Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

2004

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

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Introduction

About CIPARS

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

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Provincial Public Health Laboratories

We are grateful for the participation of the Provincial Public Health Laboratory group for voluntarily forwarding human *Salmonella* isolates to the National Microbiology Laboratory (Winnipeg, Manitoba). This group includes Laboratory Services, British Columbia Centre for Disease Control (BC) (Judy Isaac-Renton); the Provincial Laboratory of Public Health (AB) (Marie Louie); the Saskatchewan Laboratory and Disease Control Services; Cadham Provincial Laboratory (MB) (Paul Van Caeseele); the Central Public Health Laboratory, Public Health Laboratories Branch, Ontario Ministry of Health and Long Term Care (ON) (Frances Jamieson); Laboratoire de santé publique du Québec (QC) (Johanne Ismail); the New Brunswick Enteric Reference Centre (NB) (Glenna Hardy); the Microbiology Laboratory, Queen Elizabeth II Health Sciences Centre (NS) (Kevin Forward); Laboratory Services, Queen Elizabeth Hospital (PE) (Lewis Abbott); and the Newfoundland Public Health Laboratory (NL) (Sam Ratnam).

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of Institut national de santé animale (QC), Provincial Veterinary Laboratory, Dept. of Agriculture, Fisheries, and Aquaculture (NB), Veterinary Pathology Laboratory, Truro (NS), Diagnostic Services, Atlantic Veterinary College (PE).

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.

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Public Health Agency of Canada:

Infectious Disease and Emergency Preparedness Branch:

- Laboratory for Foodborne Zoonoses
- Centre for Infectious Disease Prevention and Control
- National Microbiology Laboratory

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Abbreviations

A2C:	resistance to amoxicillin-clavulanic acid, cefoxitin and ceftiofur
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
CAHI:	Canadian Animal Health Institute
CCAR:	Canadian Committee on Antibiotic Resistance
CCS:	Canadian CompuScript
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
CLSI:	Clinical and Laboratory Standards Institute
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
ICD-9:	International Classification of Diseases Ninth Revision System
ISO:	International Standards Organization
IMS HEALTH:	Intercontinental Medical Statistics
LB:	Luria-Bertani agar
LFZ:	Laboratory for Foodborne Zoonoses
MAC:	MacConkey agar
MDR:	multidrug resistant
MIC:	minimum inhibitory concentration
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
PHAC:	Public Health Agency of Canada
PPHL:	Provincial Public Health Laboratory
PT:	Phage type
STL:	*Salmonella* Typing Laboratory
TSI:	triple sugar iron
VDD:	Veterinary Drugs Directorate
WHO:	World Health Organization

Antimicrobial Abbreviations:

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

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

Table of Contents

List of Figures

List of Tables

List of Boxes

Executive Summary

CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) is a national program dedicated to the collection, integration, analysis, and communication of trends in antimicrobial use and the development of resistance in selected bacterial organisms from humans, animals and animal-derived food sources across Canada. This information supports (i) the creation of evidence-based policies to control antimicrobial use in hospital, community, and agricultural settings and thus prolong the effectiveness of these drugs, and (ii) the identification of appropriate measures to contain the emergence and spread of resistant bacteria between animals, food, and people.

This publication represents the third annual CIPARS report being released by the Government of Canada under the coordination of the Public Health Agency of Canada (formerly Population and Public Health Branch, Health Canada). Additional details are available on the CIPARS website (*http://www.phac-aspc.gc.ca/cipars-picra/index.html*).

CIPARS Activities

In 2004, CIPARS operated two active surveillance components: 1) ***abattoir surveillance*** involves the collection and analysis of isolates of generic *Escherichia coli* and *Salmonella* from the intestinal contents of healthy animals at slaughter across Canada; and 2) ***retail surveillance*** involves the collection and analysis of isolates of generic *E. coli*, *Salmonella*, *Campylobacter*, and *Enterococcus* from retail meat in Ontario and Québec. The 2005 CIPARS report will contain retail surveillance data from Saskatchewan. In 2006, CIPARS begins its *On-Farm Surveillance* component that will provide on-farm data regarding antimicrobial use and resistance among enteric bacteria using a sentinel farm framework (Box 3).

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

Human (Intercontinental Medical Statistics Health) antimicrobial use information is also incorporated into CIPARS. Antimicrobial use is a recognized risk factor for antimicrobial resistance and monitoring baseline use data is valuable to evaluate prudent use strategies and other interventions. CIPARS focuses particularly on resistance to antimicrobial classes of high human health importance (Category I) such as newer cephalosporins (e.g. ceftiofur, ceftriaxone) and fluoroquinolones (e.g. ciprofloxacin). Nalidixic acid resistance is also highlighted because it can predict reduced efficacy or clinical failure to fluoroquinolones.

2004 CIPARS Results

Agrifood Surveillance

Abattoir surveillance: Generic *E. coli* from abattoir samples showed resistance to one or more antimicrobials in 80% of swine, 78% of chicken, and 31% of cattle isolates. Ciprofloxacin resistance was noted in less than one percent of cattle isolates from abattoir surveillance. Resistance to ceftiofur was observed in one percent of cattle and 25% of chicken *E. coli* isolates, the latter representing a significant increase from 16% ceftiofur resistance observed in 2002/2003. In the case of *Salmonella*, 40% of isolates from chickens and 48% from swine were resistant to one or more antimicrobials. In chickens, one percent of *Salmonella* isolates were resistant to ceftriaxone and 13% showed reduced susceptibility to ceftriaxone. A significantly increased number of isolates were resistant to ceftiofur between 2002/2003 (7%) and 2004 (22%).

Retail surveillance: The percentage of *E. coli* isolates demonstrating resistance was lower overall than that seen among the abattoir samples. In 2004, resistance to ceftiofur in *E. coli* was highest among chicken (28% of isolates from Ontario and Québec overall), as was the case in 2003, than in other commodity. In the case of *Salmonella*, 63% of all chicken isolates

from Ontario and Québec were resistant to one or more antimicrobials. Ceftiofur resistance was detected in 45% and 40% of chicken isolates from Ontario and Québec, respectively. For *Campylobacter* isolates from chicken, 53% from Ontario and 81% from Québec were resistant to one or more antimicrobials. Two percent of *Campylobacter* isolates from Ontario and three percent from Québec were resistant to ciprofloxacin. For *Enterococcus* isolates from chicken, 98% from Ontario and 94% from Québec were resistant to one or more antimicrobials. No resistance was detected in the *Enterococcus* isolates to ciprofloxacin, linezolid, or vancomycin. However, 100% of all *E. faecium* isolates from Ontario (6 isolates) and Québec (5 isolates) were resistant to quinupristine-dalfopristine.

Animal clinical isolates: Salmonella isolates from passive animal surveillance of animal clinical submissions animals that do not enter the food-chain) showed resistance to one or more antimicrobials in 83% of turkey, 77% of swine, 57% of cattle, and 40% of chicken isolates. Notably, ceftiofur resistance was observed in 21% of chicken, 20% of cattle, 17% of turkey, and 2% of swine isolates.

Human Surveillance
In 2004, 3147 *Salmonella* isolates from humans were collected from provincial public health laboratories. The prevalence of resistance to one or more of 16 antimicrobials tested varied by serovar: 58% - of *S*. Typhi isolates, 56% - of *S*. Heidelberg isolates, 47% - of *S*. Typhimurium, 29% - of *S*. Enteritidis, and 14% - isolates of *S*. Newport.

Resistance to ceftiofur was identified in seven percent of all isolates; 33% - of *S*. Heidelberg, nine percent - of *S*. Newport isolates, two percent -of *S*. Typhimurium isolates, and less than one percent - of S. Enteritidis isolates.

Resistance to ceftriaxone was identified in less than one percent of all isolates but reduced susceptibility was observed in six percent of all isolates. Reduced susceptibility and resistance to ceftriaxone in *S.* Heidelberg isolates increased significantly between 2003 (8%) and 2004 (26%). Less than one percent of *S*. Typhimurium isolates and one (1/5) *S*. Indiana isolate were resistant to ciprofloxacin, however resistance to nalidixic acid, which can predict reduced clinical efficacy of fluoroquinolones, was observed in 23% of S. Enteritidis and 57% of S. Typhi isolates.

Human Antimicrobial Use: The human systemic antibacterial classes most frequently dispensed by retail pharmacies in Canada, as a proportion of total defined daily doses), were extended-spectrum penicillins (25%); macrolides (20%); tetracyclines (14%); fluoroquinolones (12%); and second-generation cephalosporins (5%).

Decreases were noted in the total number of prescriptions per 1000 inhabitant-years (739 in 2000 to 661 in 2004) and in the number of defined daily doses per 1000 inhabitant-days (19.23 in 2000 to 17.35 in 2004). However, despite a decrease in consumption, the amount of money spent by Canadians to purchase oral drugs through retail pharmacies increased from $20,853 per 1000 inhabitants in 2000 to $21,053 per 1000 inhabitants in 2004. This rise is attributed in part to the growing proportion of more costly Category I drugs dispensed in 2004 (12%) compared to 2000 (10%).

Antimicrobials of Very High Human Health Importance (Category I) represented a consistently increasing proportion of the total DDDs dispensed from 10% in 2000 compared to 12% in 2004.

Of the total number of patient visits in which sampled physicians mentioned an antimicrobial therapy between 2000 and 2004, 51% of associated diagnoses were respiratory system diseases. During this period, the primary antimicrobial classes mentioned during visits for respiratory disease were extended spectrum macrolides (32%), amoxicillin (25%), cephalosporins (14%) and oral quinolones (11%).

Conclusions and future plans

CIPARS 2004 data describe patterns in human antimicrobial useand antimicrobial resistance in selected enteric organisms in human and animals across Canada. Multidrug-resistance in numerous *Salmonella* serovars and the identification of strains resistant to ciprofloxacin and the cephalosporins are of particular concern, as is the observation of fluoroquinolone resistance in *Campylobacter* isolated from retail

chicken (also noted in 2003). In 2003, the prevalences of resistance to beta-lactam antimicrobials was significantly higher among retail chicken and human *S*. Heidelberg isolates from Québec, than retail chicken and human isolates from Ontario. In 2004, although the relative frequency of this serovar, in comparison to all isolated *Salmonella*, decreased significantly for both retail chicken and human isolates, the prevalence of beta-lactam resistance significantly increased in Ontario in both retail chicken and human isolates to reach the same levels found in Québec.

The current lack of detailed data describing antimicrobial use in food animals limits exploration of links between antimicrobial use and resistance in livestock. The on-farm component of CIPARS being introduced in 2006 will provide useful information in this regard and assist in the development of prudent use guidelines. Other efforts are also being made by CIPARS and several provinces to obtain more detailed national or provincial animal drug use data. Antimicrobial distribution data from animals will be made available to CIPARS by the Canadian Animal Health Institute; these data will be posted on our website later in 2006.

Potential explanations for AMR differences within and between humans and animal species include differing antimicrobial exposures, animal husbandry practices, and species-specific bacterial populations. To shed more light on this complex issue, further laboratory characterization and epidemiologic research are being conducted to identify risk factors for the development and spread of antimicrobial resistance along specific points of the food chain. CIPARS integration of data over time will help to identify temporal relationships between human and animal/food data.

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

Species	Bacterial species	Number (%) of isolates resistant to one or more antimicrobials	Number (%) of isolates resistant to five or more antimicrobials[1]	Number (%) of isolates resistant to category I antimicrobials[2]	Number (%) of isolates resistant expressing intermediate resistance to ceftriaxone[3] or to nalidixic Acid[4]	Number of different antimicrobial resistance patterns / number of resistant isolates[5]
Enhanced Passive Surveillance of Clinical Isolates						
Human	*Salmonella*	1160/3147 (37%)	341/3147 (11%)	Ceftiofur: 227/3147 (7%) Ceftriaxone: 12/3147 (0.4%) Ciprofloxacine: 2/3147 (0.1%)	Ceftriaxone: 174/3147 (5.5%) Nalidixic acid: 310/3147 (10%)	143/1160
Active Abattoir Surveillance						
Beef	*E. coli*	52/167 (31%)	6/167 (4%)	Ceftiofur: 2/167 (1%) Ciprofloxacine: 1/167 (0.6%)		18/52
Swine	*E. coli*	114/142 (80%)	16/142 (11%)			35/114
	Salmonella	131/270 (49%)	30/270 (11%)			31/131
Chicken	*E. coli*	102/130 (78%)	45/130 (35%)	Ceftiofur: 33/130 (25%) Ceftriaxone: 1/130 (0.8%)	Ceftriaxone: 22/130 (17%)	54/102
	Salmonella	57/142 (40%)	30/142 (21%)	Ceftiofur: 31/142 (22%) Ceftriaxone: 1/142 (0.7%)	Ceftriaxone: 19/142 (13%)	16/57
Active Retail Surveillance						
Beef	*E. coli*	65/327 (20%)	12/327 (4%)	Ceftiofur: 4/327 (1%)	Ceftriaxone: 2/327 (<1%)	26/65
Pork	*E. coli*	177/306 (58%)	27/306 (9%)	Ceftiofur: 4/306 (1%)		53/177
Chicken	*E. coli*	237/308 (77%)	112/308 (36%)	Ceftiofur: 86/308 (28%) Ceftriaxone: 1/308 (0.3%)	Ceftriaxone: 38/308 (12%)	74/237
	Salmonella	67/107 (63%)	42/107 (39%)	Ceftiofur: 46/107 (43%) Ceftriaxone: 1/107 (0.9%)	Ceftriaxone: 21/107 (20%)	14/67
	Campylobacter spp.	202/298 (68%)	n/a	Ciprofloxacin 7/298 (2.3%)		9/202
	Enterococcus spp.	307/320 (96%)	79/320 (25%)	Quinupristine-Dalfopristine 21/25 (84%)[6]		40/307
Passive Surveillance of Animal Clinical Isolates						
Bovine	*Salmonella*	61/107 (57%)	51/107 (48%)	Ceftiofur: 21/107 (20%)	Ceftriaxone: 20/107 (19%)	19/61
Swine	*Salmonella*	174/225 (77%)	93/225 (41%)	Ceftiofur: 4/225 (2%)	Ceftriaxone: 4/225 (2%)	39/174
Chickens	*Salmonella*	17/42 (40%)	11/42 (26%)	Ceftiofur: 9/42 (21%)	Ceftriaxone: 8/42 (19%)	9/17
Turkeys	*Salmonella*	30/36 (83%)	15/36 (42%)	Ceftiofur: 6/36 (17%) Ceftriaxone: 1/36 (2.8%)	Ceftriaxone: 4/36 (11%)	16/30

[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 categorization system developed in 2003 by the Veterinary Drugs Directorate; see Appendix A.1.*

[3] *Particular attention is given to isolates with reduced susceptibility (intermediate resistance) to ceftriaxone, an antimicrobial of very high importance in human medicine, because of the correlation between possible clinical implication of reduced in-vitro susceptibility*

[4] *Resistance to nalidixic acid is highlighted because Salmonella strains that are resistant to nalidixic acid may be associated with clinical failure or delayed response to fluoroquinolone therapy in cases of extra-intestinal salmonellosis (NCCLS /CLSI - M100-S15).*

[5] *Further details on AMR patterns can be found at: http://www.phac-aspc.gc.ca/cipars-picra/index.html*

[6] *E. feacium (n=11) and Enterococcus spp. other than E. feacalis (n=14).*

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

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C[1] R/n (%n) R/N (%N)	ACSSuT R/n (%n) R/N (%N)	AKSSuT R/n (%n) R/N (%N)	ACKSSuT R/n (%n) R/N (%N)	A2C+ ACSSuT R/n (%n) R/N (%N)	A2C+ AKSSuT R/n (%n) R/N (%N)	A2C+ ACKSSuT R/n (%n) R/N (%N)
Enhanced Passive Surveillance of Clinical Isolates									
Human	*S*. Enteritidis (n=550)	393/550 (71%) 393/3147 (12%)	none	1/550 (<1%) 1/3147 (<1%)	1/550 (<1%) 1/3147 (<1%)	none	1/550 (<1%) 1/3147 (<1%)	none	none
	S. Heidelberg (n=559)	244/559 (44%) 244/3147 (8%)	154/559 (28%) 154/3147 (5%)	none	none	none	21/559 (4%) 21/3147 (<1%)	none	none
	S. Newport (n=153)	131/153 (86%) 131/3147 (4%)	1/153 (<1%) 1/3147 (<1%)	1/153 (<1%) 1/3147 (<1%)	none	1/153 (<1%) 1/3147 (<1%)	12/153 (8%) 12/3147 (<1%)	none	1/153 (<1%) 1/3147 (<1%)
	S. Typhi (n=125)	52/125 (42%) 52/3147 (2%)	none	17/125 (14%) 17/3147 (<1%)	none	1/125 (<1%) 1/3147 (<1%)	none	none	none
	S. Typhimurium (n=597)	316/597 (53%) 316/3147 (10%)	1/597 (<1%) 1/3147 (<1%)	99/597 (17%) 99/3147 (3%)	17/597 (3%) 17/3147 (<1%)	61/597 (10%) 61/3147 (2%)	6/597 (1%) 6/3147 (<1%)	none	1/597 (<1%) 1/3147 (<1%)
	Other *Salmonella* serovars (n=1163)	851/1163 (73%) 851/3147 (27%)	14/1163 (1%) 14/3147 (<1%)	15/1163 (1%) 15/3147 (<1%)	2/1163 (<1%) 2/3147 (<1%)	6/1163 (<1%) 6/3147 (<1%)	1/1163 (<1%) 1/3147 (<1%)	none	none
Active Abattoir Surveillance									
Beef	*E. coli* (n=167)	115/167 (69%)	1/167 (<1%)	none	1/167 (<1%)	none	1/167 (<1%)	none	none
Swine	*E. coli* (n=142)	28/142 (20%)	none	3/142 (2%)	3/142 (2%)	none	none	none	none
	S. Enteritidis (n=1)	1/1 (100%) 1/270 (<1%)	none	none	none	none	none	none	none
	S. Heidelberg (n=8)	2/8 (25%) 2/270 (<1%)	none	none	none	none	none	none	none
	S. Typhimurium (n=41)	6/41 (15%) 6/270 (2%)	none	10/41 (24%) 10/270 (4%)	none	17/41 (41%) 17/270 (6%)	none	none	none
	Other *Salmonella* serovars (n=220)	130/220 (59%) 130/270 (48%)	none	none	none	none	none	none	none
Chickens	*E. coli* (n=130)	28/130 (22%)	25/130 (19%)	1/130 (<1%)	3/130 (2%)	1/130 (<1%)	6/130 (5%)	1/130 (<1%)	1/130 (<1%)
	S. Enteritidis (n=9)	9/9 (100%) 9/142 (6%)	none	none	none	none	none	none	none

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C[1]	ACSSuT	AKSSuT	ACKSSuT R/n (%n) R/N (%N)	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
	S. Heidelberg (n=51)	22/51 (43%) 22/142 (15%)	23/51 (45%) 23/142 (16%)	none	none	none	none	none	none
	S. Typhimurium (n=4)	2/4 (50%) 2/142 (1%)	1/4 (25%) 1/142 (<1%)	none	none	none	none	none	none
	Other *Salmonella* serovars (n=78)	52/78 (67%) 52/142 (37%)	4/78 (5%) 4/142 (3%)	none	none	none	none	none	none
Active Retail Surveillance									
Beef	*E. coli* (n=327)	262/327 (80%)	3/327 (<1%)	1/327 (<1%)	1/327 (<1%)	2/327 (<1%)	none	none	1/327 (<1%)
Pork	*E. coli* (n=306)	129/306 (42%)	3/306 (<1%)	2/306 (<1%)	6/306 (2%)	3/306 (<1%)	none	1/306 (<1%)	none
Chicken	*E. coli* (n=308)	71/308 (23%)	65/308 (21%)	3/308 (<1%)	7/308 (2%)	1/308 (<1%)	15/308 (5%)	3/308 (<1%)	3/308 (<1%)
	S. Enteritidis (n=3)	3/3 (100%) 3/107 (3%)	none	none	none	none	none	none	none
	S. Heidelberg (n=60)	15/60 (25%) 15/107 (14%)	32/60 (53%) 32/107 (30%)	none	none	none	1/60 (2%) 1/107 (<1%)	none	none
	S. Typhimurium (n=4)	none	4/4 (100%) 4/107 (4%)	none	none	none	none	none	none
	Other *Salmonella* serovars (n=40)	22/40 (55%) 22/107 (21%)	5/40 (13%) 5/107 (5%)	none	none	none	none	none	none
Passive Surveillance of Animal Clinical Isolates									
Bovine	*S*. Enteritidis (n=1)	1/1 (100%) 1/107 (<1%)	none	none	none	none	none	none	none
	S. Heidelberg (n=4)	1/4 (25%) 1/107 (<1%)	1/4 (25%) 1/107 (<1%)	none	none	none	none	none	none
	S. Newport (n=19)	1/19 (5%) 1/107 (<1%)	none	none	none	none	1/19 (5%) 1/107 (<1%)	none	17/19 (89%) 17/107 (16%)
	S. Typhimurium (n=48)	16/48 (33%) 16/107 (15%)	none	17/48 (35%) 17/107 (16%)	5/48 (10%) 5/107 (5%)	7/48 (15%) 7/107 (7%)	1/48 (2%) 1/107 (<1%)	none	none
	Other *Salmonella* serovars (n=35)	27/35 (77%) 27/107 (25%)	none	none	none	none	1/35 (3%) 1/107 (<1%)	none	none
Swine	*S*. Heidelberg (n=7)	none	2/7 (29%) 2/225 (<1%)	none	1/7 (14%) 1/225 (<1%)	none	none	none	none

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C[1]	ACSSuT	AKSSuT	ACKSSuT R/n (%n) R/N (%N)	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
	S. Typhimurium (n=121)	9/121 (7%) 9/225 (4%)	none	27/121 (22%) 27/225 (12%)	8/121 (7%) 8/225 (4%)	35/121 (29%) 35/225 (16%)	none	none	none
	Other *Salmonella* serovars (n=97)	42/97 (43%) 42/225 (19%)	none	2/97 (2%) 2/225 (<1%)	none	2/97 (2%) 2/225 (<1%)	1/97 (1%) 1/225 (<1%)	none	1/97 (1%) 1/225 (<1%)
Chickens	*S*. Enteritidis (n=6)	6/6 (100%) 6/42 (14%)	none	none	none	none	none	none	none
	S. Heidelberg (n=22)	11/22 (50%) 11/42 (26%)	7/22 (32%) 7/42 (17%)	none	none	none	none	none	1/22 (5%) 1/42 (2%)
	S. Typhimurium (n=2)	1/2 (50%) 1/42 (2%)	none	none	none	1/2 (50%) 1/42 (2%)	none	none	none
	Other *Salmonnella* serovars (n=12)	7/12 (58%) 7/42 (17%)	1/12 (8%) 1/42 (2%)	none	none	none	none	none	none
Turkeys	*S*. Heidelberg (n=6)	1/6 (17%) 1/36 (3%)	1/6 (17%) 1/36 (3%)	none	none	none	none	none	none
	S. Newport (n=1)	1/1 (100%) 1/36 (3%)	none	none	none	none	none	none	none
	S. Typhimurium (n=2)	None	none	1/2 (50%) 1/36 (3%)	1/2 (50%) 1/36 (3%)	none	none	none	none
	Other *Salmonella* serovars (n=27)	4/27 (15%) 4/36 (11%)	1/27 (4%) 1/36 (3%)	none	1/27 (4%) 1/36 (3%)	none	3/27 (11%) 3/36 (8%)	1/27 (4%) 1/36 (3%)	none

