ciprofloxacin	0.002-32	≤ 1	2	≥ 4
Clindamycin	0.016-256	≤ 0.5	1-2	≥ 4
Erythromycin	0.016-256	≤ 0.5	1-4	≥ 8
Gentamicin	0.016-256	≤ 4	8	≥ 16
Nalidixic Acid	0.016-256	≤ 16		≥ 32
Tetracycline	0.016-256	≤ 4	8	≥ 16

***Note**: Breakpoints used are those from NARMS 2000 Annual report and are based on NCCLS recommendations for Enterobacteriaceae.*

B.3. Human Antimicrobial Use Data Collection and Analysis

CompuScript

Canadian CompuScript (CCS) tracks the number and size of prescriptions dispensed (not the number written) by retail pharmacies in Canada. Data fields include product name (including manufacturer), form, and strength; province; and the number of prescriptions, units of product, and dollars spent by month for each year.

The sampling frame (or "universe") for this dataset consists of approximately 6,974 pharmacies, including approximately 4,904 chain stores (2,213 large and 2,691 small) and approximately 2,070 independent stores (285 large and 1,785 small), which covers nearly all the retail pharmacies in Canada. IMS Health stratifies the "universe" by store size (based on purchase volumes), type (chain or independent), and region (10 provincial areas).

The sample design requires approximately 1,373 stores; however, IMS Health utilizes more stores because they have a large sample base. For example, approximately 2,500 stores were used to create the estimates for 2001. From this sample, IMS Health calculates a projection factor by dividing the number of stores in the "universe" by the number of stores in the sample. The projection factor is used to extrapolate the number of prescriptions dispensed in the sample to that of the "universe" (6,974 pharmacies).

Drugs were classified and Defined Daily Doses (DDDs) were determined according to the 2004 Anatomical Therapeutic Chemical (ATC) classification system (WHO Collaborating Centre for Drug Statistics Methodology http://www.whocc.no/atcddd/). For antimicrobials not listed in this system and for those with unknown DDD values (e.g. trimethoprim-sulfamethoxazole and gatifloxacin), the WHO Collaborating Centre was contacted for additional guidance. For pediazole, the DDD for erythromycin ethyl succinate and for trisulfaminic, the DDD for sulfamerazine were used. Benzathine benzylpenicillin and benzathine phenoxymethylpenicillin did not have assigned DDDs; therefore, these drugs were excluded from DDD calculations. The veterinary drug orbenin and all antimicrobials prescribed in the form of enemas or suppositories were removed from the dataset.

For every product strength within each ATC group, the total number of drug units dispensed was calculated for the year. Data from IMS Health were compared to information in the Health Canada Drug Products Database (DPD) (http://www.hc-sc.gc.ca/hpb/drugsdpd/index.html) and the Compendium of Pharmaceuticals and Specialties (CPS, 2003). If the strength provided by IMS Health did not correspond with information in the DPD and/or CPS, the data were adjusted to reflect product information provided by the latter resources. Gantanol Duplex™ and Urasal™ did not have product strengths listed in IMS Health data; therefore, DDDs and kg active ingredient were not calculated, but these drugs were included when calculating the number of prescriptions and dollars spent.

It was assumed that the drug units dispensed were based on the product formulations provided by IMS Health (Table 47, Appendix B.3). Some injectable products dispensed as vials or minibags were available in various sizes, but no information on the size dispensed was available from IMS Health. In these cases, information from DPD and CPS was used to determine all available unit sizes, and the average size available (excluding pharmacy bulk vials) was used to estimate of the number of antimicrobial units dispensed to calculate DDDs.

Canadian Disease and Therapeutic Index

Canadian Disease and Therapeutic Index (CDTI) is a quarterly profile designed to provide information about the patterns and treatments of disease encountered by office-based physicians. Every quarter, approximately 652 physicians (specialists and general practitioners) from five regions [the Maritimes (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island), Québec, Ontario, the Prairies (Alberta, Manitoba, and Saskatchewan), and British Columbia] are surveyed. For the most part, physicians are consistent from

quarter to quarter. These physicians are selected using a two-stage sampling process: first by region and specialty and second by each 48-hour period in the quarter. For four consecutive quarters, each physician maintains a practice diary describing information on every patient visit during a randomly selected 48-hour period. Information includes patient age and sex, reason for visit, diagnosis, name(s) of the drug(s) recommended or discussed, desired therapeutic effect(s), and the presence of concomitant therapies. *CDTI* data were used to determine the most common diagnoses, defined by the International Classification of Diseases Ninth Revision System (ICD-9), associated with antimicrobial drug mentions for the sampled physicians.

Data for both *CCS* and *CDTI* datasets were analyzed using SAS®V8.1 (SAS Institute Inc., Cary, NC, USA) and Microsoft Excel 2000 (Microsoft Corp., Redmond, WA, USA). Human drug use analyses were performed by the CIDPC.