[1] *In 2003, CIPARS reported A3C patterns for human isolates. In April 2004, a new test panel (CMV1AGNF) was introduced. Antimicrobials on this test panel were the same as those included on the previous panel (CMV7CNCD) except that cephalothin was removed and sulfamethoxazole was replaced by sulfisoxazole (the same acronym SMX is used in the AMR pattern definition). Acronyms used in above table such as A2C, ACSSuT, AKSSuT and ACKSSuT refer to the phenotypic expression of resistance, and does not necessarily translate into similar genotypic grouping genetic determinants of resistance.*

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

Species	Most frequent serovars[1] (n)	Most frequent serovars with no resistance (n)	Most frequent serovars with 1 to 4 antimicrobials in resistance pattern (n)	Most frequent serovars with 5 to 8 antimicrobials in resistance pattern (n)	Most frequent serovars with 9 to 13 antimicrobials in resistance pattern (n)
Enhanced Passive Surveillance of Clinical Isolates					
Human	N=3147	N=1987	N=819	N=311	N=30
	Typhimurium[2] (597)	Enteritidis (393)	Heidelberg (260)	Typhimurium (185)	Heidelberg (13)
	Heidelberg (559)	Typhimurium (316)	Enteritidis (149)	Heidelberg (42)	Newport (9)
	Enteritidis (550)	Heidelberg (244)	Typhimurium (90)	Typhi (20)	Typhimurium (6)
	Newport (153)	Newport (131)	Hadar (78)	Newport (8)	Enteritidis (1)
	Typhi (125)	Thompson (94)	Typhi (53)	Enteritidis (7)	Indiana (1)
	Thompson (95)	Agona (54)	ParatyphiA (36)	ParatyphiBvar.Jav (7)	
	Agona (87)	Saintpaul (53)	Agona (28)		
	Hadar (85)	Typhi (52)			
		Infantis (45)			
Active Abattoir Surveillance					
Swine	N=270	N=139	N= 101	N=30	
	Derby (56)	Infantis (25)	Derby (40)	Typhimurium (27)	
	Typhimurium (41)	Derby (16)	London (11)	Brandenburg (1)	
	London (27)	London (16)	Typhimurium (8)	ssp. I:4,5,12:-:- (1)	
	Infantis (25)	Brandenburg (12)	Heidelberg (6)	Mbandaka (1)	
	Brandenburg (15)	Bovismorbificans (10)	Agona (3)		
	Bovismorbificans (12)	California (6)	California (3)		
	California (9)	Typhimurium (6)	Give (3)		
	Heidelberg (8)	Senftenberg (5)			
	Agona (6)	ssp. I:4,12:-:- (4)			
	Give (6)	Schwarzengrund (4)			
	ssp. I:4,12:-:- (6)	Agona (3)			
	Senftenberg (6)	Give (3)			
		Muenster (3)			
Chickens	N=142	N=85	N=27	N=30	
	Heidelberg (51)	Kentucky (24)	Kentucky (9)	Heidelberg (23)	
	Kentucky (35)	Heidelberg (22)	Heidelberg (6)	Kentucky (2)	
	Enteritidis (9)	Enteritidis (9)	Hadar (5)	Typhimurium (2)	
	Schwarzengrund (6)	Schwarzengrund (4)	Schwarzengrund (2)	ssp. I:4,12:r:- (1)	
	Hadar (5)	Agona (3)	Agona (1)	Infantis (1)	
	Agona (4)	Kiambu (3)	Albert (1)	Thompson (1)	
	Infantis (4)	Thompson (3)	Anatum (1)		
	Thompson (4)	Infantis (2)	ssp. I:4,12:-:- (1)		
	Typhimurium (4)	Rissen (2)	Infantis (1)		
	Kiambu (3)	Typhimurium (2)			
Active Retail Surveillance					
Chicken	N=107	N=40	N=25	N=41	N=1
	Heidelberg (60)	Heidelberg (15)	Heidelberg (12)	Heidelberg (32)	Heidelberg (1)
	Kentucky (19)	Kentucky (13)	Hadar (7)	Typhimurium (4)	
	Hadar (8)	Enteritidis (3)	Kentucky (4)	Kentucky (2)	
	Typhimurium (4)	Agona (2)	Anatum (1)	Agona (1)	
	Agona (3)	Infantis (2)	ssp. I:6,8:-:enx (1)	Bovismorbificans (1)	

Species	Most frequent serovars[1] (n)	Most frequent serovars with no resistance (n)	Most frequent serovars with 1 to 4 antimicrobials in resistance pattern (n)	Most frequent serovars with 5 to 8 antimicrobials in resistance pattern (n)	Most frequent serovars with 9 to 13 antimicrobials in resistance pattern (n)
	Enteritidis (3)	Hadar (1)		Infantis (1)	
	Infantis (3)	ssp. I:8,20:-:z6 (1)			
		Kiambu (1)			
		Mbandaka (1)			
		Montevideo (1)			
***Passive Surveillance* of Animal Clinical Isolates**					
Bovine	N=107	N=46	N=10	N=31	N= 20
	Typhimurium (48)	Typhimurium (16)	Anatum (2)	Typhimurium (30)	Newport (18)
	Newport (19)	Kentucky (10)	Heidelberg (2)	Heidelberg (1)	Mbandaka (1)
	Kentucky (12)	ssp. I:18:-:- (3)	Kentucky (2)		Typhimurium (1)
	Heidelberg (4)	Muenster (3)	Arizona (1)		
	ssp. I:18:-:- (3)	Sandiego (3)	Derby (1)		
	Muenster (3)	Brandenburg (2)	Manhattan (1)		
	Sandiego (3)	Bovismorbificans (1)	Typhimurium (1)		
		Enteritidis (1)			
		Heidelberg (1)			
		ssp. I:-,14,18:-:- (1)			
		ssp. I:6,7,14:-:1,5 (1)			
		Newport (1)			
		Orionvar.15+34+ (1)			
		Schwarzengrund (1)			
		Thompson (1)			
Swine	N=225	N=51	N=81	N=91	N=2
	Typhimurium (121)	Infantis (16)	Typhimurium (33)	Typhimurium (79)	ssp. I:6,7:-:- (1)
	Derby (20)	Typhimurium (9)	Derby (16)	Heidelberg (4)	Mbandaka (1)
	Infantis (16)	Dessau (4)	Agona (10)	ssp. I:4,12:i:- (2)	
	Agona (13)	Agona (3)	Mbandaka (4)	Muenchen (2)	
	Heidelberg (7)	Derby (3)	Heidelberg (3)		
	Mbandaka (7)	Schwarzengrund (3)	Anatum (2)		
		Brandenburg (2)	Berta (2)		
		California (2)	Brandenburg (2)		
			ssp. I:4,5,12:i:- (2)		
Chickens	N=42	N=25	N= 6	N=10	N=1
	Heidelberg (22)	Heidelberg (11)	Heidelberg (3)	Heidelberg (7)	Heidelberg (1)
	Enteritidis (6)	Enteritidis (6)	ssp. I:4,12:-:- (1)	ssp. I:4,5,12:r:- (1)	
	Kentucky (4)	Kentucky (3)	ssp. I:6,8:-:enx (1)	Montevideo (1)	
	Thompson (2)	Thompson (2)	Kentucky (1)	Typhimurium (1)	
	Typhimurium (2)	Dessau (1)			
	Dessau (1)	ssp. I:4,5,12:i:- (1)			
	ssp. I:4,12:-:- (1)	Typhimurium (1)			
	ssp. I:4,5,12:i:- (1)				
	ssp. I:4,5,12:r:- (1)				
	ssp. I:6,8:-:enx (1)				
	Montevideo (1)				
Turkeys	N= 36	N=6	N= 15	N=11	N= 4

Species	Most frequent serovars[1] (n)	Most frequent serovars with no resistance (n)	Most frequent serovars with 1 to 4 antimicrobials in resistance pattern (n)	Most frequent serovars with 5 to 8 antimicrobials in resistance pattern (n)	Most frequent serovars with 9 to 13 antimicrobials in resistance pattern (n)
	Heidelberg (6) Senftenberg (6) Infantis (4) Montevideo (4) Saintpaul (3) Albany (2) Bredeney (2) Hadar (2) Typhimurium (2) Dessau (1) ssp. Iiia:18:z4,z32:- (1) Newport (1) Schwarzengrund (1) Worthington (1)	Saintpaul (2) Heidelberg (1) ssp. Iiia:18:z4,z32:- (1) Newport (1) Worthington (1)	Heidelberg (4) Senftenberg (3) Albany (2) Hadar (2) Montevideo (2) Dessau (1) Schwarzengrund (1)	Senftenberg (3) Montevideo (2) Typhimurium (2) Bredeney (1) Infantis (1) Saintpaul (1)	Infantis (3) Bredeney (1)

[1] Most frequent serovars were those representing two percent or more of the isolates within each surveillance component and species category.

[2] For the purpose of this table, S. *Typhimurium var. Copenhagen results were combined with* S. *Typhimurium because some of the provinicial labs provide data specifying var. Copenhagen and others do not. Wherever possible, within the body of the report, these have been separated and clearly identified.*

Table 4. Number of antimicrobials in resistance patterns across species. 2004.

Species	Serovars	Number of antimicrobials in resistance pattern												
		0	1	2	3	4	5	6	7	8	9	10	11	13
		Percentage of isolates												
Enhanced Passive Surveillance of Clinical Isolates														
Human	*S*. Enteritidis (N=550)	71	21	3	2	<1	1	<1	<1				<1	
	S. Heidelberg (N=559)	44	16	4	2	25	6	<1		2	2	1		
	S. Newport (N=153)	86	3			1	1	1	1	3	4	1	1	
	S. Typhi (N=125)	42	42	1			1	2	13	1				
	S. Typhimurium (N=597)	53	5	3	4	4	18	8	4	1	1	1		
	Other *Salmonella* serovars (N=1163)	73	9	6	5	3	2	1	<1	1			<1	
	Salmonella Total (N=3147)	63	13	4	3	6	5	2	1	1	1	<1	<1	
Active Abattoir Surveillance														
Cattle	*E.coli* (N=167)	69	14	6	5	2	2	1				1		
Swine	*E.coli* (N=142)	20	18	20	18	13	10	1						
	S. Enteritidis (N=1)	100												
	S. Heidelberg (N=8)	25	25	38	13									
	S. Typhimurium (N=41)	15	5	12	2		22	34	7	2				
	Other *Salmonella* serovars (N=220)	59	17	8	11	3	1	<1						
	Salmonella Total (N=270)	51	15	10	10	3	4	6	1	<1				
Chickens	*E.coli* (N=130)	22	10	11	7	16	8	8	2	5	8	2	1	
	S. Enteritidis (N=9)	100												
	S. Heidelberg (N=51)	43	6	2	4		45							
	S. Typhimurium (N=4)	50					25		25					
	Other *Salmonella* serovars (N=78)	67	9	10	5	3	4	1	1					
	Salmonella Total (N=142)	60	7	6	4	1	19	1	1					
Active Retail Surveillance														
Beef	*E.coli* (N=327)	80	8	3	3	2	2	1	1			<1		
Pork	*E.coli* (N=306)	42	17	11	12	9	5	2	1	1		<1		
Chicken	*E.coli* (N=308)	23	15	9	7	9	13	5	5	4	6	2	1	<1
	S. Enteritidis (N=3)	100												
	S. Heidelberg (N=60)	25	10	3	2	5	52	2			2			
	S. Typhimurium (N=4)						100							
	Other *Salmonella* serovars (N=40)	55	5	23		5	8		5					
	Salmonella Total (N=107)	37	7	10	1	5	36	1	2		1			
	C. coli (n=31)	42	35	3	13	3		3						
	C. jejuni (n=262)	31	55	1	5	8								
	Other *Campylobacter* spp. (n=5)	20	60		20									
	Campylobacter Total (N=298)	32	53	1	6	7		<1						
	E. faecalis (n=295)[1]	4	13	36	5	21	8	11	3					
	E. faecium (n=11)				9	27	36		18		9			
	Other Enterococcus spp. (n=14)		7	7	7	7	29		21	21				
	Total *Enterococcus*	4	12	33	5	20	10	10	4	1	<1			
***Passive Surveillance* of Animal Clinical Isolates**														
Bovine	*S*. Enteritidis (N=1)	100												
	S. Heidelberg (N=4)	25	50				25							
	S. Newport (N=19)	5									5	89		
	S. Typhimurium (N=48)	33	2				40	17	6		2			

Species	Serovars	Number of antimicrobials in resistance pattern													
		0	1	2	3	4	5	6	7	8	9	10	11	12	13
		Percentage of isolates													
	Other *Salmonella* serovars (N=35)	77	9		11							3			
	Salmonella Total (N=107)	43	6		4		19	7	3		2	17			
Swine	*S*. Heidelberg (N=7)		14	14	14		43		14						
	S. Typhimurium (N=121)	7	2	7	3	14	29	21	13	2					
	Other *Salmonella* serovars (N=97)	43	6	10	22	8	6	2			1			1	
	Salmonella total (N=225)	23	4	9	12	11	20	12	8	1	<1			<1	
Chickens	*S*. Enteritidis (N=6)	100													
	S. Heidelberg (N=22)	50	9	5			32					5			
	S. Typhimurium (N=2)	50						50							
	Other *Salmonella* serovars (N=12)	58	8		17		8	8							
	Salmonella Total (N=42)	60	7	2	5		19	5				2			
Turkeys	*S*. Heidelberg (N=6)	17	33	17	17		17								
	S. Newport (N=1)	100													
	S. Typhimurium (N=2)						100								
	Other *Salmonella* serovars (N=27)	15	7	19	4	11	19	11			11		4		
	Salmonella Total (N=36)	17	11	17	6	8	22	8			8		3		

[1] *Maximum number of antimicrobial is 15 for E. faecalis because the species is intrinsically resistant to quinupristine-dalfopristine and lincomycin.*

Section One – Antimicrobial Resistance

Antimicrobial Resistance in Human Isolates

Salmonella – Enhanced Passive Surveillance

CIPARS *Enhanced Passive Surveillance* of antimicrobial resistance in human isolates of *Salmonella*[1] began in January 2003. Throughout 2004, provincial public health laboratories forwarded a total of 3147 *Salmonella* isolates (155 serovars) to the National Microbiology Laboratory (NML) in Winnipeg, Manitoba for phage typing and susceptibility testing (see Table 30, Appendix A.3, for more details on 2004 submissions and Appendix B.1 for methods).

The objectives of this 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 past outbreaks involving multiple drug resistant strains. *S*. Typhi, a human pathogen not of agri-food origin, is also presented 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) and also because of variation between provinces in antimicrobial use and prevailing strains and resistance patterns of Salmonella.

The history of antimicrobial use by patients where samples were sent to the NML was not known. Sample submissions may have followed therapeutic failure, which could potentially bias the resistance patterns towards multiple resistance.

In addition to resistant cases (MIC equal or above resistance breakpoint), particular attention is given to isolates where reduced susceptibility (intermediate resistance) to ceftriaxone is detected. This is an antimicrobial of very high importance in human medicine and there is a correlation between possible clinical implications and reduced susceptibility. Reduced susceptibility indicates that an isolate's MIC value falls between the resistance and susceptibility break points as outlined in CLSI M100-S15 (e.g. the intermediate MIC range for ceftriaxone is 16 to 32 μg/mL). Similarly, resistance to nalidixic acid is highlighted because *Salmonella* strains that are resistant to nalidixic acid may be associated with clinical failure or delayed response to fluoroquinolone therapy in cases of extra-intestinal salmonellosis (NCCLS /CLSI - M100-S15). Furthermore, particular attention is given to resistance profiles among outbreak-related cases because of their potential for increased infectivity. Although outbreak definitions may vary slightly by province, the Public Health Agency of Canada (PHAC) 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*". Finally, resistance profiles among isolates from blood and urine samples are highlighted because these cases are more likely to have received or to require antimicrobial treatment.

Additional information on AMR patterns and other details are available on the CIPARS website (*http://www.phac-aspc.gc.ca/cipars-picra/index.html*).

Salmonella Enteritidis

(n=550)

The provincial/territorial incidence rates of *S*. Enteritidis varied from 0 (no cases were reported in any of the territories) to 5.13 cases per 100,000 inhabitant-years[2], median=1.96). Among all isolates, the most frequent phage types (PT) were PT4 (173/550, 31%), PT13 (87/550, 16%), PT8 (64/550, 12%) and PT1 (62/550, 11%). Outbreak-related cases of *S*. Enteritidis, confirmed by the NML, are shown in Table 12. Two percent (10/550) of isolates were

[1] *With the exception of one* Salmonella bongori *(ssp IV 48:z81), CIPARS assumes that all Salmonella isolates reported here are* Salmonella enterica. *For the following descriptions of serovars and serotypes of Salmonella, the "enterica" is dropped.*

[2] *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 the province's population (Stat. Can. Post-censal population estimates Jan, 1, 2004), multiplied by 100,000.*

cultured from blood and less than one percent (5/550) of isolates were cultured from urine (Table 31).

Antimicrobial Drug Resistance: Results for *S*. Enteritidis are presented in Table 5, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was present in 29% (157/550) of isolates in 2004 compared to 22% (78/352) of isolates in 2003. No isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin in either 2003 or 2004. Resistance to ceftiofur was present in less than one percent (2/550) of isolates in 2004. These two isolates also showed reduced susceptibility to ceftriaxone (intermediate category). In 2003, two *S*. Enteritidis isolates were also resistant to ceftiofur; however, none of these isolates showed reduced susceptibility to ceftriaxone. In 2004 and 2003, resistance to nalidixic acid was present in 23% (124/550) of isolates, and 19% (66/352), respectively. There was a significant increase of the resistance to streptomycin between 2003 (5/352; 1.4%) and 2004 (22/550; 4.0%).

AMR Patterns: The most frequent AMR pattern was nalidixic acid alone (104/550, 19%). Two S. Enteritidis isolates showed reduced susceptibility to both ciprofloxacin (identified through resistance to nalidixic acid) and ceftriaxone (intermediate category). One of these isolates (PT4 from Ontario) was resistant to 11 antimicrobials (ACSSuT-A2C-NAL-SXT); the other isolate (PT6a from Ontario) was resistant to AMP-TIO-NAL. This resistance profile was not identified among any serovars in 2003. The ACSSuT (2/550) and AKSSuT (1/550) patterns were present in less than one percent of isolates in 2004, and were not present in 2003. The ACKSSuT pattern was not observed in 2004 or 2003. The A2C pattern was seen in one isolate in both 2003 and 2004. Most blood and urine isolates were susceptible to all antimicrobials tested, except two blood isolates resistant to STR and CHL-SMX-TCY. Three outbreak-related isolates were cultured from stool and were resistant to nalidixic acid.

Salmonella Heidelberg

(n=559)

The provincial/territorial incidence rates of *S*. Heidelberg varied from 0 (no cases were reported in Yukon and Nunavut) and 5.06 cases per 100,000 inhabitant-years (median=2.72). The most frequent phage types were PT19 (191/559, 34%), PT29 (124/559, 22%), PT32 (35/559, 6%), and PT41 (26/559, 5%). Outbreak-related cases of *S*. Heidelberg, confirmed by the NML, are shown in Table 12. Eight percent (45/559) of isolates were cultured from blood and three percent (15/559) were cultured from urine (Table 31).

Antimicrobial Drug Resistance: AMR results for *S*. Heidelberg are presented in Table 6, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was present in 56% (315/559) of isolates in 2004 compared to 46% (281/613) of isolates in 2003. No isolates were resistant to ciprofloxacin or amikacin in 2003 or 2004. Resistance to ceftriaxone was present in less than one percent (5/559) of isolates, which was similar to 2003 (3/613, <1%). However, reduced susceptibility to ceftriaxone (intermediate category) increased significantly between 2003 (51/613, 8%) and 2004 (143/559, 26%). Resistance to ceftiofur was present in 33% (183/559) of isolates in 2004, a significant increase from 2003 (137/613, 22%). Resistance to nalidixic acid was observed in one percent of isolates in both 2004(7/559) and 2003 (7/613).

AMR Patterns: The most frequent AMR pattern was A2C-AMP (145/559, 26%). The A2C-AMP (without resistance to other antimicrobials) pattern was primarily observed in Ontario (64/186, 34%) and in Québec (33/116, 28%), and was mainly seen across Canada among PT29 isolates (107/145, 74%). The ACSSuT-A2C pattern (without resistance to other antimicrobials) was present in three percent (17/559) of isolates. Thirteen of these 17 isolates were recovered in British Colombia (11 PT54, one PT19, and one PT53), three were PT54 from Québec, and one was PTAT04-3888 from New Brunswick. One PT53 isolate from New Brunswick showed resistance to ACSSuT-A2C-CRO. Two isolates were resistant to ACSSuT-A2C-SXT (one PT54 from Alberta and one PT21 blood isolate from Saskatchewan). One PT19 isolate from British Columbia was resistant to ACSSuT-A2C-NAL. One PT29 isolate from Alberta was resistant to A2C-AMP-

CRO-CHL. One PT53 isolate from Québec and one PT29 from Manitoba were resistant to A2C-AMP-CRO. The AKSSuT and ACKSSuT patterns were not observed among *S.* Heidelberg isolates. In comparison to 2003, resistance to the A2C pattern (with or without resistance to other antimicrobials) increased significantly in British-Columbia (2003: 13/49, 27%; 2004: 30/55, 55%), Manitoba (2003: 1/44, 2%; 2004: 9/58, 16%) and in Ontario (2003: 29/172, 17%; 2004: 67/186, 36%). There were no other significant provincial differences between 2003 and 2004. The frequency of A2C-AMP among S. Heidelberg blood isolates was 19% (9/48) in 2003 and 27% (12/45) in 2004 and among urine isolates was 25% (6/24) in 2003 and 40% (6/15) in 2004. Five isolates with the A2C-AMP pattern were related to outbreaks (two stool isolates with additional resistance to CRO, one stool isolate, and two isolates from unknown sources).

Box 1. New Risk Factor for *Salmonella* Heidelberg Identified in Canada

In 2003, an investigation into a British Columbia family cluster of *Salmonella* Heidelberg phage type (PT) 26 infection led to the isolation of the pathogen from chicken nuggets recovered from their household (Box 5). Cases diagnosed after the index family cluster also reported exposure to either chicken nuggets or chicken strips. A provincial epidemiologic investigation was undertaken to determine if exposure to chicken nuggets and/or strips were in fact a risk factor for *S.* Heidelberg infections.

All *S.* Heidelberg cases diagnosed between January 1 and April 1, 2003 in BC were included in the case-control study. A total of 20 cases were identified during this time period; a quarter of these cases occurred in children between 1 and 4 years of age. Duration of illness ranged from 2 to 72 days (median 11 days), with 65% of cases seen in an emergency room and 42% of cases hospitalized. Two *S.* Heidelberg isolates were recovered from blood samples, while 40% of cases experienced bloody diarrhea. The majority of cases (52%) were infected with *S.* Heidelberg PT26.

The odds of *S.* Heidelberg infection was 11 times higher in individuals having consumed frozen processed chicken nuggets or strips compared with those that had not. Several handling misconceptions were identified during this investigation. A number of cases and controls (33% each) considered frozen, processed chicken products to be precooked products, with respondents always (27%) and sometimes (15%) using a microwave for reheating the products.

Similar results were obtained through a nationwide case-control study conducted by the Foodborne, Waterborne and Zoonotic Infections Division of the Public Health Agency of Canada on all laboratory-confirmed cases of *S.* Heidelberg diagnosed between 1 January 2003 and 31 May 2003 (MacDougall, 2004). Cases that participated in the BC study were excluded from the nationwide survey.

A total of 95 matched pairs and 16 unmatched cases were interviewed, with 31% of cases under the age of 6 years old. As observed in British Columbia, the median length of illness was 10 days, with 47% of cases admitted to a hospital and 33% of cases having experienced bloody diarrhea. The most common phage types observed were PT19, followed by PT26, PT29, PT4 and PT35. Phage type 26 was the main phage type observed in the initial investigation conducted in British Columbia.

Results showed that cases were more likely than controls to have consumed chicken nuggets and/or strips (matched OR=4.0) and to have consumed undercooked eggs (matched OR=7.5). It was concluded that if the study participants are considered to be representative of the Canadian population, then 34% of all *S.* Heidelberg infections are attributable to consumption of chicken nuggets and strips and 16% to eating undercooked eggs.

As a result of the findings from these two investigations, the Canadian Food Inspection Agency (CFIA) proposed in August 2003 amendments to the Meat Inspection Regulations. The proposed amended regulation will require all meat products that are not ready to eat but have a cooked appearance and are raw to include in their labels the expression ‘ready to cook’, ‘uncooked’ or an equivalent term in the name of the product to indicate that the product requires cooking before consumption. At the same time, Health Canada’s Food Directorate is drafting an addition to the Food and Drug Regulations to make mandatory the inclusion of safe handling labels on raw ground meat and poultry products that have a cooked appearance, including chicken nuggets and strips (Currie et al, 2005).

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Salmonella Newport

(n=153)

The provincial/territorial incidence rates of *S*. Newport varied from 0 (no cases reported in the territories) and 2.18 cases per 100,000 inhabitant-years (median=0.41). In 2004, S. Newport was reported in all 10 provinces, whereas in 2003 it was not identified in Newfoundland. The most frequent phage types were PT9 (45/153; 29%), PT13 (20/153; 13%), and PT4 (16/153; 10%). Outbreak-related cases of *S*. Newport, confirmed by the NML, are shown in Table 12. Three percent of isolates were cultured from both blood (4/153) and urine (5/153).

Antimicrobial Drug Resistance: AMR results for *S*. Newport are presented in Table 7, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was present in 14% of isolates in both 2004 (22/153) and 2003 (27/175). No isolates were resistant to amikacin or ciprofloxacin. Resistance to ceftriaxone was present in two percent (3/153) of the 2004 isolates, but was not present in 2003. Seven percent of isolates showed reduced susceptibility to ceftriaxone (intermediate category) in both 2004 (11/153) and 2003 (12/175). Resistance to ceftiofur was present in nine percent (14/153) of isolates in 2004.

AMR Patterns: As in 2003, the most frequent AMR pattern in 2004 was ACSSuT-A2C (8/153, 5%) and was observed in three PT14a isolates from Ontario and in four PT14b isolates from Alberta and one from Saskatchewan. This pattern was also observed with resistance to other antimicrobials: ACSSuT-A2C-CRO was present in two PT14a isolates from Ontario and one PT14b isolate from British Columbia, ACSSuT-A2C-GEN was present in one PT14a isolate from Québec and ACKSSuT-A2C-GEN-SXT was present in one PT17 isolate from Ontario. The ACKSSuT-SXT pattern was seen in one PT14c isolate from Ontario. One PT17c isolate from Québec was resistant to A2C-AMP-NAL-STR and had reduced susceptibility to ceftriaxone. The ACSSuT pattern was observed in relatively similar frequencies in 2003 (11/175, 6%) and 2004 (13/153, 8%), as was the ACKSSuT pattern (2003: 5/175, 3%; 2004: 2/153, 1%). There were no significant differences in the frequency of the A2C pattern between 2003 and 2004 (2003: 17/175, 10%; 2004: 14/153, 9%). All blood and urine isolates and all outbreak-related isolates were susceptible to all antimicrobials tested in 2004.

Box 2. Multi-provincial/territorial enhanced surveillance for *Salmonella* Newport in Humans, April 1 to December 31, 2004.

In response to the emerging issue of MDR *S*. Newport in North America[1], a multi-provincial/territorial enhanced surveillance study for *S*. Newport in humans was conducted. The main study objectives were (1) to describe MDR *S*. Newport in Canada, and (2) to identify the risk factors for illness due to MDR *S*. Newport infections. Laboratory-confirmed cases of *S*. Newport residing in Canada with a date of specimen collection between April 1 and December 31, 2004, were considered for inclusion in the study. Cases were interviewed by telephone to obtain information on patient demographics, illness history, secondary transmission, foreign travel, animal/farm exposure, and food exposures. Data obtained from the PPHL and the NML included demographic information (used to link laboratory and case interview data), AMR profiles, phage types, and PFGE data.

Description of all *S*. Newport Cases: A total of 76 laboratory-confirmed *S*. Newport cases were included in the study, of which 90.8% (69/76) were susceptible and 9.2% (7/76) were resistant to at least one antimicrobial. Approximately five percent of the cases (4/76) exhibited the MDR*ampC S*. Newport pattern. The MDR*ampC* pattern includes resistance to amoxicillin-clavulanic acid, ampicillin, cefoxitin, ceftiofur, cephalothin, chloramphenicol, streptomycin, sulfamethoxazole, tetracycline, and intermediate or full resistance (MIC ≥16 ug/ml) to ceftriaxone [2, 3]. The majority of *S*. Newport cases were from Ontario (53.9%; 41/76), Québec (15.8%; 12/76), and Alberta (11.8%; 9/76). Most of the *S*. Newport infections occurred during the summer months, with 23.7% (18/76) occurring in August. Males accounted for 53.9% (41/76) of the cases. The most affected age groups were 40 to 49 year olds (23.7%; 18/76), 0 to 9 year olds (18.4%; 14/76), and 30 to 39 year olds (17.1%; 13/76). The most commonly reported symptoms were diarrhoea (97.4%; 74/76), abdominal cramps (88.6%; 62/70), and fever (65.3%; 47/72). None of the reported cases had exposure to a petting zoo, animal fair, or livestock farm (including dairy farm) in the three days prior to onset of illness. However, 7.0% (5/71) had reported antimicrobial use in the four weeks prior to onset of illness, and 26.1% (18/69) had travelled outside of Canada in the 7 days prior to onset of illness. Of the remaining cases (after excluding secondary and foreign travel-related cases), 61.2% (30/49) had reported contact with pets and 54.5% (24/44) had consumed ground beef, in the three days prior to illness onset. The predominant phage types were PT 9 (25.0%; 19/76) and PT 13 (22.4%; 17/76).

Description of resistant *S*. Newport isolates: Of the seven resistant *S*. Newport isolates, the majority (85.7%; 6/7) were resistant to five or more antimicrobials. Of those, 66.7% (4/6) were resistant to 9 or more antimicrobials. One isolate (14.3%; 1/7) was resistant to one antimicrobial. Five isolates exhibited the ACSSuT resistance pattern, one of which also exhibited the ACKSSuT resistance pattern. Three of the seven resistant isolates (42.9%; 3/7) were intermediately resistant to ceftriaxone, and one isolate (14.3%; 1/7) was fully resistant to ceftriaxone. The phage types of the seven resistant isolates were as follows: PT14b (three isolates), and one isolate each of PT 14a, PT 13, PT 17, and Atypical.

Description and comparison between AMR and susceptible *S*. Newport Cases: Of the seven resistant cases, three were from Ontario and one each was from British Columbia, Alberta, Manitoba and Québec. Resistant cases occurred during the first or last few months of the study (with the exception of one resistant isolate collected in August). Gender comparisons indicated that males had a higher proportion of resistant cases (12.2%; 5/41) compared to females (5.7%; 2/35). The largest proportion of resistant cases (per age group) occurred in those aged 60 to 69 years (40.0%; 2/5). Prolonged symptoms (longer than 7 days) were reported by 71.4% (5/7) of resistant cases compared to 44.8% (26/58) of susceptible cases. Differences in the severity of symptoms (such as bloody diarrhoea) between susceptible and resistant cases were not found. Of the resistant cases, 57.1% (4/7) were hospitalized, compared to 19.4% (13/67) of susceptible cases. Of the six resistant cases for which data was available, all reported having visited an emergency room; this may or may not be an indicator of severity, as patients without physicians may use the emergency room for primary care. Approximately 57% (4/7) of the resistant cases and 44.1% (30/68) of the susceptible cases were treated with antibiotics. Of the seven resistant cases, 28.6% (2/7) had used antibiotics in the four weeks prior to illness (amoxicillin and cefprozil, respectively), and 57.1% (4/7) had travelled outside of Canada in the 7 days

prior to illness onset (two to the United States, and one each to Cuba and Mexico). After exclusion of foreign travel-related cases, 66.7% (2/3) had reported contact with pets (domestic cats). Resistant cases were more likely than susceptible cases to have used antibiotics prior to illness onset (OR 8.1, 95% CI 1.1-60.6, p=0.02), visited an emergency room (OR 19.9, 95%CI 1.1-367.6, p=0.00), or be hospitalized (OR 5.5, 95% CI 1.1-27.8, p=0.02). However, interpretation of these results is limited due to the small number of cases.

Description of MDR*ampC S*. Newport Cases: Of the seven resistant *S*. Newport isolates, 57.1% (4/7) exhibited the MDR*ampC* pattern. Of the four MDR*ampC S*. Newport cases, two were from Ontario and one each was from British Columbia and Alberta. The majority of the MDR*ampC* cases occurred in the first few months of the study (one case each occurred in April, May, and June), and one case occurred in November. Two (50.0%; 2/4) of the MDR*ampC* cases had bloody diarrhea. All four cases visited an emergency room as a result of their illness, one of which also visited a doctor or walk-in clinic. One case was hospitalized. The two resistant cases that had reported antibiotic use prior to illness onset were MDR*ampC* cases. Of these, one case also had contact with a pet cat. The remaining two MDR*ampC* cases travelled outside of Canada in the seven days prior to onset of illness, both visiting the United States.

CIPARS data (April 1 – December 31, 2004): One hundred and thirty-one *S*. Newport isolates were collected by CIPARS *Enhanced Passive Surveillance* of human clinical isolates, including the 76 described above. Twelve percent (16/131) were resistant to one or more antimicrobials, compared to 16.7% (24/144) of isolates during the same time period in 2003. Half of the resistant isolates (50.0%; 8/16) exhibited intermediate resistance to ceftriaxone (CRO) and 18.8% (3/16) were fully resistant to ceftriaxone. During the same time period in 2003, 45.8% (11/24) showed intermediate resistance to CRO (i.e. there were no fully resistant isolates). Approximately eight percent (10/131) of the total *S*. Newport isolates and 62.5% (10/16) of resistant isolates exhibited the MDR*ampC* pattern, compared to 6.9% (10/144) of total *S*. Newport isolates and 41.7% (10/24) of resistant isolates, during the same time period in 2003.

Five *S*. Newport isolates came from CIPARS *Passive Surveillance* of animal clinical isolates during the same time period in 2004 (all from Ontario), and three of these were resistant to 9 or more antimicrobials. These three isolates exhibited the MDR*ampC* pattern; all three were bovine isolates. During the same time period in 2003, CIPARS *Passive Surveillance* of animal clinical isolates identified 56 MDR*ampC S*. Newport, all from bovine samples from Ontario, which included 14 isolates obtained from the same farm on the same day.

Conclusions: Data from the National Enteric Surveillance Program indicates that the rate of *S*. Newport decreased slightly from 0.51 cases per 100,000 population in 2003, to 0.47 cases per 100,000 population in 2004. However, the proportion of MDR*ampC* within recovered *S*. Newport in Canada during the study period was similar to that reported in 2003 during the same time period. Of additional concern, though, is the increased proportion of isolates testing non-susceptible to ceftriaxone during the study period, compared to the same time period in 2003.

Resistant cases may have prolonged duration and increased severity of illness (measured by hospitalization or emergency room visits). Exposure to dairy cattle, which was identified as a main risk factor for MDR*ampC S*. Newport infection in the U.S., was not observed in Canada throughout the study period. However, in 2003, several human MDR *S*. Newport cases had been epidemiologically linked to a dairy cattle outbreak [4]. Of the risk factors examined, previous antibiotic use was the only significant risk factor observed among resistant cases of *S*. Newport in Canada. Among MDR*ampC S*. Newport cases, both previous antibiotic use and travel to the United States were reported.

Interpretation of the results is limited due to the small number of *S*. Newport cases included in the study. There were also difficulties connecting case interview data with laboratory isolate data, and the exposure

histories of cases were difficult to interpret without comparison groups. Further investigation is required to validate risk factor and severity of illness findings.

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Salmonella Typhi

(n=125)

Unlike non-typhoidal salmonellosis, which has widespread global distribution in animals and humans and is typically food-borne, salmonellae causing typhoid and other enteric fevers are spread mainly from person-to-person, have no significant animal reservoirs, and are less common in developed countries. CIPARS includes surveillance of typhoidal salmonellosis because of its clinical severity, the importance of effective antimicrobial treatment, and international public health concerns. Monitoring of risk factors (eg travel history) is also important for effective control measures and CIPARS is working to enhance this information in the future.

The provincial/territorial incidence rates of *S.* Typhi varied from 0 (no cases reported in any territories, Saskatchewan, Manitoba or any Atlantic provinces) and 0.79 cases per 100,000 inhabitant-years (median=0). Among all isolates, the most frequent phage types were PTE1 (38/125, 30%), PTE9 (17/125, 14%), and PTUVS-(I+IV) (8/125, 6%). The phage type could not be identified in 11% (14/125) of isolates. There were no outbreak associated isolates. Forty-seven percent (59/125) of isolates were cultured from blood and two percent (2/125) of isolates were cultured from urine.

Antimicrobial Drug Resistance: AMR results for *S.* Typhi are presented in Table 8, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was present in 58% (73/125) of isolates in 2004 compared to 50% (63/127) of isolates in 2003. As in 2003, there was no resistance to ceftriaxone, ciprofloxacin, gentamicin, or amikacin in 2004. There was also no resistance to ceftiofur, cephalothin, cefoxitin, and amoxicillin-clavulinic acid in 2004 while it was observed in less than one percent (1/127) of isolates in 2003. There was no intermediate resistance to ceftriaxone in 2003 or in 2004. However, resistance to nalidixic acid increased significantly between 2003 (56/127, 44%) and 2004 (71/125, 57%).

AMR Patterns: The most frequent AMR patterns were NAL alone (52/125, 42%; including 22 blood isolates) and ACSSuT-NAL-SXT (16/125, 13%; including 8 blood isolates). The most frequent phage types resistant to NAL alone were PTE1 (17/52, 33%) and PTE9 (11/52, 21%). Ten of the isolates with ACSSuT-NAL-SXT pattern were from Ontario (six PTE1, one PTE9 and three unidentifiable), three from Québec (two PTE1 and one unidentifiable) and three unidentifiable isolates from British Columbia. The ACSSuT-NAL-SXT pattern was observed in six percent (7/127) of isolates in 2003. The A2C pattern was not observed among *S.* Typhi isolates in 2004, while one isolate with A2C-AMP resistance was identified in 2003. Forty-four percent (26/59) of blood isolates and all urine isolates (2/2) were susceptible to all antimicrobials tested, while 19% (11/59) of blood isolates showed resistance to between five and eight antimicrobials. One PTE1 blood isolate from Ontario was resistant to the ACKSSuT-NAL-SXT pattern in 2004, yet this was not detected in 2003. Two other blood isolates showed resistance to ACSSuT-SXT and AMP-CHL-SMX-TCY-SXT.

Salmonella Typhimurium

(n=597)

The provincial incidence rates of *S.* Typhimurium varied from 0 (no cases reported in Nunavut) and 4.93 cases per 100,000 inhabitant-years (median=2.78). Among all isolates the most frequent phage types were PT104 (96/597 isolates, 16%), PT108 (68/597 isolates, 11%), PT10 and PT104b (38/597 isolates each, 6%), and PT46 (29/597 isolates, 5%). Outbreak-related cases of *S.* Typhimurium, confirmed by the NML, are shown in Table 12. Two percent of isolates were cultured from blood (9/597) and one percent from urine (5/597) isolates.

Antimicrobial Drug Resistance: AMR results for *S.* Typhimurium are presented in Table 9, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was present in 47% (281/597) of isolates in 2004, as compared to 52% (315/610) of isolates in 2003. No isolates were resistant to amikacin. Resistance to ciprofloxacin was observed in less than one percent of all isolates in 2004 (1/597 isolates) and in 2003 (2/610 isolates). Ceftriaxone resistance was present in less than one percent of all isolates in 2004 (2/597) and was not present in 2003. Less than one percent of isolates showed reduced susceptibility (intermediate category) to ceftriaxone in both

2004 (4/597) and 2003 (5/610). Resistance to ceftiofur was present in two percent (9/597) of isolates. Resistance to nalidixic acid was present in one percent of isolates in both 2004 (8/597) and 2003 (7/610). There was a significant decrease in ampicillin resistance between 2003 (44.3%; 270/610) and 2004 (37.3%; 223/597).

AMR Patterns: The most frequent AMR patterns were ACSSuT alone (91/597 isolates, 15%) or in combination with resistance to other antimicrobials (14/597 isolates; 2%), to ACKSSuT alone (41/597 isolates, 7%) or in combination with resistance to other antimicrobials (21/597 isolates; 4%). Most isolates with the ACSSuT pattern were PT104 and PT104b, while most ACKSSuT patterns were PT104 and PTUT1. The AKSSuT pattern was present alone (9/597 isolates; 2%) but was also observed with resistance to other antimicrobials (8/597 isolates; 1%) and mainly observed in PTUT1 and PT208 var. The A2C pattern was identified in one percent of isolates in 2004 (8/597) and in 2003 (8/610) and was always observed with resistance to other antimicrobials (ACSSuT-SXT, ACSSuT-CRO, ACKSSuT-SXT, ACSSuT, and AMP). The ACSSuT-A2C pattern (without resistance to other antimicrobials) was observed in less than one percent (3/597) of isolates. All three isolates were from Ontario (one PT104 and two PT108). The most resistant isolates were PT193 from Alberta (one resistant to ACSSuT-AMC-CIP-GEN-NAL-SXT and one resistant to ACSSuT-A2C-SXT) and PTUT2 (ACKSSuT-A2C-SXT pattern). The following AMR patterns, identified in 2004, were new to CIPARS: ACSSuT-AMC-CIP-GEN-NAL-SXT (1 PT193 isolate), ACSSuT-A2C-CRO (2 PTAT03-3596 isolates), ACSSuT-AMC-SXT (1 PTU302 isolate), AKSSuT-GEN-SXT (6 isolates), and AMP-CHL-KAN-SMX-TCY-SXT (one isolate). Among the nine blood isolates, three were susceptible to all antimicrobials and the others were resistant to: ACSSuT-SXT, ACKSSuT, AMP-CHL-KAN-STR-SMX, AMP-CHL-SMX-TCY, ACSSuT-A2C-SXT, ACKSSuT-A2C-SXT and SMX-TCY-SXT. Two urine isolates were susceptible to all antimicrobials while two were resistant to ACSSuT and one to ACKSSuT. Most outbreak-related isolates (34/39 isolates; 87%) were susceptible to all antimicrobials and the others had the following patterns: TCY, NAL, GEN-SMX-TCY, and GEN-SMX.

"Other Serovars"

(n=1163)

In 2004, "other serovars" represented 37% of all isolates and 150 different serovars (see Table 11). Outbreak-related cases of "other serovars", confirmed by the NML, are shown in Table 12. Among all "other serovar" isolates, five percent (62/1163) of isolates were cultured from blood, including one outbreak-related *S.* Saintpaul PT2, and six percent (70/1163) of isolates were cultured from urine, including one outbreak-related case of *S.* Braenderup PT2.

Antimicrobial Drug Resistance: AMR results for "other serovars" are presented in Table 10, Table 11, and Table 32 (Appendix A.3). Resistance to one or more antimicrobials was similar between 2004 (312/1163; 27%) and 2003 (300/1179; 25%). Resistance to ciprofloxacin was detected in less than one percent (1/1163) of isolates (serovar Indiana) for the first time in 2004. Resistance to nalidixic acid was present in eight percent (98/1163) of isolates in 2004 and in six percent (66/1179) of isolates in 2003. Resistance to ceftriaxone was identified for the first time in 2004 in less than one percent (2/1163) of isolates (serovars Mbandaka and Anatum). One percent (14/1163) of isolates (serovars Litchfield, Thompson, Montevideo, Infantis, Hadar, Kentucky, Bardo, Agona, 4,5,12:-:1,2, and 4,12:-:-) showed reduced susceptibility (intermediate category) to ceftriaxone in 2004; similar to 2003 (4/1179; <1%). Resistance to ceftiofur was present in two percent of isolates in 2004 (19/1163; serovars Litchfield, Agona, Hadar, Anatum, Bardo, Infantis, Montevideo, Kentucky, Thompson, Mbandaka, Stanley, 4,5,12:-:1,2, and 4,12:-:-) and in 2003 (20/1179; 2%). Of note is the first case of resistance to amikacin (among all CIPARS human and agri-food *E. coli* and *Salmonella* isolates since the beginning of the surveillance program in 2002) detected in one *S.* Indiana isolate.

AMR Patterns: The most frequent AMR patterns were NAL alone (58/1163, 5%) and STR-TCY (37/1163, 3%). The ACSSuT pattern (with or without resistance to other antimicrobials) was present in one percent (16/1163) of isolates. The ACKSSuT pattern (with or without resistance to other antimicrobials) was present in less than one percent (6/1163) of isolates. The pattern

AKSSuT-TIO-SXT was present in less than one percent (1/1163) of isolates. The A2C pattern was identified with resistance to other antimicrobials (ACSSuT, AMP-CRO, AMP-TCY, AMP) in one percent (15/1163) of isolates. There were no significant differences between 2003 and 2004 in the frequency of ACSSuT, ACKSSuT, AKSSuT, and the A2C patterns. One *S.* Indiana isolate, recovered in Alberta, from urine, was resistant to 11 antimicrobials (ACKSSuT-AMK-CIP-GEN-NAL-SXT). This pattern was not identified in 2003. The following multi-drug resistant pattern/serovar combinations were also identified for the first time in 2004: one S. Anatum isolate resistant to A2C-AMP-CRO, one *S.* Bovismorbificans resistant to ACKSSuT-NAL-SXT, one *S.* Bardo resistant to ACSSuT-A2C, two *Salmonella* serotype 4,5,12:i:- resistant to ACSSuT-GEN-NAL-SXT, one *S.* Bareilly resistant to ACSSuT-NAL-SXT, one *S.* Haifa resistant to ACSSuT-NAL-SXT, one *S.* Panama resistant to ACSSuT-SXT, one *S.* Stanley resistant to AKSSuT-GEN-NAL-SXT and one *S.* Hadar resistant to AKSSuT-TIO-SXT. Outbreak-related cases were susceptible to all antimicrobials tested. Forty-seven percent of the blood isolates were susceptible to all antimicrobials, whereas 15% (9/62) of blood isolates showed multiple resistance. Among urine isolates, 73% were susceptible to all antimicrobials while 19% (13/70) of urine isolates were resistant to more than one antimicrobial.