Differences in 2002 and 2003 Reports

In the 2002 report, the DDD/1000 inhabitant-days was 19.9 for the fiscal year of April 2000 to March 2001 and the 2003 report showed the DDD/inhabitant-days to be 18.5 for calendar year 2001. These numbers should not be compared because the methodology differed between the two reports. In 2002 if more than one vial size was possible then the smallest vial size was used and for 2003 the average vial size was used (excluding bulk pharmacy vials except for one instance where it was the only possible vial size). Another difference between methodologies was the population size. In 2002 the entire 2001 Canadian population was used and in 2003 only the provinces population were used. There were also drugs in the 2003 report that were not included in the 2002 report and some drugs differed in the total number of units from the IMS data for both years.

Table 47 Quantity units used for each product formulation for human systemic antibacterial drug pharmacy dispensing data.

Formulation	Quantity Units
Tablets, caplets	Pills
Suspension, liquid	Millilitres
Vial, syringe, minibag	Vial, syringe, minibag

Appendix C - References

Aarestrup F, Wiuff C, Molbak K, and E. Threlfall. (2003). Is it time to change fluoroquinolone breakpoints for *Salmonella* spp.? Antimicrob Agents Chemother. 47:827-829.

Allen K, and C Poppe. (2002). Phenotypic and genotypic characterization of food animal isolates of *Salmonella* with reduced sensitivity to ciprofloxacin. Microbial Drug Resist. 8:375-383.

Anderson E and R Williams. (1956). Bacteriophage typing of enteric pathogens and staphylococci and its use in epidemiology. J. Clin. Pathol. 9: 94-127.

Anderson E. (1964). The phagetyping of *Salmonella* other than *S. typhi*. In: Van Oye E, ed. The world problem of salmonellosis. The Hague, The Netherlands: Dr W. Junk Publishers: 89-100.

Anderson E, Ward L, de Saxe M, and J de Sa. (1977). Bacteriophage-typing designations of *Salmonella typhimurium*. J Hyg. 78:297-300.

Callow B. (1959). A new phage typing scheme for *Salmonella typhimurium.* J Hyg. 57:346-59.

CDC. (2001). National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS) 2001 Annual Report. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2003.

CIPARS (2002). Canadian Integrated Program for Antimicrobial Resistance Surveillance Annual Report. Health Canada, Canada, 98 pp.

Crump J, Barrett T, Nelson J, and F Angulo. (2003). Reevaluating fluoroquinolone breakpoints for *Salmonella enterica* serotype Typhi and for non-Typhi salmonellae. Clin Infect Dis. 37:75-81.

DANMAP. (2002). DANMAP 2001 - Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, foods and humans in Denmark. 69 pg.

Demczuk W, Soule G, Clark C, Ackermann H, Easy R, Kahkhria R, Rodgers F, and R Ahmed. (2003). Phage-based typing scheme for *Salmonella* enterica serovar Heidelberg, a causative agent of food poisonings in Canada. J. Clin. Microbiol. 41: 4279-4284.

Ewing W. (1986). Serologic identification of *Salmonella*. In: Ewing WH, ed. Edwards and Ewing's Identification of *Enterobacteriaceae*, 4th ed. New York: Elsevier Science Publishing Co., Inc., 201-38.

Farmer J, Hickman F, and J Sikes. (1975). Automation of *Salmonella* typhi phage-typing. Lancet ii:787-90.

Hilton A, and M Braoudaki. (2004). Low level of cross-resistance between triclosan and antibiotics in *Escherichia coli* K-12 and *E. coli* O55 compared to *E. coli* O157. Microbiol. Lett. Jun 15; 235 (2):305-9.

Larkin C, Poppe C, McNab B, McEwen B, Mahdi A, and J Odumeru. (2004). Antibiotic resistance of *Salmonella* isolated from hog, beef and chicken carcass samples from provincially inspected abattoirs in Ontario. J Food Protect 67:448-455.

Le Minor L and M Popoff. (2001). Antigenic formulas of the *Salmonella* serovars. 8th ed., WHO Collaborating Centre for Reference and Research on *Salmonella*, Paris.

National Studies on Acute Gastrointestinal Illness (NSAGI). Antimicrobial Sensitivity Testing on Enteric Pathogens: Provincial Laboratory Survey Summary Report. June 2001.

NCCLS. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically; approved standard – Fifth Edition. NCCLS document M7-A5, Wayne Pennsylvania 19087 – 1898.

NCCLS. Performance standards for antimicrobial susceptibility testing; Twelfth informational supplement. NCCLS document M100-S14, Wayne, Pennsylvania 19087 – 1898.

Ravel A (2001). Development of the Canadian antimicrobial resistance surveillance system (agri-food sector) – sampling design options. Presented to the National Steering Committee on Antimicrobial Resistance in Enterics, Canada. 79 pp.

Ravel A. (2002). AMR Surveillance in food at retail – Proposal for a pilot project – DRAFT #2. 13pp.

Shipp C and B Rowe. (1980). A mechanised microtechnique for *Salmonella* serotyping. J. Clin. Path. 33: 595-597.

Threlfall J, Ward L, and D Old. (1999). Changing the nomenclature of *Salmonella*. Communicable Disease and Public Health. 2(3):156-157.

Ward L, de Sa J, and B Rowe. (1987). A phage-typing scheme for *Salmonella enteritiditis.* Epidemiol. Infect. 99:291-294.