The prevalence of resistance to one or more of the 15 or 16 antimicrobials tested in 2004 was 58% (73/125) of *S.* Typhi isolates, 56% (315/559) of *S.* Heidelberg isolates, 47% (281/597) of *S.* Typhimurium isolates, 29% (157/550) of *S.* Enteritidis isolates, 27% (312/1163) of "other serovar" isolates, and 14% (22/153) of *S.* Newport isolates. Among antimicrobials of Very High Human Health Importance (Category I), resistance to ceftiofur was identified in seven percent of all isolates; 33% (183/559) of *S.* Heidelberg, nine percent (14/153) of *S.* Newport isolates, two percent (9/597) of *S.* Typhimurium isolates, and less than one percent (2/550) *S.* Enteritidis isolates. Resistance to ceftriaxone was identified in less than one percent (12/3147) of all isolates; two percent (3/153) of *S.* Newport isolates, less than one percent of both *S.* Heidelberg (5/559) and *S.* Typhimurium (2/597) isolates, and eight percent of both *S.* Anatum (1/12) and *S.* Mbandaka (1/13) isolates. Reduced susceptibility (intermediate category) to ceftriaxone was observed in six percent (174/3147) of all *Salmonella* isolates, 26% (143/559) of *S.* Heidelberg isolates, in seven percent (11/153) of *S.* Newport isolates, and in less than one percent of both *S.* Enterititdis (2/550) and *S.* Typhimurium (4/597). Less than one percent (1/597) of *S.* Typhimurium isolates and 20% of *S.* Indiana isolates (1/5) were resistant to ciprofloxacin. However, resistance to nalidixic acid, which can indicate reduced clinical efficacy to fluoroquinolones, was observed in 23% (124/550) of S. Enteritidis, 57% (71/125) of *S.* Typhi, , ,,90% (36/40) of *S.* Paratyphi A isolates, and occasionally in 31 other serovars, including *S.* Heidelberg, *S.* Newport, and *S.* Typhimurium. Two *S.* Enteritidis isolates and one *S.* Newport isolates showed reduced susceptibility to ceftriaxone together with resistance to nalidixic acid and other antimicrobials, which could result in reduced efficacy of both third generation cephalosporins and fluoroquinolones. Resistance to five or more antimicrobials was most frequent in *S.* Typhimurium (191/597, 32%), *S.* Typhi (20/125, 16%), *S.* Newport (17/153, 11%) and *S.* Heidelberg (55/559, 10%). There were three isolates with resistance to 11 antimicrobials out of 15 to 16 tested: one *S.* Newport isolate (ACKSSuT-A2C-GEN-SXT), one *S.* Enteritidis isolate (ACSSuT-A2C-NAL-SXT-CEP) and one *S.* Indiana (ACKSSuT-AMK-CIP-GEN-NAL-SXT). Between 2003 and 2004 there was an increase in prevalence of resistance to one or more antimicrobials in *S.* Enteritidis and *S.* Heidelberg. Of particular concern was the increase in prevalence of A2C resistance in three provinces (BC, MB and ON), the reduced susceptibility to ceftriaxone in *S.* Heidelberg (including blood isolates), and the increased frequency of the ACSSuT-NAL-SXT pattern among *S.* Typhi. Ceftriaxone resistance in *S.* Newport was also identified for the first time in 2004.

Table 5. Individual antimicrobial drug resistance for *Salmonella* Enteritidis (N=550) by province[1].

Category of human health importance	Antimicrobial	BC N=62	AB N=80	SK N=29	MB N=20	ON N=213	QC N=82	NB N=20	NS N=34	PE N=3	NL N=7	Canada
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	%
I	ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	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 (0)	0 (0)	0 (0)	0 (0)	0
II	amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	amoxicillin-clavulanic acid	1 (2)	0 (0)	0 (0)	0 (0)	3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	gentamicin	0 (0)	0 (0)	0 (0)	1 (5)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	kanamycin	0 (0)	1 (1)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	nalidixic acid	16 (26)	12 (15)	5 (17)	8 (40)	48 (23)	16 (20)	7 (35)	12 (35)	0 (0)	0 (0)	22
	streptomycin	1 (2)	0 (0)	1 (3)	2 (10)	13 (6)	3 (4)	2 (10)	0 (0)	0 (0)	0 (0)	4
	trimetoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	5 (2)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1
III	ampicillin	5 (8)	3 (4)	0 (0)	2 (10)	9 (4)	1 (1)	1 (5)	0 (0)	0 (0)	0 (0)	4
	cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	cephalothin[2]	1 (6)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2
	chloramphenicol	1 (2)	2 (3)	0 (0)	0 (0)	4 (2)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	2
	sulfamethoxazole	2 (3)	3 (4)	0 (0)	3 (15)	11 (5)	4 (5)	2 (10)	0 (0)	0 (0)	0 (0)	5
	tetracycline	3 (5)	4 (5)	0 (0)	2 (10)	11 (5)	3 (4)	2 (10)	0 (0)	0 (0)	0 (0)	5
IV												

[1] *Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

[2] *Only a small proportion of the isolates were tested for cephalothin (BC: N=17, ON: N=67) due to a change in sensititre plates in April 2004.*

Table 6. Individual antimicrobial drug resistance for *Salmonella* Heidelberg (N=559) by province [1].

Category of Human health importance	Antimicrobial	BC N=55 n (%)	AB N=55 n (%)	SK N=27 n (%)	MB N=58 n (%)	ON N=186 n (%)	QC N=116 n (%)	NB N=35 n (%)	NS N=13 n (%)	PE N=4 n (%)	NL N=9 n (%)	Canada %
I	ceftiofur	30 (55)	3 (5)	7 (26)	9 (16)	71 (38)	42 (36)	16 (46)	2 (15)	0 (0)	2 (22)	33
	ceftriaxone	0 (0)	1 (2)	0 (0)	1 (2)	1 (1)	1 (1)	1 (3)	0 (0)	0 (0)	0 (0)	<1
	ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	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 (0)	0 (0)	0 (0)	0 (0)	0
	amoxicillin-clavulanic acid	30 (55)	3 (5)	7 (26)	9 (16)	70 (38)	41 (35)	15 (43)	2 (15)	0 (0)	2 (22)	32
	gentamicin	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	3 (3)	2 (6)	1 (8)	0 (0)	0 (0)	1
	kanamycin	0 (0)	0 (0)	0 (0)	2 (3)	1 (1)	1 (1)	1 (3)	1 (8)	0 (0)	0 (0)	<1
	nalidixic acid	2 (4)	0 (0)	0 (0)	0 (0)	3 (2)	0 (0)	1 (3)	0 (0)	0 (0)	1 (11)	1
	streptomycin	14 (25)	4 (7)	3 (11)	10 (17)	4 (2)	6 (5)	5 (14)	1 (8)	0 (0)	0 (0)	8
	trimetoprim-sulfamethoxazole	0 (0)	3 (5)	1 (4)	0 (0)	0 (0)	2 (2)	1 (3)	0 (0)	0 (0)	0 (0)	1
III	ampicillin	35 (64)	9 (16)	7 (26)	16 (28)	92 (49)	63 (54)	20 (57)	4 (31)	1 (25)	4 (44)	45
	cefoxitin	30 (55)	3 (5)	7 (26)	10 (17)	67 (36)	39 (34)	15 (43)	2 (15)	0 (0)	2 (22)	31
	cephalothin[2]	7 (58)	1 (6)	2 (29)	2 (20)	15 (37)	18 (46)	2 (40)	0 (0)	0 (0)	0 (0)	8
	chloramphenicol	14 (25)	3 (5)	1 (4)	0 (0)	1 (1)	3 (3)	2 (6)	0 (0)	0 (0)	0 (0)	4
	sulfamethoxazole	15 (27)	5 (9)	2 (7)	2 (3)	3 (2)	8 (7)	6 (17)	1 (8)	0 (0)	0 (0)	8
	tetracycline	17 (31)	9 (16)	5 (19)	29 (50)	13 (7)	11 (9)	3 (9)	1 (8)	0 (0)	1 (11)	16
IV												

[1] *Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

[2] *Only a small proportion of the isolates were tested for cephalothin (BC: N=12, AB: N=17, SK: N=7, MB: N=10, ON: N=41,QC:N=39, NB: N=5) due to a change in sensititre plates in April 2004.*

Table 7. Individual antimicrobial drug resistance for *Salmonella* Newport (N=153) by province.

Category of Human health importance	Antimicrobial	BC N=14	AB N=16	SK N=4	MB N=5	ON N=64	QC N=26	NB N=5	NS N=15	PE N=3	NL N=1	Canada
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	%
I	ceftiofur	1 (7)	4 (25)	1 (25)	0 (0)	6 (9)	2 (8)	0 (0)	0 (0)	0 (0)	0 (0)	9
	ceftriaxone	1 (7)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2
	ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	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 (0)	0 (0)	0 (0)	0 (0)	0
	amoxicillin-clavulanic acid	1 (7)	4 (25)	1 (25)	0 (0)	6 (9)	2 (8)	0 (0)	0 (0)	0 (0)	0 (0)	9
	gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	1
	kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	3 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2
	nalidixic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (8)	0 (0)	0 (0)	0 (0)	0 (0)	1
	streptomycin	2 (14)	4 (25)	1 (25)	0 (0)	8 (13)	3 (12)	0 (0)	0 (0)	0 (0)	0 (0)	12
	trimetoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
III	ampicillin	1 (7)	4 (25)	1 (25)	0 (0)	8 (13)	3 (12)	0 (0)	0 (0)	0 (0)	0 (0)	11
	cefoxitin	1 (7)	4 (25)	1 (25)	0 (0)	6 (9)	2 (8)	0 (0)	0 (0)	0 (0)	0 (0)	9
	cephalothin[1]	0 (0)	3 (60)	0 (0)	0 (0)	2 (15)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	4
	chloramphenicol	2 (14)	4 (25)	1 (25)	0 (0)	8 (13)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	10
	sulfamethoxazole	3 (21)	4 (25)	1 (25)	0 (0)	8 (13)	2 (8)	0 (0)	0 (0)	0 (0)	0 (0)	12
	tetracycline	2 (14)	4 (25)	1 (25)	1 (20)	8 (13)	3 (12)	0 (0)	0 (0)	0 (0)	0 (0)	12
IV												

[1]Only a small proportion of the isolates were tested for cephalothin (AB: N=5, ON: N=13, QC: N=2) due to a change in sensititre plates in April 2004.

Table 8. Individual antimicrobial drug resistance for *Salmonella* Typhi (N=125) by province.

Category of Human health importance	Antimicrobial	BC N=33	AB N=9	SK N=0	MB N=0	ON N=73	QC N=10	NB N=0	NS N=0	PE N=0	NL N=0	Canada
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	%
I	ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	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 (0)	0 (0)	0 (0)	0 (0)	0
II	amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	nalidixic acid	22 (67)	2 (22)	0 (0)	0 (0)	42 (58)	5 (50)	0 (0)	0 (0)	0 (0)	0 (0)	57
	streptomycin	4 (12)	0 (0)	0 (0)	0 (0)	13 (18)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	16
	trimetoprim-sulfamethoxazole	3 (9)	0 (0)	0 (0)	0 (0)	14 (19)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	16
III	ampicillin	3 (9)	0 (0)	0 (0)	0 (0)	14 (19)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	16
	cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	cephalothin[1]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	chloramphenicol	3 (9)	0 (0)	0 (0)	0 (0)	14 (19)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	16
	sulfamethoxazole	3 (9)	0 (0)	0 (0)	0 (0)	14 (19)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	16
	tetracycline	3 (9)	0 (0)	0 (0)	0 (0)	13 (18)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	15
IV												

[1]*Only a small proportion of the isolates were tested for cephalothin due to a change in sensititre plates in April 2004.*

Table 9. Individual antimicrobial drug resistance for *Salmonella* Typhimurium (N=597) by province[1].

Category of Human health importance	Antimicrobial	BC N=67 n (%)	AB N=74 n (%)	SK N=16 n (%)	MB N=38 n (%)	ON N=239 n (%)	QC N=103 n (%)	NB N=44 n (%)	NS N=8 n (%)	PE N=2 n (%)	NL N=6 n (%)	Canada %
I	ceftiofur	1 (1)	4 (5)	0 (0)	0 (0)	4 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2
	ceftriaxone	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	ciprofloxacin	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
	amoxicillin-clavulanic acid	1 (1)	6 (8)	0 (0)	0 (0)	5 (2)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	3
	gentamicin	3 (4)	2 (3)	0 (0)	3 (8)	3 (1)	1 (1)	2 (5)	0 (0)	0 (0)	0 (0)	2
	kanamycin	22 (33)	15 (20)	1 (6)	5 (13)	36 (15)	31 (30)	1 (2)	1 (13)	0 (0)	0 (0)	20
	nalidixic acid	2 (3)	1 (1)	0 (0)	2 (5)	1 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1
	streptomycin	31 (46)	21 (28)	2 (13)	7 (18)	92 (38)	49 (48)	3 (7)	3 (38)	1 (50)	1 (17)	37
	trimetoprim-sulfamethoxazole	21 (31)	4 (5)	0 (0)	1 (3)	6 (3)	9 (9)	1 (2)	0 (0)	0 (0)	0 (0)	8
III	ampicillin	29 (43)	23 (31)	5 (31)	12 (32)	98 (41)	51 (50)	3 (7)	1 (13)	0 (0)	1 (17)	37
	cefoxitin	1 (1)	4 (5)	0 (0)	0 (0)	3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
	cephalothin[2]	3 (30)	1 (4)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5
	chloramphenicol	22 (33)	13 (18)	1 (6)	10 (26)	80 (33)	47 (46)	2 (5)	2 (25)	0 (0)	1 (17)	31
	sulfamethoxazole	32 (48)	26 (35)	5 (31)	14 (37)	103 (43)	55 (53)	5 (11)	3 (38)	0 (0)	1 (17)	41
	tetracycline	28 (42)	25 (34)	5 (31)	10 (26)	116 (49)	53 (51)	5 (11)	4 (50)	0 (0)	1 (17)	41
IV												

[1]*Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

[2]*Only a small proportion of the isolates were tested for cephalothin (BC: N=10 , AB: N=25 , ON: N=67) due to a change in sensititre plates in April 2004.*

Table 10. Individual antimicrobial drug resistance for "Other Serovars" of *Salmonella* (N=1163) by province [1].

Category of Human health importance		BC N=172 n (%)	AB N=100 n (%)	SK N=56 n (%)	MB N=51 n (%)	ON N=516 n (%)	QC N=160 n (%)		NS N=42 n (%)	PE N=5 n (%)	NL N=8 n (%)	Canada %
I	ceftiofur	1 (1)	0 (0)	1 (2)	2 (4)	6 (1)	6 (4)	3 (6)	0 (0)	0 (0)	0 (0)	2
	ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	<1
	ciprofloxacin	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	amikacin	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	amoxicillin-clavulanic acid	0 (0)	1 (1)	0 (0)	2 (4)	6 (1)	7 (4)	3 (6)	0 (0)	0 (0)	0 (0)	2
	gentamicin	2 (1)	4 (4)	1 (2)	7 (14)	2 (0)	2 (1)	1 (2)	1 (2)	0 (0)	0 (0)	2
	kanamycin	4 (2)	3 (3)	2 (4)	1 (2)	8 (2)	4 (3)	3 (6)	1 (2)	0 (0)	0 (0)	2
	nalidixic acid	17 (10)	7 (7)	3 (5)	2 (4)	55 (11)	6 (4)	4 (8)	4 (10)	0 (0)	0 (0)	8
	streptomycin	27 (16)	15 (15)	10 (18)	6 (12)	47 (9)	23 (14)	3 (6)	3 (7)	0 (0)	1 (13)	12
	trimetoprim-sulfamethoxazole	9 (5)	2 (2)	2 (4)	1 (2)	16 (3)	5 (3)	0 (0)	1 (2)	0 (0)	0 (0)	3
III	ampicillin	19 (11)	8 (8)	3 (5)	4 (8)	28 (5)	23 (14)	5 (9)	2 (5)	0 (0)	0 (0)	8
	cefoxitin	0 (0)	0 (0)	0 (0)	2 (4)	5 (1)	7 (4)	3 (6)	0 (0)	0 (0)	0 (0)	1
	cephalothin[2]	2 (3)	0 (0)	0 (0)	0 (0)	4 (3)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	3
	chloramphenicol	8 (5)	4 (4)	2 (4)	3 (6)	11 (2)	11 (7)	3 (6)	1 (2)	0 (0)	0 (0)	4
	sulfamethoxazole	20 (12)	8 (8)	4 (7)	11 (22)	38 (7)	27 (17)	3 (6)	2 (5)	0 (0)	0 (0)	10
	tetracycline	45 (26)	20 (20)	18 (32)	13 (25)	77 (15)	31 (19)	6 (11)	4 (10)	0 (0)	1 (13)	18
IV												

[1] *Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (see Appendix B.1).*

[2] *Only a small proportion of the isolates were tested for cephalothin (BC: N=67 , ON: N=133 , QC: N=50) due to a change in sensititre plates in April 2004.*

Table 11. *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	9-16
		Number of isolates			
British Columbia (N=403)					
Typhimurium	67 (16.6)	35	4	27	1
Enteritidis	62 (15.4)	43	19	0	0
Heidelberg	55 (13.6)	17	24	7	7
Typhi	33 (8.2)	11	19	3	0
Hadar	20 (5)	0	18	2	0
Newport	14 (3.5)	11	2	0	1
Brandenburg	10 (2.5)	10	0	0	0
Agona	9 (2.2)	3	5	1	0
Paratyphi A	9 (2.2)	2	7	0	0
Less common serovars	124 (30.8)	97	22	5	0
Total		**229**	**120**	**45**	**9**
Alberta (N=334)					
Enteritidis	80 (24)	62	18	0	0
Typhimurium	74 (22.2)	41	16	13	4
Heidelberg	55 (16.5)	37	16	1	1
Newport	16 (4.8)	12	0	1	3
Hadar	9 (2.7)	0	9	0	0
Typhi	9 (2.7)	7	2	0	0
Saintpaul	8 (2.4)	7	1	0	0
spp I 4,5,12:i:-	7 (2.1)	7	0	0	0
Less common serovars	76 (22.8)	61	11	3	1
Total		**234**	**73**	**18**	**9**
Saskatchewan (N=132)					
Enteritidis	29 (22)	23	6	0	0
Heidelberg	27 (20.5)	16	9	1	1
Typhimurium	16 (12.1)	11	4	1	0
Hadar	11 (8.3)	0	11	0	0
spp I 4,5,12:i:-	4 (3)	4	0	0	0
Newport	4 (3)	3	0	1	0
Oranienburg	4 (3)	4	0	0	0
Javiana	3 (2.3)	3	0	0	0
Panama	3 (2.3)	1	0	2	0
Saintpaul	3 (2.3)	3	0	0	0
Thompson	3 (2.3)	3	0	0	0
Less common serovars	25 (18.9)	20	5	0	0
Total		**91**	**35**	**5**	**1**

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
		Number of isolates			
Manitoba (N=172)					
Heidelberg	58 (33.7)	15	40	3	0
Typhimurium	38 (22.1)	21	10	7	0
Enteritidis	20 (11.6)	11	7	2	0
Agona	10 (5.8)	0	9	1	0
Infantis	7 (4.1)	6	1	0	0
Newport	5 (2.9)	4	1	0	0
Saintpaul	5 (2.9)	4	1	0	0
Less common serovars	29 (16.9)	23	4	2	0
Total		**84**	**73**	**15**	**0**
Ontario (N=1291)					
Typhimurium	239 (18.5)	117	35	86	1
Enteritidis	213 (16.5)	150	59	3	1
Heidelberg	186 (14.4)	84	88	14	0
Typhi	73 (5.7)	29	30	14	0
Newport	64 (5)	55	1	4	4
Thompson	39 (3)	39	0	0	0
Hadar	34 (2.6)	2	32	0	0
Paratyphi A	28 (2.2)	2	26	0	0
Less common serovars	415 (32.1)	344	57	14	0
Total		**822**	**328**	**135**	**6**
Québec (N=497)					
Heidelberg	116 (23.3)	46	55	12	3
Typhimurium	103 (20.7)	44	12	47	0
Enteritidis	82 (16.5)	60	21	1	0
Newport	26 (5.2)	22	1	2	1
Thompson	26 (5.2)	25	1	0	0
Saintpaul	12 (2.4)	11	1	0	0
Oranienburg	11 (2.2)	11	0	0	0
Agona	10 (2)	3	5	2	0
Typhi	10 (2)	5	2	3	0
Less common serovars	101 (20.3)	68	22	11	0
Total		**295**	**120**	**78**	**4**
New Brunswick (N=157)					
Typhimurium	44 (28)	37	5	2	0
Heidelberg	35 (22.3)	14	17	3	1
Enteritidis	20 (12.7)	12	7	1	0
Agona	17 (10.8)	17	0	0	0
Newport	5 (3.2)	5	0	0	0
Braenderup	4 (2.5)	4	0	0	0
Dublin	4 (2.5)	4	0	0	0
Saintpaul	4 (2.5)	4	0	0	0
Less common serovars	24 (15.3)	13	7	4	0
Total		**110**	**36**	**10**	**1**

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
		Number of isolates			
Nova Scotia (N=112)					
Enteritidis	34 (30.4)	22	12	0	0
Thompson	16 (14.3)	16	0	0	0
Newport	15 (13.4)	15	0	0	0
Heidelberg	13 (11.6)	8	4	1	0
Typhimurium	8 (7.1)	4	3	1	0
Agona	5 (4.5)	4	1	0	0
Oranienburg	4 (3.6)	4	0	0	0
Less common serovars	17 (15.2)	10	5	2	0
Total		**83**	**25**	**4**	**0**
Prince Edward Island (N=17)					
Heidelberg	4 (23.5)	3	1	0	0
Enteritidis	3 (17.6)	3	0	0	0
Newport	3 (17.6)	3	0	0	0
Typhimurium	2 (11.8)	1	1	0	0
Bredeney	1 (5.9)	1	0	0	0
spp II 50:b:z6	1 (5.9)	1	0	0	0
Orion	1 (5.9)	1	0	0	0
Paratyphi B var. Jav	1 (5.9)	1	0	0	0
Thompson	1 (5.9)	1	0	0	0
Total		**15**	**2**	**0**	**0**
Newfoundland and Labrador (N=31)					
Heidelberg	9 (29)	4	5	0	0
Enteritidis	7 (22.6)	7	0	0	0
Agona	6 (19.4)	6	0	0	0
Typhimurium	6 (19.4)	5	0	1	0
Hadar	1 (3.2)	0	1	0	0
Javiana	1 (3.2)	1	0	0	0
Newport	1 (3.2)	1	0	0	0
Total		**24**	**6**	**1**	**0**
Nunavut (N=1)					
Heidelberg	1 (100)	0	1	0	0

Note: Serovars with less than 2% prevalence are categorized as "less common serovars"

Table 12. Summary of confirmed outbreak-related cases of *Salmonella* in 2004 by serovar and province among isolates received by CIPARS[1].

Serovar	Phage Type	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	Canada
		n	n	n	n	n		n	n	n	n	n
Enteritidis	1							2				2
	4					1		1				2
	4a					1						1
	13					1						1
Heidelberg	19		1					1				2
	25							1				1
	29				3							3
	32				4							4
	45				1							1
	47							2				2
	53						2					2
Newport	3								3			3
	9								7			7
	13							2				2
Typhimurium	10					11						11
	40				1							1
	46				1			20				21
	108				3							3
	124var.							2				2
	206							1				1
Saintpaul	1							4				4
	2						1					1
Braenderup	1							1				1
	2							2				2
Thompson	1					3	5					8
	5							3				3
Agona	8										3	3

[1] *This table does not include outbreaks that occurred during the second half of the month in those larger provinces where isolates are only submitted during the first half of the month.*

Antimicrobial Resistance in the Agri-Food Sector

CIPARS relies primarily on *Active Surveillance* to monitor the occurrence of AMR in the agri-food sector. Currently, *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 purchased by consumers. A third Active Surveillance program is being launched in the Fall 2005; *On-Farm Surveillance* will provide on-farm data on antimicrobial use and resistance among enteric bacteria (Box 3). The *Abattoir Surveillance*, which involves voluntary participation of abattoirs, began in September 2002. For this surveillance component caecal samples from cattle, swine, and broiler chickens are collected and AMR in generic *E. coli* (all commodities) and *Salmonella* (swine and broiler chickens) are investigated. The *Retail Surveillance* component, launched in the summer of 2003, involves the collection of fresh store samples of ground beef, pork (shoulder chops), and chicken (legs or wings with skin on) and investigates AMR in generic *E. coli* (all commodities), *Salmonella* (chicken), *Campylobacter* spp. (chicken), and *Enterococcus* spp. (chicken). This reporting year (2004) represents the first full year of data collection for the *Retail Surveillance* component. CIPARS also reports on isolates obtained through animal clinical case submissions. These isolates are from clinical *Salmonella* cases 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 of Animal Clinical Isolates.*

The objectives of the agri-food AMR section are to present antimicrobial resistance results 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* of *Animal Clinical Isolates*.

In addition to resistant cases (MIC equal or above resistance breakpoint), particular attention is given to isolates where reduced susceptibility (intermediate resistance) to ceftriaxone is detected. This is an antimicrobial of very high importance in human medicine and there is a correlation between possible clinical implications and reduced susceptibility, or intermediate resistance. Reduced susceptibility indicates that an isolate's MIC value falls between the resistance and susceptibility break points as outlined in CLSI M100-S15 (e.g. the intermediate MIC range for ceftriaxone is 16 to 32 μg/mL). Similarly, resistance to nalidixic acid is highlighted because *Salmonella* strains that are resistant to nalidixic acid may be associated with clinical failure or delayed response to fluoroquinolone therapy in cases of extra-intestinal salmonellosis (NCCLS/CLSI - M100-S15).

Box 3. Introduction of new CIPARS component: On-Farm Surveillance.

The *On-Farm Active Surveillance* program is the most recent component being added to the repertoire of CIPARS programs. This initiative will focus on the development of a sentinel farm framework to provide data on antimicrobial use and on-farm samples for bacterial isolation and antimicrobial susceptibility testing. The objectives of the CIPARS on-farm program are to:

- establish an infrastructure supporting a national surveillance framework with emphasis on collection of data and samples pertaining to on-farm antimicrobial use and resistance;
- provide on-farm data regarding antimicrobial use and resistance among enteric bacteria;
- investigate potential associations between antimicrobial use and resistance in the agri-food sector;
- provide data for future human health risk assessments.

The on-farm program is currently in the development and early implementation stages. CIPARS on-farm activities for Year 1 (April 2003 – March 2004) involved consultation with potential federal and provincial government partners as well as various livestock producer and industry groups.

On-farm activities for Year 2 (April 2004 – March 2005) included continued involvement with on-farm research projects that served as models for surveillance activities and provided preliminary data.

In Years 3 through 5 (April 2005 – March 2008), data collection and sampling will focus on swine production. The swine industry was selected as the "pilot commodity" because 1) of the widespread use of the Canadian Quality Assurance (CQA®-AQC) program, which includes an antimicrobial drug use recording component; 2) the Canadian swine industry has not experienced a Foreign Animal Disease outbreak in recent years; and 3) there is a similar project in the United States, the Collaboration in Animal Health, Food Safety and Epidemiology (CAHFSE), which has designated swine as the pilot commodity, thus allowing for potential international harmonization.

Swine veterinarians are an integral component of the CQA program and are, therefore, a logical choice to provide the link between the producer and the surveillance program. Weighted selection of swine veterinarians from provincial sampling frames will be based on the estimated number of finisher hogs in a practice. Once selected, veterinarians that agree to participate will then select sampling sites according to specified inclusion/exclusion criteria. The primary focus will be the major pork-producing provinces of Alberta, Saskatchewan, Manitoba, Ontario, and Québec. The number of sampling sites per province will be proportional to national production based on the number of grower/finisher sites in each participating province.

Pooled fecal samples will be collected from hogs at close to market weight. The samples will be cultured for generic *E. coli* and *Salmonella* spp. Antimicrobial susceptibility testing will be performed using the Sensititre® Microbiology System (Trek Diagnostics Cleveland, Ohio, USA, www.trekds.com) and the National Antimicrobial Resistance Monitoring System (NARMS) Veterinary Public Health Plate configuration.

Antimicrobial use information will be collected across all available stages of production using enhanced CQA forms. Additionally, information will be collected on herd demographics and husbandry practices through the use of short annual and sampling day questionnaires.

Swine veterinarians were enrolled in the fallof 2005. Participating veterinarians would then enrol sentinel herds and conduct pre-test sampling in a sub-set of these sites in the fall of 2005. Starting January 1, 2006 the program started its first full year of sampling.

Beef Cattle – Generic E. coli

(*Abattoir Surveillance* n=167)

Note: *In 2004, generic E. coli isolates were recovered from 98% of the beef cattle caecal samples.*

Antimicrobial Drug Resistance: See Figure 1 and Table 33 (Appendix A.4). The prevalence of resistance to one or more antimicrobials tested was 32% (74/228) of isolates in 2002/2003 and 31% (52/167) of isolates in 2004. In 2002/2003, resistance was not detected to ceftriaxone, amikacin, gentamicin, ciprofloxacin, kanamycin, or nalidixic acid. In 2004, resistance to nalidixic acid (1/167, <1%), kanamycin (3/167, 2%) gentamicin (1/167, <1%), and ciprofloxacin (1/167, <1%) were detected for the first time. The percentage of isolates with resistance to ceftiofur was one percent in both 2002/2003 (2/228) and 2004 (2/167). Overall, despite small changes in resistance, there were no significant differences between resistance prevalence to individual antimicrobial drugs between 2002/2003 and 2004.

AMR Patterns: In 2004, the most common patterns were resistance to STR-SMX-TCY (8/167, 5%) and resistance to TCY alone (18/167, 11%). The isolates resistant to the greatest number of antimicrobials were resistant to ACSSuT-A2C-STX (1/167, <1%). The isolate resistant to ciprofloxacin had the following resistance pattern: AMP-CEP-CIP-GEN-NAL-TCY. With or without resistance to other antimicrobials, A2C (2/167, 1%), ACSSuT (1/167, <1%) and AKSSuT (1/167, <1%) were detected in 2004, whereas only A2C (2/228, 1%) and ACSSUT (2/228, 1%) were detected in 2002/2003. Resistance to greater than five antimicrobials was detected in four percent (6/167) of isolates in 2004 and in one percent (2/167) of isolates in 2002/2003.

For 2004, results from *Abattoir Surveillance* showed that 31% (52/167) of generic *E. coli* isolates from bovine 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 one percent (2/167) of isolates and ciprofloxacin resistance was detected in less than one percent (1/167) of isolates. Four percent (4/167) of isolates were resistant to five or more antimicrobials.

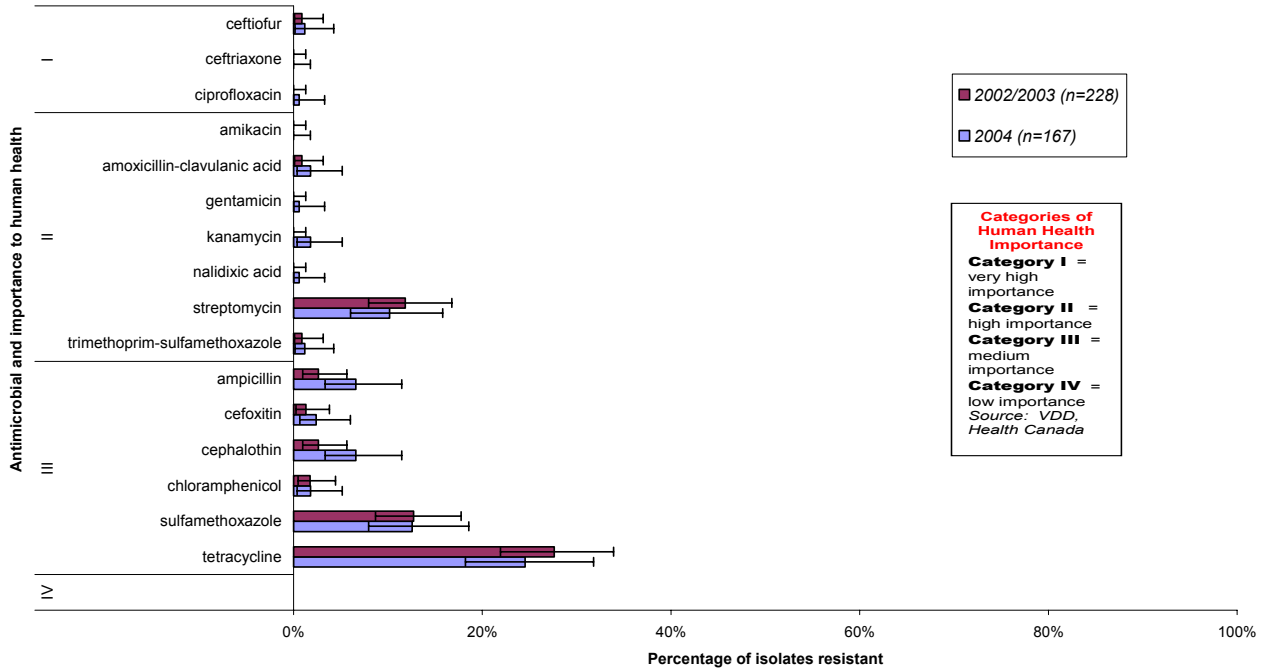

Figure 1. Individual antimicrobial drug resistance in generic *E. coli* from bovine isolates in 2002/2003 (n=228) and 2004 (n=167); *Abattoir Surveillance*.

Swine – Generic E. coli

(*Abattoir Surveillance* n=142)

Note: *In 2004, generic E. coli isolates were recovered from 99% of the swine caecal samples.*

Antimicrobial Drug Resistance: See Figure 2 and Table 34 (Appendix A.4). Eighty-seven percent (167/193) of isolates were resistant to one or more antimicrobials in 2002/2003 in comparison to 80% (114/142) of isolates in 2004. No resistance to antimicrobials of Very High Human Health Importance (ceftiofur, ceftriaxone, and ciprofloxacin) was observed in 2002/2003 or 2004. There were no significant differences between the prevalence of resistance to individual antimicrobial drugs between 2002/2003 and 2004.

AMR Patterns: In 2004, the most common patterns were resistance to TCY alone (19/142, 13%) and resistance to SMX-TCY or AMP-TCY (10/142, 7% each). The isolates resistant to the greatest number of antimicrobials were resistant to AKSSuT-SXT (1/142, <1%) and to FOX-CEP-AMP-STR-SMX-TCY (1/142, <1%). Alone or in combination with other antimicrobials, ACSSuT and AKSSuT patterns were each identified in two percent (3/142) of isolates while the ACKSSuT pattern was not detected in 2004 isolates. In 2002/2003, the ACKSSuT pattern was detected in three percent (5/193) of isolates, the ACSSuT pattern was detected in two percent (4/193) of isolates, and the AKSSuT pattern was detected in four percent (7/193) of isolates. Resistance to greater than five antimicrobials was detected in 11% (16/142) of isolates in 2004 and 20% (29/142) of isolates 2002/2003.

For 2004, results from *Abattoir Surveillance* showed that 80% (114/142) of generic *E. coli* isolates from swine caecal samples were resistant to one or more antimicrobials. There was no resistance to antimicrobials of Very High Importance to Human Health (Category I). Eleven percent (16/142) of isolates were resistant to five or more antimicrobials.

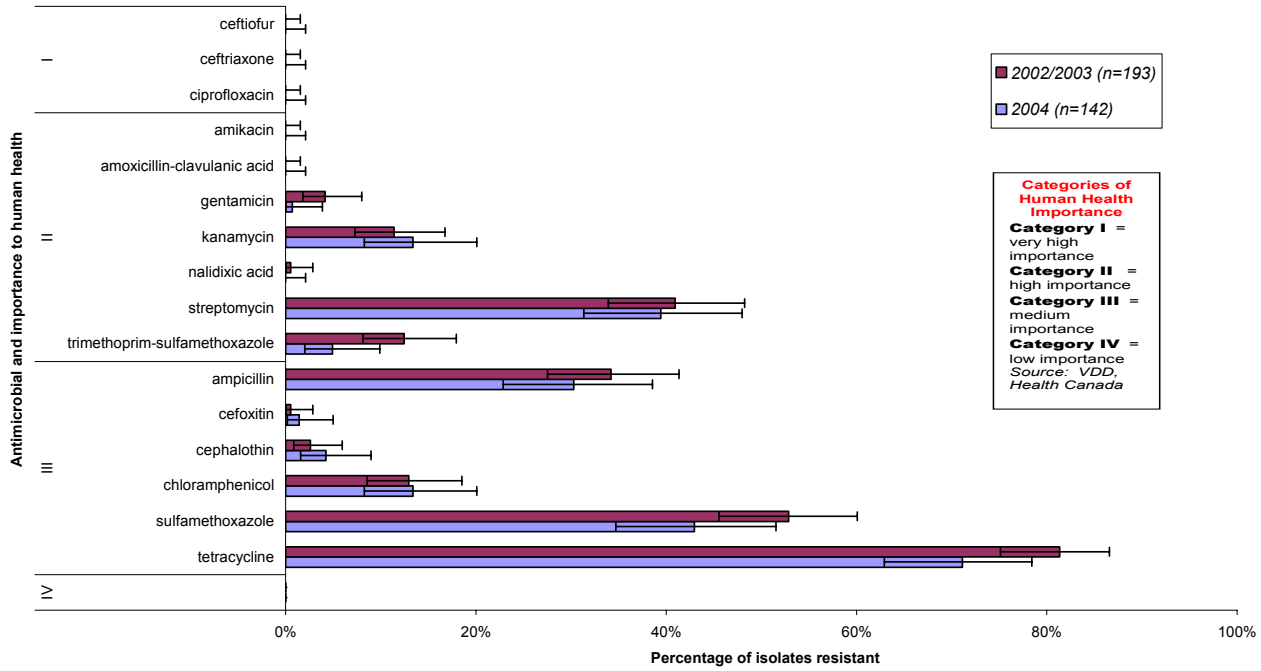

Figure 2. Individual antimicrobial drug resistance in generic *E. coli* from swine isolates in 2002/2003 (n=193) and 2004 (n=142); *Abattoir Surveillance*.

Swine – Salmonella

(*Abattoir Surveillance* n=270)

Note: *In 2004, Salmonella isolates were recovered from 38% of the swine caecal samples.*

Antimicrobial Drug Resistance: See Figure 3, Table 13, and Table 35 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 48% of isolates in both 2002/2003 (237/496) and 2004 (131/270). No resistance to ceftriaxone, ciprofloxacin, nalidixic acid, or amikacin was detected in 2002/2003 or 2004. No resistance to ceftiofur was detected in 2004 and in less than one percent (1/496) of isolates in 2002/2003. Reduced susceptibility to ceftriaxone was detected in less than one percent (1/496) of isolates in 2002/2003; this was the same *Salmonella* isolate that was also resistant to ceftiofur. There were no significant differences in the prevalence of resistance to individual antimicrobial drugs between 2002/2003 and 2004.

AMR Patterns: The most common patterns were resistance to TCY alone (2002/2003: 53/496, 11%; 2004: 36/270, 13%) and resistance to STR-SMX-TCY (2002/2003: 42/496, 8%; 2004: 21/270, 8%). Resistance patterns ACKSSuT (2002/2003: 25/496, 5%; 2004: 17/270, 6%), AKSSuT (2002/2003: 6/496, 1%; 2004: 0/270, 0%), and ACSSuT (2002/2003: 40/496, 8%; 2004: 10/270, 4%) had a combined frequency of 14% (71/496) of isolates in 2002/ 2003 and 10% (27/270) in 2004. In 2002/2003, there was one isolate (S. infantis), which was resistant to 9 antimicrobials (ACSSuT+A2C). Of the 37 different resistance patterns found in 2002/2003, 12 patterns involved five or more antimicrobials; these patterns were seen in 17% (85/496) of isolates. In 2004, there were nine patterns (out of 32) with five or more antimicrobials; these patterns were seen in 11% (30/270) of isolates. There was one isolate (*S*. Infantis) in 2002/2003 and none in 2004 with resistance to A2C.

Serovars: See Table 13. The most frequent *Salmonella* serovars in 2004 were Derby,

London, Infantis, and Typhimurium, compared to Derby, Typhymurium var Copenhagen, and Infantis in 2002/2003. Of note was the significant increase in S. London isolates between 2002/2003 (5/496, 1%) and 2004 (27/270, 10%). In 2004, 54% (13/24) of *S.* Typhimurium and 82% (14/17) of *S.* Typhimurium var Copenhagen were resistant to between five and eight antimicrobials, compared to 2002/2003 where 34% (14/41) of *S.* Typhimurium isolates and 54% (43/80) *S.* Typhimurium var Copenhagen isolates were resistant to between five and eight antimicrobials. In 2004, the serovar resistant to the greatest number of antimicrobials was a *S.* Typhimurium var Copenhagen isolate (PT193) that was resistant to ACKSSuT-GEN-SXT.

For 2004, results from *Abattoir Surveillance* showed that 48% (131/270) of *Salmonella* isolates from swine caecal samples were resistant to one or more antimicrobials tested. No resistance was detected to any antimicrobials of Very High Importance to Human Health (Category I). Eleven percent (30/270) of isolates were resistant to five or more antimicrobials. Serovars resistant to between five and eight antimicrobials were *S.* typhimurium var Copenhagen (14/17, 82%) and *S.* Typhimurium (13/24, 54%). *Salmonella* Typhimurium var Copenhagen showed a significant increase in resistance to between five and eight antimicrobials in 2004 (14/17, 82%) compared to 2002/2003 (43/80; 54%).

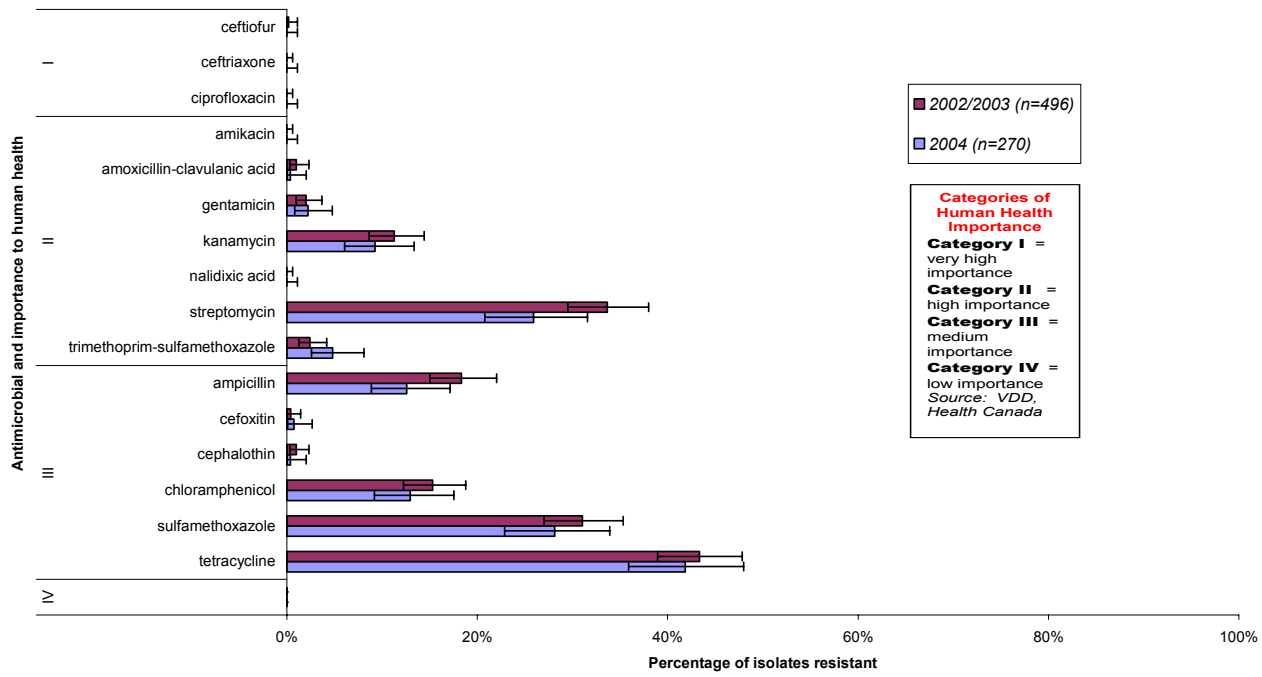

Figure 3. Individual antimicrobial drug resistance in *Salmonella* from swine isolates in 2002/2003 (n=496) and 2004 (n=270); *Abattoir Surveillance*.

Table 13. *Salmonella* serovars from swine; *Abattoir Surveillance* 2004.

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
***Abattoir Surveillance* (n=270)**		Number of isolates			
Derby	56 (20.7)	16	40	0	0
London	27 (10)	16	11	0	0
Infantis	25 (9.3)	25	0	0	0
Typhimurium	24 (8.9)	5	6	13	0
Typhimurium var. copenhagen	17 (6.3)	1	2	14	0
Brandenburg	15 (5.6)	12	2	1	0
Bovismorbificans	12 (4.4)	10	2	0	0
California	9 (3.3)	6	3	0	0
Heidelberg	8 (3)	2	6	0	0
Agona	6 (2.2)	3	3	0	0
Give	6 (2.2)	3	3	0	0
ssp. I:4,12:-:-	6 (2.2)	4	2	0	0
Senftenberg	6 (2.2)	5	1	0	0
Less common serovars	53 (19.6)	31	20	2	0
Total		**139**	**101**	**30**	**0**

Note: Serovars with less than 2% prevalence are categorized as "less common serovars"

Broiler Chickens – Generic E. coli

(*Abattoir Surveillance* n=130)

Note: *In 2004, generic E. coli isolates were recovered from 99% of the chicken caecal samples.*

Antimicrobial Drug Resistance: See Figure 4 and Table 36 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 83% (158/190) of isolates in 2002/2003 and 78% (102/130) of isolates in 2004. In 2002/2003 no resistance to ceftriaxone or ciprofloxacin was observed. In 2004, ciprofloxacin resistance was not detected, but ceftriaxone resistance was identified in less than one percent (1/130) of isolates. Seventeen percent (22/130) of isolates had reduced susceptibility to ceftriaxone (intermediate category) in 2004. Ceftiofur resistance was identified in 16% (30/190) of isolates in 2002/2003 and 25% (33/130) of isolates in 2004. There were no significant differences between prevalences of resistance to individual antimicrobial drugs between 2002/2003 and 2004.

AMR Patterns: In 2004, 54 (of 102 resistant isolates) different resistance patterns were observed. The most common patterns were resistance to STR-TCY (8/130, 6%), KAN-STR-SMX-TCY (8/130, 6%), and TCY alone (7/130, 5%). The isolates resistant to the greatest number of antimicrobials were resistant to ACKSSuT-A2C-GEN (1/130, 1%), ACSSuT-A2C-STX (1/130, 1%), ACSSuT-A2C-NAL (1/130, 1%), and A2C-AMP-GEN-STR-SMX-TCY-SXT (1/130, 1%). Alone or in combination with other antimicrobials, the ACSSuT pattern was present in five percent (7/130) of isolates, the ACKSSuT pattern in two percent (2/130) of isolates, the AKSSuT pattern in three percent (4/130) of isolates, and the A2C pattern in 25% (33/130) of isolates. In 2002/2003, the ACSSuT pattern was detected in six percent (12/190) of isolates, the ACKSSuT pattern in one percent (2/190) of isolates, the AKSSuT pattern in two percent (4/190) of isolates, and the A2C pattern in 16% (30/190) of isolates. Resistance to greater than five antimicrobials was detected in 35% (45/130) of isolates in 2004 and 29% (56/190) of isolates in 2002/2003.

For 2004, results from *Abattoir Surveillance* showed that 78% (102/130) 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 25% (33/130) of isolates and ceftriaxone resistance was detected in less than one percent (1/130) of isolates. Thirty-five percent (45/130) of isolates were resistant to five or more antimicrobials. The prevalence of the A2C pattern of resistance increased significantly from 16% to 25% between 2002/2003 and 2004.

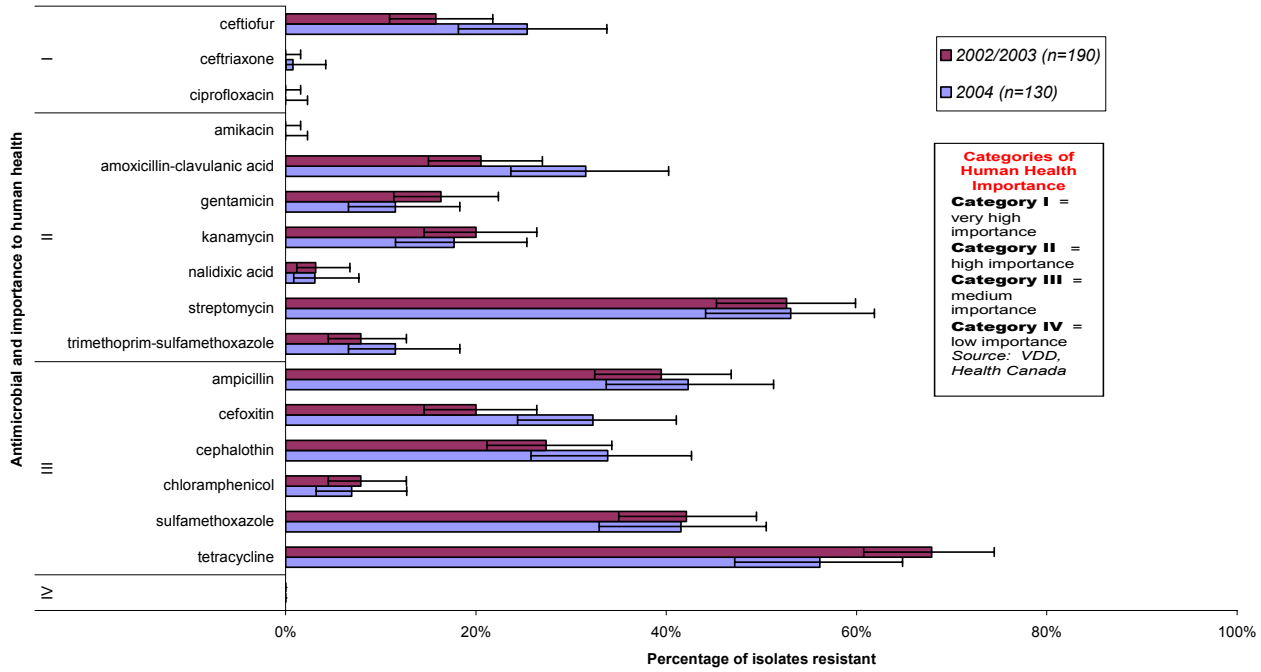

Figure 4. Individual antimicrobial drug resistance in generic *E. coli* from broiler chicken isolates in 2002/2003 (n=190) and 2004 (n=130); *Abattoir Surveillance.*

Broiler Chickens – Salmonella

(*Abattoir Surveillance* n= 142)

Note: *In 2004, Salmonella isolates were recovered from 16% of the chicken caecal samples.*

Antimicrobial Drug Resistance: See Figure 5 and Table 37 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was found in 42% (64/151) of isolates in 2002/2003 and 40% (57/142) of isolates in 2004. No resistance to amikacin or ciprofloxacin was detected in either 2002/2003 or 2004. Resistance to chloramphenicol (2/151, 1%), trimethoprim-sulfamethoxazole (1/151, 1%), and nalidixic acid (1/151, 1%) was detected in 2002/2003, but not in 2004. Resistance to ceftriaxone was equally detected in both 2002/2003 (1/151, 1%) and 2004 (1/142, 1%). However, reduced susceptibility (intermediate category) to ceftriaxone was observed in five percent (8/151) of isolates in 2002/2003 and in 13% (19/142) of isolates in 2004. In 2004 resistance to ceftiofur was significantly higher (31/142, 22%) compared to 2002/2003 (11/151, 7%). Similar differences were also observed between 2004 and 2002/2003 in resistance to amoxicillin-clavulanic acid (2002/2003: 10/151, 7%; 2004: 30/142, 21%), and cefoxitin (2002/2003: 10/151, 7%; 2004: 28/142, 20%).

AMR Patterns: In 2004, the most frequent pattern was resistance to A2C-AMP (27/142, 19%), which was significantly higher than in 2002/2003 (10/151, 7%). Another frequent

pattern in 2004 was STR-TCY (7/142, 5%), compared to 7% (11/151) of isolates in 2002/2003. In 2002/2003, the A2C-AMP pattern was found in seven *S*. Heidelberg isolates, one *S.* Agona isolate, one *S*. Derby isolate, and one *S*. Thompson isolate. In 2004, the A2C-AMP pattern was found in 23 *S*.Heidelberg isolates (15 of them were PT15), one *S*. Typhimurium var Copenhagen isolate, one S. Thompson isolate, one S. Infantis isolate, and one I:4,12:r:- isolate. Of the new patterns identified in 2004 data, one *S*. Kentucky isolate was resistant to AMC-AMP-TIO-STR-TCY and another *S*. Kentucky isolate was resistant to A2C-AMP-STR-TCY. The ACSSuT pattern was observed in 2002/2003 (2/151, 1%) but not in 2004. The AKSSuT or ACKSSuT patterns were not observed over the three-year period. Of the 20 resistance patterns found in 2002/2003, three patterns involved five or more antimicrobials; these patterns were seen in nine percent (13/151) of isolates. In 2004, there were four patterns with resistance to five or more antimicrobials. These patterns were observed in 21% (30/142) of isolates. The AMR patterns with resistance to the greatest number of antimicrobials in 2004 were AMP-TIO-CRO-CEP-GEN-STR-SMX (*S*. Typhimurium PTU301, 1/142, 1%) and A2C-AMP-STR-TCY (*S*. Kentucky, 1/142, 1%). The AMP-TIO-CRO-CEP-GEN-STR-SMX pattern was also the pattern with resistance to the greatest number of antimicrobials in 2002/2003 (*S*. Oranienburg).

Serovars: See Table 14. In 2004, the most common serovars were Heidelberg, Kentucky, and Enteritidis. S. Heidelberg was seen less frequently in 2004 (51/142, 36%) than in 2002/2003 (80/151, 53%). Resistance to one or more antimicrobials among S. Heidelberg isolates was 44% (35/80) in 2002/2003 and 57% (29/51) in 2004. The 2004 *S*. Heidelberg isolates were more frequently resistant to between five and eight antimicrobials (23/51; 45%) than in 2002/2003 (7/80; 9%). Among the "Less Common Serovars", those resistant to more than five antimicrobials were S.Typhimurium var Copenhagen and I:4,12:r:-. There was one isolate of each of these serovars that was resistant to A2C-AMP.

For 2004, results from *Abattoir Surveillance* in chicken showed that 40% (57/142) of *Salmonella* isolates from caecal samples were resistant to one or more antimicrobials. Of the antimicrobials of Very High Importance to Human Health (Category I), one percent (1/142) of isolates were resistant to ceftriaxone and no isolates were resistant to ciprofloxacin. Resistance to ceftiofur was significantly higher in 2004 isolates (31/142, 22%) than in 2002/2003 isolates (11/151, 7%). Reduced susceptibility to ceftriaxone increased from five percent (8/151) of isolates in 2002/2003 to 13% (19/142) of isolates in 2004. The most common resistance pattern in the 2004 isolates was A2C-AMP (27/142, 19%), which was primarily found in S. Heidelberg isolates (23/51) and represented a significant increase from the prevalence of A2C-AMP found in 2002/2003 (10/151, 7%). Fifty-seven percent (29/51) of S. Heidelberg isolates were resistant to one or more antimicrobials. In 2004, 21% (30/142) of isolates were resistant to five or more antimicrobials.

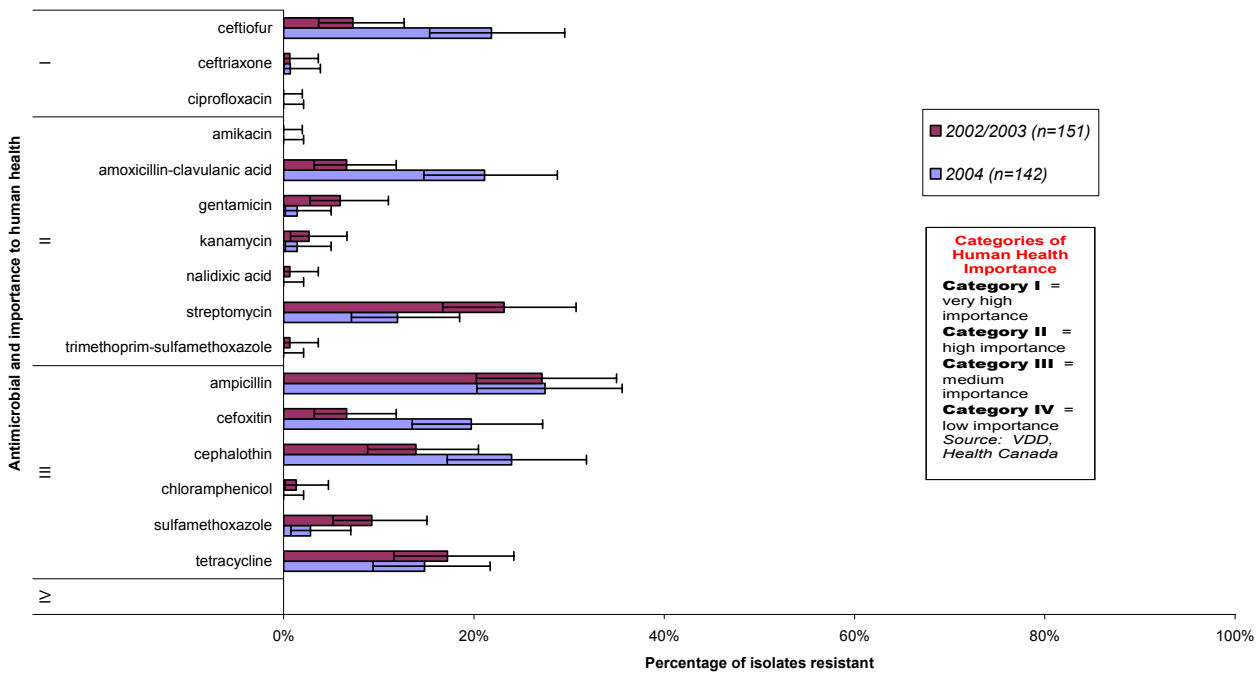

Figure 5. Individual antimicrobial drug resistance in *Salmonella* isolates from broiler chickens in 2002/2003 (n=151) and 2004 (n=142); *Abattoir Surveillance.*

Table 14. *Salmonella* serovars from chicken; *Abattoir Surveillance* 2004.

Serovar	n (% total)				
		0	1-4	5-8	9-16
***Abattoir Surveillance* (n=142)**		Number of isolates			
Heidelberg	51 (35.9)	22	6	23	0
Kentucky	35 (24.6)	24	9	2	0
Enteritidis	9 (6.3)	9	0	0	0
Schwarzengrund	6 (4.2)	4	2	0	0
Hadar	5 (3.5)	0	5	0	0
Agona	4 (2.8)	3	1	0	0
Infantis	4 (2.8)	2	1	1	0
Thompson	4 (2.8)	3	0	1	0
Kiambu	3 (2.1)	3	0	0	0
Typhimurium	3 (2.1)	2	0	1	0
Less common serovars	18 (12.7)	13	3	2	0
Total		**85**	**27**	**30**	**0**

Note: Serovars with less than 2% prevalence are categorized as "less common serovars"

Retail Beef – Generic E. coli

(n=327; Ontario n=190; Québec n=137)

Note: *In 2004, generic* E. coli *isolates were recovered from 67% of beef retail samples overall; the recovery rate was 80% in Ontario and 56% in Québec.*

Antimicrobial Drug Resistance: See Figure 6 and Table 38 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 21% (40/190) of isolates in Ontario and 18% (25/137) of isolates in Québec in 2004, compared to 27% (27/100) of isolates in Ontario and 23% (19/84) of isolates in Québec in 2003. Over both years no resistance to ceftriaxone, ciprofloxacin, or amikacin was detected. In 2004, resistance was detected to ceftiofur (Ontario: 1/190, <1%; Québec: 3/137, 2%). All isolates from Ontario and Québec were susceptible to cefriaxone in 2003. In 2004, one Ontario isolate (1/190, <1%) and one Québec isolate (1/137, <1%) showed reduced susceptibility (intermediate category) to ceftriaxone. There were no significant differences in the prevalence of resistance to individual antimicrobial drugs between 2003 and 2004 retail beef isolates.

AMR Patterns: The most common patterns were resistance to TCY alone (2003: 8/184, 4%; 2004: 21/327, 6%), STR-SMX-TCY (2003: 2/184, 1%; 2004: 7/327, 2%), and resistance to SMX-TCY (2003: 11/184, 6%; 2004: 6/327, 2%). Of the 23 different resistance patterns found in 2003, five patterns involved five or more antimicrobials; these patterns were seen in three percent (5/184) of isolates. In 2004, there were 12 patterns that involved five or more antimicrobials; these patterns were seen in four percent (12/327) of isolates. In 2004, one percent (3/327) of isolates were resistant to ACKSSuT in combination with other antimicrobials; ACSSuT and AKSSuT resistance alone occurred in single isolates (1/327; <1%). The AMR pattern with resistance to the greatest number of antimicrobials in 2004 was ACKSSuT-A2C; this was seen in less than one percent of isolates (1/327). One isolate in 2003 demonstrated resistance to ACSSuT-A2C (1/185, <1%). All isolates with the A2C pattern were resistant to other antimicrobials (4/327, 1%). All isolates with ACKSSuT and/or A2C resistance were new patterns identified in 2004.

For 2004, results from *Retail Surveillance* showed that in Ontario 21% (40/190) and in Québec 18% (25/137) of generic *E. coli* isolates from ground beef 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 less than one percent of Ontario (1/190) and two percent of Québec (3/137) isolates.

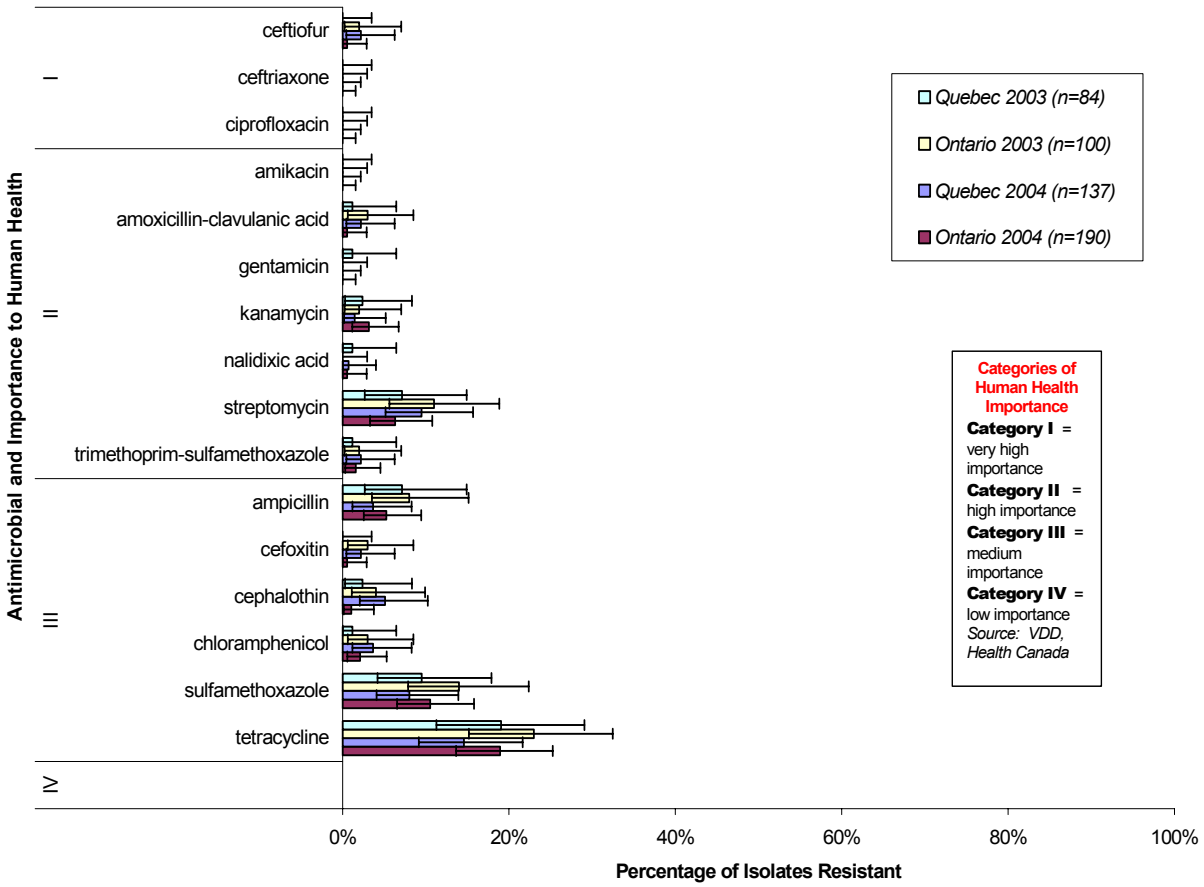

Figure 6. Individual antimicrobial drug resistance in generic *E. coli* isolates from beef samples collected in Ontario and Québec in 2003 and 2004; *Retail Surveillance.*

Retail Pork – Generic E. coli

(n=306; Ontario n=198; Québec n=108)

Note: *in 2004, generic E. coli isolates were recovered from 53% of the pork retail samples overall; the recovery rate was 71% in Ontario and 38% in Québec.*

Antimicrobial Drug Resistance: See Figure 7 and Table 39 (Appendix A.4). Sixty-four percent of isolates were resistant to one or more antimicrobials in Ontario in both 2003 (58/91) and 2004 (126/198). In Québec, the prevalence of resistance to one or more antimicrobials was 54% (33/61) of isolates in 2003 and 47% (51/108) of isolates in 2004. No resistance to ceftriaxone, ciprofloxacin, amikacin, or nalidixic acid was detected in either 2003 or 2004. Resistance was detected to ceftiofur (Ontario: 2/198, 1%; Québec: 2/108, 2%) in 2004. All isolates from Ontario were susceptible to ceftriaxone in both 2003 and 2004. One Québec isolate (1/61, 2%) showed reduced susceptibility (intermediate category) to ceftriaxone in 2003, but none in 2004. There were no significant differences in the prevalence of resistance to individual antimicrobial drugs between 2003 and 2004. The prevalence of tetracycline resistance was significantly higher in Ontario isolates (108/198, 54%) than the prevalence among isolates from Québec (40/108, 37%) in 2004.

AMR Patterns: The five most prevalent patterns were resistance to TCY alone (2003: 18/152, 12%; 2004: 36/306, 12%), AMP-TCY (2003: 6/152, 4%; 2004: 12/306, 4%), SMX-TCY (2003: 10/152, 7%; 2004: 12/306, 4%), AMP-STR-TCY (2003: 3/152, 2%; 2004: 10/306, 3%) and resistance to CHL-SMX-TCY (2003: 4/152, 3%; 2004: 8/306, 3%). Of the 37 different

resistance patterns found in 2003, 10 patterns involved five or more antimicrobials; these patterns were shown in seven percent (10/152) of isolates. In 2004, there were 18 patterns with resistance to five or more antimicrobials; these were seen in nine percent (27/306) of isolates. In 2004, four percent (12/306) of isolates demonstrated variations of the ACKSSuT resistance pattern compared to three percent (4/152) of isolates in 2003. In 2004, resistance was seen to AKSSuT (4/306, 1%), ACKSSuT (2/306, 1%), ACSSuT (2/306, 1%), AKSSuT-SXT (2/306, 1%), ACKSSuT-SXT (1/306, <1%), and ACSSuT-A2C-GEN (1/306, <1%). All isolates with A2C resistance (4/177, 2%) were resistant to other antimicrobials. Eleven of the twelve isolates with ACKSSuT resistance and all of the A2C resistant isolates were new patterns identified in 2004.

For 2004, results from *Retail Surveillance* showed that in Ontario 64% (126/198) and in Québec 47% (51/108) of generic *E. coli* isolates from ground pork 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 one percent of Ontario (2/198) and two percent of Québec (2/108) isolates. In 2004, nine percent (27/306) of isolates showed resistance to five or more antimicrobials.

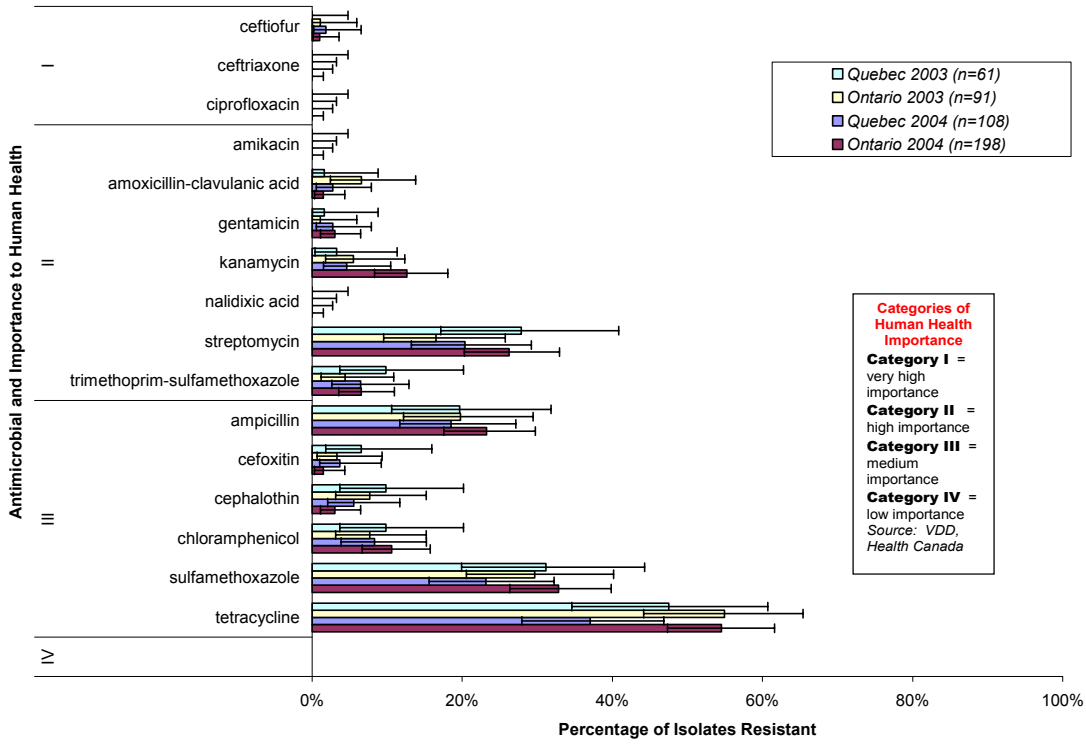

Figure 7. Individual antimicrobial drug resistance in generic *E. coli* isolates from pork samples collected in Ontario and Québec in 2003 and 2004; *Retail Surveillance*.

Retail Chicken – Generic E. coli

(n=308; Ontario n=150; Québec n=158)

Note: *In 2004, generic E. coli isolates were recovered from 96% of the chicken retail samples overall. Generic E. coli isolates were recovered from 95% and 98% of the chicken leg samples from Ontario and Québec, respectively.*

Antimicrobial Drug Resistance: See Figure 8 and table 42 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 72% (108/150) of isolates in Ontario and 82% (129/158) of isolates in Québec in 2004 compared to 65% (88/136) of isolates in Ontario and 76% (85/112) of isolates in Québec in 2003. No resistance to ciprofloxacin and amikacin was detected in either 2003 or 2004. Ceftriaxone resistance was detected in one percent (1/158) of isolates from Québec in 2004 while ceftriaxone resistance was not detected in either province in 2003. Reduced susceptibility (intermediate category) to ceftriaxone was observed in ten percent (15/150) of Ontario isolates and 15% (23/158) of Québec isolates in 2004 compared to eight percent (11/136) of Ontario isolates and ten percent (11/112) of Québec isolates in 2003. Ceftiofur resistance was detected in 21% (32/150) of Ontario isolates and 34% (54/158) of Québec isolates in 2004, while 18% (24/136) of Ontario isolates and 33% (37/112) of Québec isolates were resistant to ceftiofur in 2003. There were no significant differences in the prevalence of resistance between Ontario and Québec for cefoxitin and cephalothin in 2004.

AMR Patterns: In 2004, the most common resistance patterns observed across all isolates were to TCY alone (Ontario: 18/150, 12%; Québec: 17/158, 11%), followed by resistance to A2C-AMP (Ontario: 17/150, 11%; Québec: 15/158, 9%). In 2003, the most common resistance patterns were to TCY alone (11/136, 8%) in Ontario and ACSSuT-A2C (10/112, 9%) in Québec.

For 2004 in Ontario, 21% (32/150) of isolates showed resistance to the A2C pattern (always in combination with resistance to other antimicrobials), three percent (5/150) to the AKSSuT pattern, two percent (3/150) to the ACSSuT pattern, and one percent (2/150) to the ACKSSuT pattern. In Québec, 34% (54/158) of isolates showed resistance to the A2C pattern (always in combination with resistance to other antimicrobials), nine percent (15/158) to the ACSSuT pattern, three percent (5/158) to the AKSSuT, and one percent (2/158) to the ACKSSuT pattern. The isolates resistant to the greatest number of antimicrobials were resistant to ACKSSuT-A2C-GEN-SXT (Québec: 1/308, <1%) and ACKSSuT-A2C-GEN (Ontario: 1/308, <1%). A single isolate from Ontario showed joint resistance to nalidixic acid and reduced susceptibility (intermediate category) to ceftriaxone.

For 2004, results from *Retail Surveillance* showed that in Ontario 72% (108/150) and in Québec 82% (129/158) of generic *E. coli* isolates showed resistance to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftriaxone resistance was detected in one percent (1/158) of Québec isolates and ceftiofur resistance was detected in 21% (32/150) of Ontario isolates and 34% (54/158) of Québec isolates. Twenty-seven percent (41/150) of isolates from Ontario and 45% (71/158) of isolates from Québec were resistant to five or more antimicrobials. In both Ontario and Québec, the second most common resistance pattern was A2C-AMP. This pattern was identified in 11% (17/150) of isolates from Ontario and nine percent (15/158) of isolates from Québec. Differences were found between the provinces in the prevalence of resistance to individual antimicrobial drugs, highlighting the need to conduct surveillance in multiple provinces.

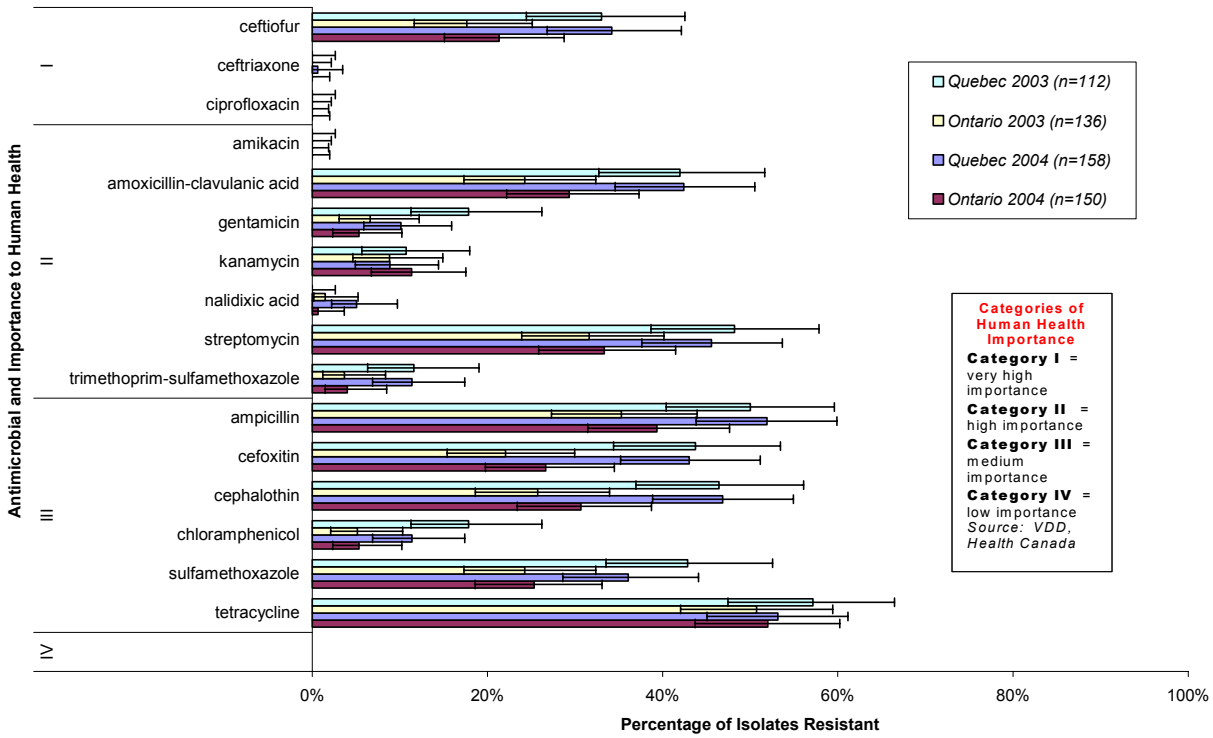

Figure 8. Individual antimicrobial drug resistance in generic *E. coli* isolates from chicken samples collected in Ontario and Québec in 2003 and 2004; *Retail Surveillance*.

Chicken – Salmonella spp.

(n=107; Ontario n=55; Québec n=52)

Note: *In 2004, Salmonella isolates were recovered from 17% of chicken retail samples. Salmonella isolates were recovered from 17% of the chicken leg samples received from Ontario and Québec.*

Antimicrobial Drug Resistance: See Figure 9, Table 15, and Table 41 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 56% (31/55) of isolates in Ontario and 69% (36/52) of isolates in Québec in 2004, as compared to 19% (5/26) of isolates in Ontario and 79% (22/28) of isolates in Québec in 2003. There was no resistance detected to ciprofloxacin, amikacin, or nalidixic acid in either 2003 or 2004. Ceftriaxone resistance was detected in two percent (1/52) of isolates from Québec in 2004, while ceftriaxone resistance was not detected in either province in 2003. Reduced susceptibility to ceftriaxone (intermediate category) was observed in 24% (13/55) of Ontario isolates and in 15% (8/52) of Québec isolates in 2004, as compared with eight percent (2/26) of Ontario isolates and 46% (13/28) of Québec isolates in 2003. Ceftiofur resistance was detected in 45% (25/55) of Ontario isolates and 40% (21/52) of Québec isolates in 2004 while 12% (3/26) of Ontario isolates and 50% (14/28) of Québec isolates were resistant to ceftiofur in 2003. In 2004, chloramphenicol resistance was detected for the first time in Québec and trimethoprim-sulfamethoxazole resistance was detected for the first time in Ontario. There were no significant differences in the prevalence of resistance between Ontario and Québec for streptomycin and tetracycline in 2004.

AMR Patterns: In 2004, the most common resistance patterns observed in Ontario were A2C-AMP (21/55, 38%), AMC-AMP-TIO-CEP (2/55, 4%), and AMP alone (2/55, 4%) and in Québec, the most common resistance patterns were A2C-AMP (17/52, 33%) and STR-TCY (8/52, 15%). In 2003, the most common resistance pattern observed for both provinces

was A2C-AMP (Ontario: 2/26, 8%; Québec: 13/28, 46%).

Serovars: See Table 15. *Salmonella* Heidelberg was the most frequent serovar detected followed by *S*. Kentucky and *S*. Hadar, respectively for both provinces in 2004. In 2003, *S*. Heidelberg was the most frequent serovar in both provinces followed by *S*. Kentucky in Ontario and *S*. Kentucky and *S*. Hadar in Québec. Of the five serovars from Ontario in 2004 showing resistance to five or more antimicrobials, the most predominant serovar was *S*. Heidelberg (PT29 – 13 isolates; PT41 – two isolates; PT52 – one), which all showed resistance to the A2C-AMP pattern. Two isolates of *S*. Kentucky were also resistant to five or more antimicrobials from Ontario in 2004 (one A2C-AMP pattern and one A2C-AMP-SMX-SXT pattern). *Salmonella* Typhimurium var. Copenhagen (one isolate; PT35), *S*. Typhimurium (one isolate; PT94), and *S*. Infantis (one isolate) were also resistant to five or more antimicrobials from Ontario in 2004 with all three serovars showing resistance to the A2C-AMP pattern. In 2003, *S*. Heidelberg was the only serovar among the Ontario isolates that was resistant to five or more antimicrobials (one isolate was PT18, resistant to AMP-CEP-GEN-STR-SMX; two isolates were PT29, resistant to A2C-AMP pattern). In Québec in 2004, the serovar showing resistance to five or more antimicrobials was predominantly serovar Heidelberg (PT29 - 10 isolates; PT52 – one isolate; PT41 – one isolate; PT39 – one isolate; PT19 – one isolate; PT Atypical – one isolate). All these showed resistance to the A2C-AMP pattern, except one PT29 isolate that was resistant to A2C-AMP-CRO and the single PT Atypical isolate that was resistant to ACSSuT-A2C. *Salmonella*. Typhimurium var. Copenhagen was also resistant to five or more antimicrobials from Québec in 2004 (one isolate was PTU285; one isolate was PT208) with both isolates showing resistance to the A2C-AMP pattern. A single isolate of *S*. Agona (pattern A2C-AMP-SMX-TCY) and a single isolate of *S*. Bovismorbificans (pattern A2C-AMP) were also resistant to five or more antimicrobials in isolates from Québec in 2004. In Québec in 2003, the serovar showing resistance to five or more antimicrobials was predominantly *S*. Heidelberg (PT4 - three isolates; PT29 – 7 isolates; PT32 – two isolates; PT53 – one isolate). All these showed resistance to the A2C-AMP pattern, except one PT32 isolate that was resistant to A2C-AMP-GEN-STR-TCY. A single *S*. Agona isolate was also resistant to five or more antimicrobials (pattern A2C-AMP).

(36/52) of *Salmonella* isolates from chicken samples were resistant to one or more antimicrobials. For antimicrobials of Very High Importance to Human Health (Category I), ceftriaxone resistance was detected in two percent (1/52) of Québec isolates and ceftiofur resistance was detected in 45% (25/55) of Ontario isolates and 40% (21/52) of Québec isolates. Forty percent (22/55; 17 isolates were *S*. Heidelberg) of Ontario isolates and 38% (20/52; 16 isolates were *S*. Heidelberg) of Québec isolates were resistant to five or more antimicrobials. Differences were found between the provinces in the prevalence of resistance to individual antimicrobial drugs, highlighting the need to conduct surveillance in multiple provinces.

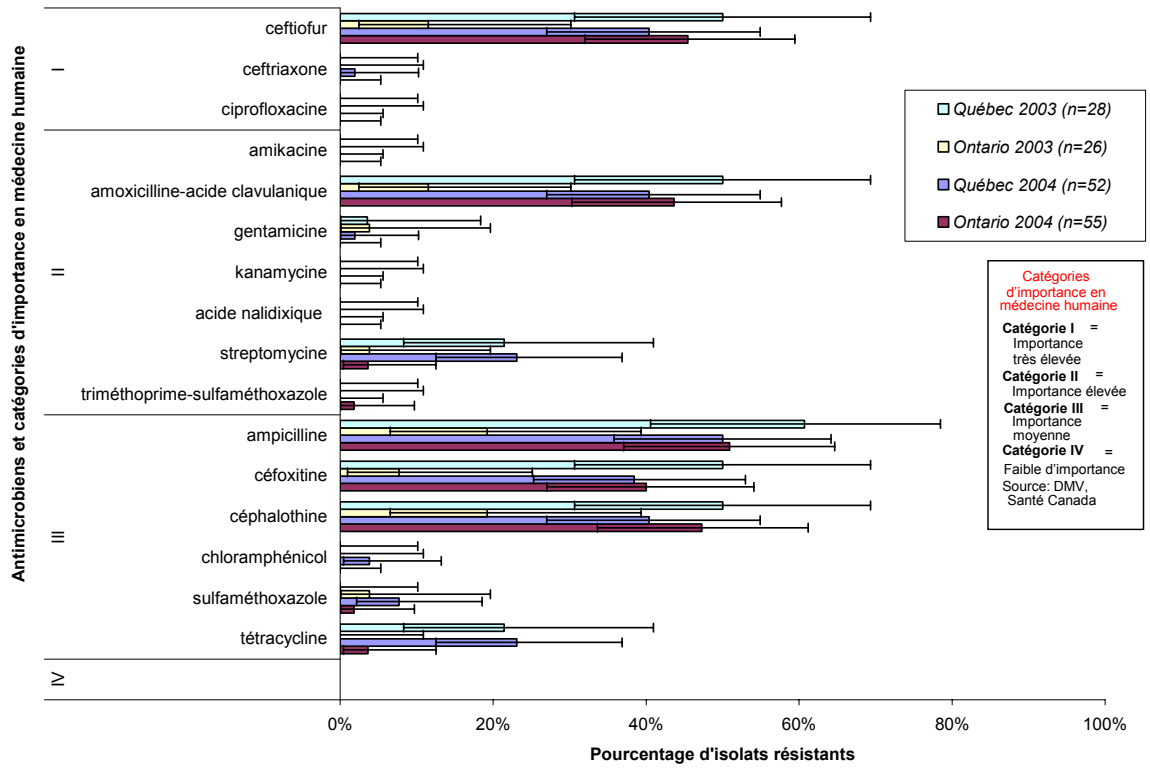

Figure 9. Individual antimicrobial drug resistance in *Salmonella* isolates from chicken samples collected in Ontario and Québec in 2003 and 2004; *Retail Surveillance*.

Table 15. *Salmonella* serovars from chicken; *Retail Surveillance* 2004.

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
Retail Surveillance		Number of isolates			
Ontario (n=55)					
Heidelberg	32 (58.2)	10	5	17	0
Kentucky	10 (18.2)	7	1	2	0
Hadar	3 (5.5)	1	2	0	0
Enteritidis	2 (3.6)	2	0	0	0
Infantis	2 (3.6)	1	0	1	0
Less common serovars	6 (10.9)	3	1	2	0
Total		**24**	**9**	**22**	**0**
Québec (n=52)					
Heidelberg	28 (53.8)	5	7	15	1
Kentucky	9 (17.3)	6	3	0	0
Hadar	5 (9.6)	0	5	0	0
Agona	3 (5.8)	2	0	1	0
Typhimurium var. copenhagen	2 (3.8)	0	0	2	0
Less common serovars	5 (9.6)	3	1	1	0
Total		**16**	**16**	**19**	**1**

Note: Serovars with less than 2% prevalence are categorized as "less common serovars".

Chicken – Campylobacter spp.

(n=298; Ontario n=140; Québec n=158)

Note: *In 2004, Campylobacter spp. isolates were recovered from 47% of the chicken retail sample with 45% and 50% recovery rates from chicken leg samples from Ontario and Québec, respectively.*

Antimicrobial Drug Resistance: See Figure 10, Table 16, and Table 42 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 53% (74/140) of isolates in Ontario and 81% (128/158) of isolates in Québec in 2004 compared to 72% (56/78) of isolates in Ontario and 79% (74/94) of isolates in Québec in 2003. Resistance to ciprofloxacin was detected in both provinces in 2004 (Ontario: 3/140, 2%; Québec: 4/159, 3%) and 2003 (Ontario: 3/78, 4%; Québec: 3/94, 3%). No resistance to gentamicin or chloramphenicol was detected in either province in 2004 compared to 2003 where resistance to gentamicin was detected in a single isolate from Québec and resistance to chloramphenicol was detected in a single isolate from Ontario. There was a significant difference in the prevalence of resistance between Ontario and Québec for tetracycline in 2004, whereas in 2003 there were no significant differences among these provinces in the prevalence of resistance for any antimicrobials tested.

AMR Patterns: The most frequent resistance pattern in both 2003 (Ontario: 40/78, 51%; Québec: 48/94, 51%) and 2004 (Ontario: 60/140, 43%; Québec: 99/158, 63%) was TCY alone. Of the seven isolates with resistance to ciprofloxacin, four were resistant to CIP-NAL-TCY (two *C. coli*, one *C. jejuni*, one *Campylobacter spp),* two isolates were resistant to CIP-NAL (one *C. coli* and one *C. jejuni*), and one *C. coli* isolate from Ontario was resistant to AZM-CIP-CLI-ERY-NAL-TCY.

For 2004, results from *Retail Surveillance* showed that in Ontario 53% (74/140) and in Québec 81% (128/158) of *Campylobacter* spp. isolates from chicken were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), two percent (3/140) of isolates from Ontario and three percent (4/158) of isolates from Québec were resistant to ciprofloxacin. This is of particular importance because ciprofloxacin is the most commonly used drug to treat undifferentiated diarrhea and chicken is considered to be the major source of fluoroquinolone resistant *Campylobacter* for humans (pers. com., J. Conly). One *C. coli* isolate expressed the pattern AZM-CIP-CLI-ERY-NAL-TCY and was therefore resistant to six of the eight antimicrobials.

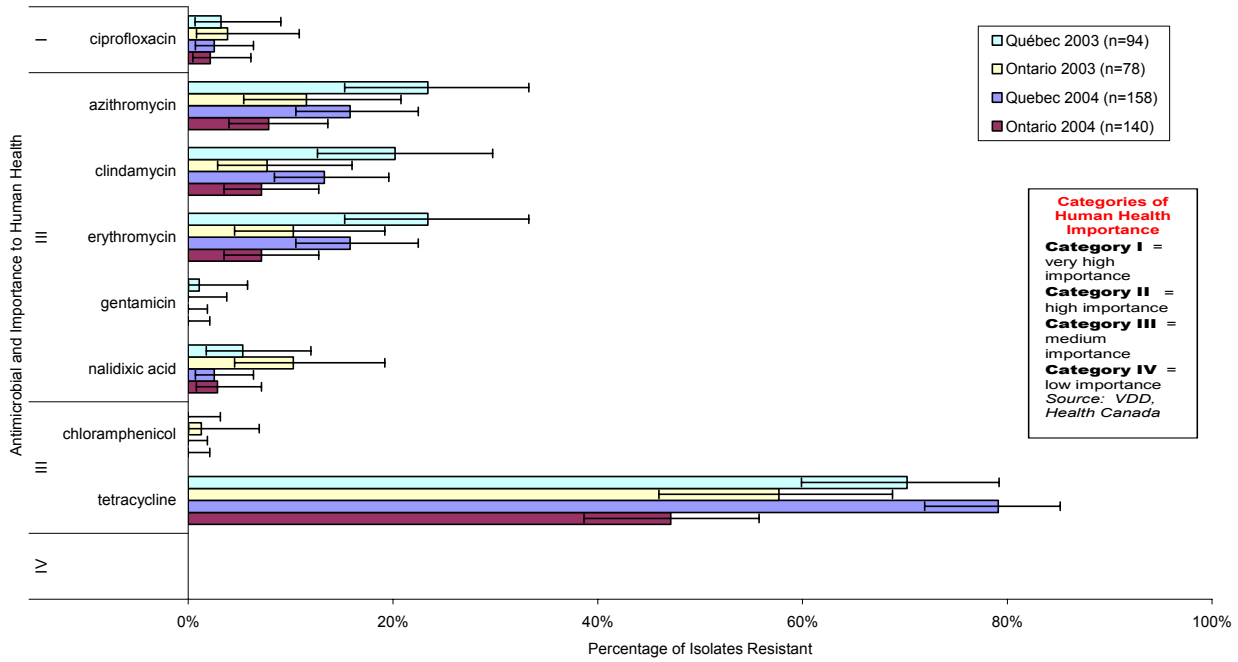

Figure 10. Individual antimicrobial drug resistance in *Campylobacter* spp. isolates from chicken samples collected in Ontario and Québec in 2003 and 2004; *Retail Surveillance.*

Table 16. *Campylobacter* species from chicken; *Retail Surveillance* 2004.

Species	n (% total)	No. of antimicrobials in resistance pattern			
Retail Surveillance		**0**	**1-2**	**3-4**	**5-8**
		Number of isolates			
Ontario (n=140)					
C. jejuni	119 (85)	57	55	7	0
C. coli	17 (12)	8	6	2	1
Campylobacter spp.	3 (2)	0	2	1	0
C. lari	1 (1)	1	0	0	0
Total		**66**	**63**	**10**	**1**
Québec (n=158)					
C. jejuni	143 (91)	25	93	25	0
C. coli	14 (9)	5	6	3	0
Campylobacter spp.	1 (1)	0	1	0	0
Total		**30**	**100**	**28**	**0**

Chicken – Enterococcus spp.

(n=320; Ontario n=158; Québec n=162)

Note: *In 2004, Enterococcusbacter spp. isolates were recovered from 100% of the chicken retail samples from both Ontario and Québec.*

Antimicrobial Drug Resistance: See Figure 11, Table 17, and Table 42 (Appendix A.4). The prevalence of resistance to one or more antimicrobials was 98% (155/158) of isolates in Ontario and 94% (152/162) of isolates in Québec in 2004 compared to 98% (140/143) of isolates in Ontario and 97% (121/125) of isolates in Québec in 2003. No resistance was detected to ciprofloxacin, linezolid, vancomycin, chloramphenicol, or salinomycin in either Ontario or Québec in 2004. Vancomycin was the only antimicrobial for which resistance was not detected in 2003. All *E. faecium* from both Ontario (six isolates) and Québec (five isolates) were resistant to quinupristine/dalfopristine (QDA). Among non- speciated *Enterococcus,* 67% (6/9) of Ontario isolates and 80% (4/5) of Québec isolates were also resistant to quinupristine-dalfopristine. There was no significant difference in the prevalence of resistance between Ontario and Québec for any of the antimicrobials tested.where resistance was detected in 2004.

AMR Patterns: The most frequent resistance pattern among *E. faecalis* in 2004 (Ontario: 52/143, 36%; Québec: 53/152, 35%) was BAC-TCY. Resistance to BAC-ERY-TCY-TYL was the second common pattern among *E. faecalis* isolates from both Ontario (26/143, 18%) and Québec (30/152, 20%). The *E. faecium* isolates resistant to the greatest number of antimicrobials were resistant to BAC-ERY-LIN-PEN-QDA-TCY-TYL in Ontario (2/6, 33%) and BAC-ERY-LIN-NIT-PEN-STR-QDA-TCY-TYL in Québec (1/5, 20%). The *E. faecalis* isolates resistant to the greatest number of antimicrobials were resistant to BAC-ERY-GEN-KAN-STR-TCY-TYL in Ontario (4/143, 3% isolates) and BAC-ERY-GEN-KAN-LIN-STR-TCY-TYL in Québec (4/152, 3% isolates).

For 2004, results from *Retail Surveillance* showed that 98% (155/158) of the *Enterococcus spp.* isolates from chicken from Ontario and 94% (152/162) of the isolates from Québec were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), no resistance was detected to ciprofloxacin, linezolid or vancomycin. However, 100% of all *E. faecium* isolates from Ontario (6 isolates) and Québec (5 isolates) were resistant to quinupristine/dalfopristine. The patterns which included the greatest number of antimicrobials among *E. faecium* were BAC-ERY-LIN-PEN-QDA-TCY-TYL in Ontario (2/6 isolates) and BAC-ERY-LIN-NIT-PEN-STR-QDA-TCY-TYL in Québec (1/5 isolates).

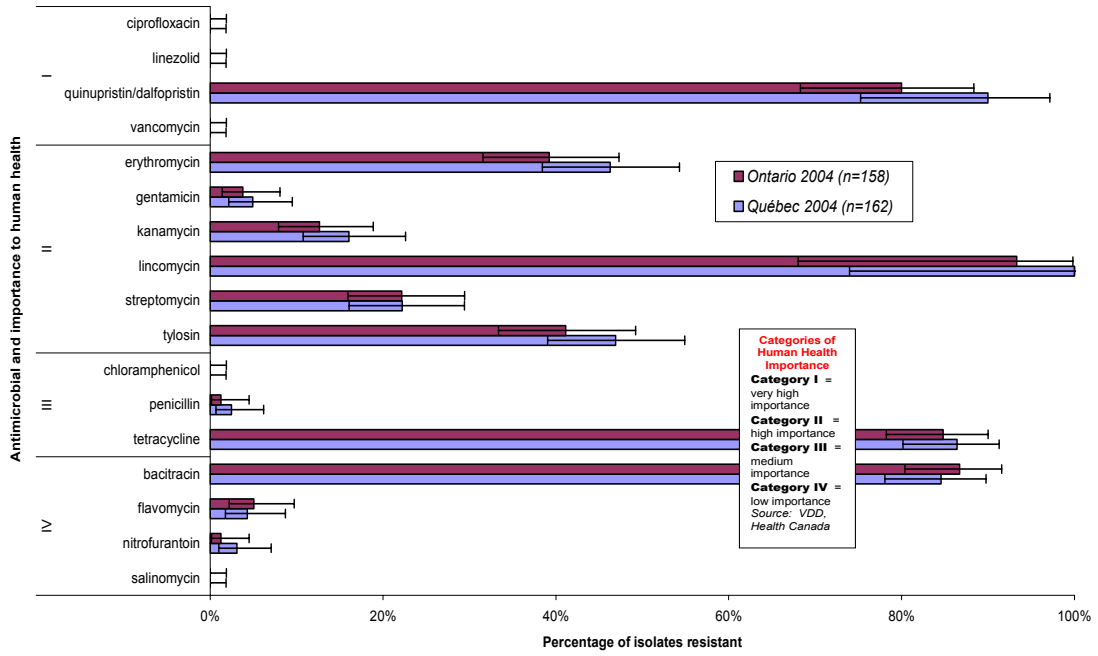

Figure 11. Individual antimicrobial drug resistance in *Enterococcus* spp. isolates from chicken samples collected in Ontario and Québec in 2004; *Retail Surveillance.*

Note: Resistance to quinupristine-dalfopristine and lincomycin is reported for non E. faecalis only (ON, n=15; QC, n=10) because of intrinsic resistance among E. feacalis to these antimicrobials).

Table 17. *Enterococcus* species from chicken; *Retail Surveillance* 2004.

Species	n (% total)	No. of antimicrobials in resistance pattern			
		0	**1-4**	**5-8**	**9-17**
		Number of isolates			
Ontario (n=158)					
E. faecalis[1]	143 (91)	3	111	29	0
Enterococcus spp.	9 (6)	0	3	5	1
E. faecium	6 (4)	0	3	3	0
Total		**3**	**117**	**37**	**1**
Québec (n=162)					
E. faecalis	152 (94)	10	109	33	0
E. faecium	5 (3)	0	0	4	1
Enterococcus spp.	5 (3)	0	0	3	2
Total		**10**	**109**	**40**	**3**

[1]*Maximum number of antimicrobials is 15: resistance to quinupristine-dalfopristine and lincomycin not included because of intrinsic resistance.*

Part III – *Passive Surveillance* of Animal Clinical Isolates

Salmonella isolates from animal clinical submissions (animals that do not necessarily enter the food-chain) originated primarily from veterinary diagnostic submissions. Most samples were obtained from diseased animals that may or may not have received antimicrobials before sample collection. Sample submissions may have also followed therapeutic failure. Furthermore, the reason for submission may have varied by region, animal species, or veterinarian/producer. Due to these external validity (representativeness) concerns, clinical isolates are not well suited for assessing the prevalence of antimicrobial resistance or the magnitude of the problem in healthy animals. They are, however, suitable for detecting emerging AMR, identifying new multiple drug resistance patterns, and assessing the occurrence of AMR resulting from veterinary therapy. The 2004 *Passive Surveillance of Animal Clinical Isolates* data were compared to similar data from 2003[3]. These comparisons should be interpreted with caution for the reasons described above.

Cattle – Clinical Salmonella

(*Passive Surveillance of Animal Clinical Isolates* n=107)

Antimicrobial Drug Resistance: See Table 18 and Table 46 (Appendix A.4). The frequency of resistance to one or more antimicrobials was 66% (175/264) of isolates in 2003 and 57% (61/107) of isolates in 2004. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin, or nalidixic acid in 2004. Twenty percent (21/107) of isolates were resistant to ceftiofur in 2004. In 2003, less than one percent (2/264) and 38% (101/264) of isolates were resistant to ceftriaxone and ceftiofur, respectively. However, reduced susceptibility (intermediate category) to ceftriaxone was observed in 19% (20/107) of isolates in 2004.

AMR Patterns: The most common resistance patterns in 2004 were ACKSSuT-A2C (17/107, 16%), ACSSuT (17/107, 16%), and ACKSSuT (5/107, 5%). The pattern ACKSSuT-A2C-CRO observed in one percent (2/264) of the isolates in 2003 was not observed in 2004. Similar to 2003, all isolates in 2004 that had reduced susceptibility (intermediate category) to ceftriaxone also showed resistance to the A2C pattern and one of the following patterns: ACKSSuT (17 *S*. Newport), ACSSuT-SXT (one *S*. Mbandaka), or ACSSuT (one *S*. Newport and one *S*. Typhimurium). The ACKSSuT-A2C-GEN-SXT pattern identified in 14 S. Typhimurium var Copenhagen isolates in 2003 was not detected in 2004.

Serovars: See Table 18. The most frequent serovars in 2004 were *S.* Typhimurium (32/107, 30%), *S.* Newport (19/107, 18%), *S.* Typhimurium var. Copenhagen (16/107, 15%), and *S.* Kentucky (12/107,11%). All but one of the *S.* Newport isolates (18/19, 95%) were resistant to nine or more antimicrobials. All multiresistant *S*. Newport were PT14a while the isolate susceptible to all antimicrobials was PT9. Fifty-six percent (18/32) of *S.* Typhimurium isolates and 81% (13/16) of the *S.* Typhimurium var. Copenhagen isolates were resistant to five or more antimicrobials. Among the 24 Typhimurium that were phagetyped, ten phage types were noted, the most frequent being PT104 (6/24,25%), PT135 (3/24, 12%) and PT170 (3/24, 13%). Among the 12 S. Typhimurium var. Copenhagen phagetyped, six phage types were noted, the most frequent being PT104 (5/12, 42%) and PT110 (3/12, 25%).

[3] *The 2003 data presented in this report differ slightly from those presented in 2003 CIPARS report due to the addition of about 30 isolates that were not tested until after the 2003 report publication.*

For 2004, results from *Passive Surveillance of Animal Clinical Isolates* showed that 57% (61/107) of bovine *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 20% (21/107) of isolates and no ceftriaxone resistance was detected. Nineteen percent (20/107) of isolates showed reduced susceptibility (intermediate category) to ceftriaxone. Forty-eight percent (51/107) of isolates were resistant to five or more antimicrobials. *Salmonella* Typhimurium, *S.* Newport and *S.* Typhimurium var Copenhagen were the most common serovars detected. All but one of the *S.* Newport isolates (18/19, 95%) were resistant to nine or more antimicrobials, whereas 56% (18/32) of *S.* Typhimurium isolates and 81% (13/16) of the *S.* Typhimurium var. Copenhagen isolates were resistant to five or more antimicrobials.

Table 18. *Salmonella* serovars from cattle; *Passive Surveillance* of Animal Clinical Isolates, 2004.

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
***Passive Surveillance* of Animal Clinical Isolates (n=107)**		Number of isolates			
Typhimurium	32 (29.9)	13	1	17	1
Newport	19 (17.8)	1	0	0	18
Typhimurium var. Copenhagen	16 (15)	3	0	13	0
Kentucky	12 (11.2)	10	2	0	0
Heidelberg	4 (3.7)	1	2	1	0
spp. I:18:-:-	3 (2.8)	3	0	0	0
Muenster	3 (2.8)	3	0	0	0
Sandiego	3 (2.8)	3	0	0	0
Less common serovars	15 (14)	9	5	0	1
Total		**46**	**10**	**31**	**20**

Note: Serovars with less than 2% prevalence are categorized as "Less Common Serovars".

Swine – Clinical Salmonella

(*Passive Surveillance of Animal Clinical Isolates* n=225)

Antimicrobial Drug Resistance: See Table 19 and Table 45 (Appendix A.4). The prevalence of resistance to one or more antimicrobials tested was in 74% (81/110) of isolates in 2003 and 77% (174/225) of isolates in 2004. No resistance to amikacin, ceftriaxone, ciprofloxacin, or nalidixic acid was detected in either 2003 or 2004. However, reduced susceptibility to ceftriaxone (intermediate category) was observed in two percent (4/225) of isolates in 2004 compared to one percent in 2003 (1/110). Two percent of clinical isolates from swine were resistant to ceftiofur in 2003 (2/110) and 2004 (4/225).

AMR Patterns: The most common resistance patterns were ACSSuT (24/225, 11%), ACKSSuT (23/225,10%), and STR-SMX-TCY (19/225, 8%). Alone and in combination with other antimicrobials, the ACSSuT pattern was present in 13% (30/225) of isolates, ACKSSuT in 17% (38/225) of isolates, and the AKSSuT in four percent (9/225) of isolates. One *Salmonella* ssp. I:6,7:-:- showed the ACKSSuT-A2C-GEN-SXT pattern (the AMR pattern with resistance to the greatest number of antimicrobials - a pattern not seen in 2003). This isolate also showed reduced susceptibility (intermediate category) to ceftriaxone, along with one *S.* Mbandaka isolate (ACSSuT-A2C), and two *S.* Heidelberg isolates (A2C-AMP).

Serovars: See Table 19. The most frequent serovars in 2004 were *S*. Typhimurium (93/225, 41%), *S*. Typhimurium var. Copenhagen (28/225, 12%), S. Derby (20/225, 9%) and S. Infantis (16/225, 7%). Fifty-eight percent (54/93) of *S*. Typhimurium isolates and 89% (25/28) of *S*. Typhimurium var. Copenhagen were resistant to five or more antimicrobials. Among the 70 *S.*

Typhimurium that were phage typed, 13 phage types were identified, the most frequent ones being PT104 (21/70, 30%) and PT110 (14/70, 20%). The most frequent phage types among *S.* Typhimurium var Copenhagen were PT104 (16/27, 59%) and PT104b (3/27, 11%).

For 2004, results from *Passive Surveillance of Animal Clinical Isolates* showed that 77% (174/225) of *Salmonella* isolates from swine were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance (4/225) and reduced susceptibility to ceftriaxone (4/225) were detected in two percent of isolates. Forty-one percent (93/225) of isolates were resistant to five or more antimicrobials. *Salmonella* Typhimurium and *S.* Typhimurium var. Copenhagen were the most common serovars isolated. The ACSSuT pattern was the most common pattern observed (24/225, 11%). One *Salmonella* ssp. I:6,7:-:- isolate was resistant to ACKSSuT-A2C-GEN-SXT, a pattern not identified in 2003 in swine.

Table 19. *Salmonella* serovars from swine; *Passive Surveillance* of Animal Clinical Isolates, 2004.

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
***Passive Surveillance* of Animal Clinical Isolates (n=225)**		Number of isolates			
Typhimurium	93 (41.3)	9	30	54	0
Typhimurium var. Copenhagen	28 (12.4)	0	3	25	0
Derby	20 (8.9)	3	16	1	0
Infantis	16 (7.1)	16	0	0	0
Agona	13 (5.8)	3	10	0	0
Heidelberg	7 (3.1)	0	3	4	0
Mbandaka	7 (3.1)	1	4	1	1
Senftenberg	5 (2.2)	5	0	0	0
Less common serovars	36 (16)	14	15	6	1
Total		**51**	**81**	**91**	**2**

Note: Serovars with less than 2% prevalence are categorized as "Less Common Serovars".

Chicken – Clinical Salmonella

(*Passive Surveillance of Animal Clinical Isolates* n=42)

Antimicrobial Drug Resistance: See Table 20 and Table 46 (Appendix A.4). In 2003 and 2004, 35% (13/37) and 40% (17/42) of isolates were resistant to one or more antimicrobials tested, respectively. As in 2003, no resistance to amikacin, ceftriaxone, ciprofloxacin, or nalidixic acid was detected in 2004. However, reduced susceptibility (intermediate category) to ceftriaxone was observed in three percent (1/37) and 19% (8/42) isolates in 2003 and 2004, respectively. In 2003 and 2004, eight percent (3/37) and 21% (9/42) of isolates were resistant to ceftiofur, respectively.

AMR Patterns: The most common resistance pattern observed was A2C-AMP (8/42, 19%). These isolates all showed reduced susceptibility (intermediate category) to ceftriaxone. One S. Heidelberg isolate showed the ACKSSuT-A2C pattern. This specific pattern had not been identified previously among clinical chicken isolates but had been identified among retail and abattoir isolates in 2003 (2 isolates) and 2004 (4 isolates). One S. Typhimurium showing the ACKSSuT pattern was also identified for the first time in 2004 among CIPARS chicken isolates collected from all surveillance components since 2001.

Serovars: See Table 20. The most frequent serovars observed in 2004 were *S.* Heidelberg

(22/42, 52%), *S*. Enteritidis (6/42, 14%), and *S*. Kentucky (4/42, 10%). The main phage types among *S*. Heidelberg were PT19 (11/22, 50%), PT29 (5/22, 23%) and PT11 (3/22, 14%). While most PT19 were susceptible to all antimicrobials (7/11, 64%), one PT19 isolate showed resistance to the largest number of antimicrobials (ACKSSuT-A2C). All PT29 were resistant to A2C-AMP. *Salmonella*. Enteritidis isolates were PT13 (5/6, 83%) and PT8 (1/6, 17%).

For 2004, results from *Passive Surveillance of Animal Clinical Isolates* showed that 40% (17/42) of *Salmonella* isolates from chickens were resistant to one or more antimicrobials tested. For antimicrobials of Very High Human Health Importance (Category I), ceftiofur resistance was detected in 21% (9/42) of isolates, as well as reduced susceptibility to ceftriaxone 19% (8/42) in 2004. In 2004, 26% (11/42) of isolates were resistant to five or more antimicrobials. *Salmonella* Heidelberg, *S*. Enteritidis, and *S*. Kentucky were the most common serovars isolated. One *S*. Heidelberg PT19 showed resistance to ACKSSuT-A2C, a pattern not identified previously among clinical chicken isolates but which had been identified among retail and abattoir isolates in 2003 and 2004.

Table 20. *Salmonella* serovars from chickens; *Passive Surveillance* of Animal Clinical Isolates, 2004.

Serovar	n (%total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
***Passive Surveillance* of Animal Clinical Isolates (n=42)**		Number of isolates			
Heidelberg	22 (52.4)	11	3	7	1
Enteritidis	6 (14.3)	6	0	0	0
Kentucky	4 (9.5)	3	1	0	0
Thompson	2 (4.8)	2	0	0	0
ssp. I:4,12:-:-	1 (2.4)	0	1	0	0
ssp. I:4,5,12:i:-	1 (2.4)	1	0	0	0
ssp. I:4,5,12:r:-	1 (2.4)	0	0	1	0
ssp. I:6,8:-:enx	1 (2.4)	0	1	0	0
Montevideo	1 (2.4)	0	0	1	0
Senftenberg	1 (2.4)	1	0	0	0
Typhimurium	1 (2.4)	0	0	1	0
Typhimurium var. Copenhagen	1 (2.4)	1	0	0	0
Total		**25**	**6**	**10**	**1**

Turkeys - Clinical Salmonella

(*Passive Surveillance of Animal Clinical Isolates* n=36)

Antimicrobial Drug Resistance: See Table 21 and Table 47 (Appendix A.4). In 2003 and 2004, 87% (33/38) and 83% (30/36) of isolates were resistant to one or more antimicrobials tested, respectively. No resistance to ciprofloxacin, amikacin, nalidixic acid, or trimethoprim-sulfamethoxazole was detected in 2004. No isolates were resistant to ceftriaxone in 2003, as compared to three percent (1/36) of isolates in 2004. However, 16% (6/38) and 11% (4/36) of isolates showed reduced susceptibility (intermediate category) to ceftriaxone in 2003 and 2004, respectively. In 2003 and 2004, 16% (6/38) and 17% (6/36) of isolates were resistant to ceftiofur, respectively.

AMR Patterns: The most common resistance patterns were ACSSuT-A2C (3/36, 8%), AMP-CEP-GEN-KAN-STR (3/36, 8%), and KAN-STR (3/36, 8%). The AKSSuT-A2C-CRO-GEN pattern (the resistance pattern with the greatest number of antimicrobials) was observed in three percent (1/36; *S*. Bredeney) of isolates. The A2C pattern was also observed in combination with ACSSuT (3/36, 8%; S. Infantis) and AMP (2/36, 6%; one S. Infantis and one S. Heidelberg). All but one (S. Heidelberg) of these isolates also showed reduced susceptibility (intermediate category) to ceftriaxone.

Serovars: See Table 21. In 2004, the most frequently observed serovars were *S*. Senftenberg (7/36, 19%), *S*. Heidelberg (6/36, 17%), *S*. Infantidis (4/36, 11%), and *S* Montevideo (4/36, 11%). *Salmonella*. Heidelberg had 3 phage types: PT47 (3/6, 50%), PT32 (2/6, 33%) and PT29 (1/6, 17%).

For 2004, results from *Passive Surveillance of Animal Clinical Isolates* showed that 83% (30/36) of turkey *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 17% (6/36) of isolates and 11% (4/36) of isolates showed reduced susceptibility to ceftriaxone. Forty-two percent (15/36) of isolates were resistant to five or more antimicrobials. *Salmonella* Senftenberg and *S*. Heidelberg were the most common serovars isolated. One S. Bredeney isolate showing the AKSSuT- A2C-CRO-GEN pattern was detected for the first time in 2004 among turkey clinical isolates.

Table 21. *Salmonella* serovars from turkeys; *Passive Surveillance* of Animal Clinical Isolates, 2004.

Serovar	n (% total)	No. of antimicrobials in resistance pattern			
		0	1-4	5-8	9-16
***Passive Surveillance* of Animal Clinical Isolates (n=36)**		Number of isolates			
Senftenberg	7 (19.4)	0	4	3	0
Heidelberg	6 (16.7)	1	4	1	0
Infantis	4 (11.1)	0	0	1	3
Montevideo	4 (11.1)	0	2	2	0
Saintpaul	3 (8.3)	2	0	1	0
Albany	2 (5.6)	0	2	0	0
Bredeney	2 (5.6)	0	0	1	1
Hadar	2 (5.6)	0	2	0	0
Final English	1 (2.8)	1	0	0	0
Newport	1 (2.8)	1	0	0	0
Schwarzengrund	1 (2.8)	0	1	0	0
Typhimurium	1 (2.8)	0	0	1	0
Typhimurium var. Copenhagen	1 (2.8)	0	0	1	0
Worthington	1 (2.8)	1	0	0	0
Total		**6**	**15**	**11**	**4**

Box 4. **Increase in ceftiofur resistance among clinical avian *E. coli* and *Salmonella*- results from the Québec Ministry of Agriculture, Fisheries, and Food (MAPAQ) passive surveillance program, 1994-2004.**

The "Institut national de santé animale" (INSA) of the **MAPAQ** has been testing avian clinical *E. coli* and *Salmonella* isolates for ceftiofur resistance since 1994. Results indicate that resistance and intermediate resistance to ceftiofur from avian sources has increased from 3% to 50% among *E. coli* isolates between 1994 and 2004, and from 3% to 32% among *Salmonella* isolates during the same period. These resistance data are analyzed by disk diffusion technique.

Ceftiofur is used in Canada in eggs and day-old chickens in order to control *E. coli*-related infections. Due to public health concerns raised by the release of the CIPARS 2003 report, the chicken hatcheries from Québec voluntarily stopped the use of ceftiofur in February 2005.

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Integrated Human and Agri-Food Antimicrobial Resistance Results

Antimicrobial Resistance Across Animal Species

In 2004, *Abattoir Surveillance* identified for the first time ceftriaxone resistance in *E. coli* from broiler chickens and ciprofloxacin resistance in *E. coli* from beef cattle (Figure 12). There was no resistance to amikacin in either *E. coli* or *Salmonella* isolates across animal species and no resistance to ciprofloxacin in *Salmonella* isolates from broiler chickens or swine. Overall, the highest prevalence of resistance in *E. coli* across species was seen in tetracycline, sulfamethoxazole, cephalothin, ampicillin, and streptomycin (Figure 12).

Differences in prevalence of individual antimicrobial resistance across commodities were noted for several antimicrobials for both *E. coli* and *Salmonella* (Figure 12 and Figure 13). In general, among the 2004 abattoir isolates, the prevalence of resistance was higher among broiler chicken and swine isolates, than beef isolates. The prevalence of resistance in *E. coli* isolates from chickens was significantly higher than the prevalence of resistance from cattle or swine isolates for: ceftiofur, amoxicillin-clavulanic acid, cephalothin, cefoxitin[4], and gentamicin (Figure 12). *Salmonella* isolates from chickens showed significantly higher prevalence of individual AMR than swine isolates for: ceftiofur, amoxicillin-clavulanic acid, ampicillin, cefoxitin, and cephalothin (Figure 13). However, *Salmonella* isolates from swine had a significantly higher prevalence of resistance than isolates from broiler chicken for: streptomycin, kanamycin, tetracyline, sulfamethoxazole, and chloramphenicol (Figure 13). *Retail Surveillance* from Ontario and Québec in 2004 (Figure 14) showed similar AMR trends across species to those found in the *Abattoir Surveillance* for *E. coli*. In general, the prevalence of resistance was higher among isolates recovered from chicken and pork, than from beef. *E. coli* isolates from chicken showed significantly greater individual AMR than beef and pork for: ceftiofur, amoxicillin-clavulanic acid, streptomycin, ampicillin, cephalothin, and cefoxitin. It must be noted that 2004 *Retail Surveillance* data were not necessarily nationally representative as samples were collected only from Ontario and Québec.

The impact of antimicrobial use in each commodity on AMR cannot currently be determined due to the lack 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 the occurrence of AMR requires surveillance at the farm level. In January 2006, CIPARS launched its *On-Farm Surveillance* with the intent of collecting parallel information on use and antimicrobial resistance (Box 3).

[4] *ceftiofur, amoxicillin-clavulanic acid, cephalothin, and cefoxitin belong to the same β-lactam class and therefore resistance to ceftiofur usually implies resistance to all other drugs in this class .*

In both abattoir and retail surveillance, differences in the prevalence of individual antimicrobial resistance across commodities were noted for several antimicrobials for both *E. coli* and *Salmonella.* In general, the prevalence of resistance was higher among broiler chicken and swine isolates, than beef isolates. In abattoir isolates, the prevalence of ceftiofur resistance in *E. coli* isolates from chickens was significantly higher than in cattle or swine isolates. *Salmonella* isolates from chickens showed significantly higher prevalence of ceftiofur resistance than in swine isolates. Although not nationally representative, the prevalence of ceftiofur resistance in *E. coli* isolates from retail chicken was significantly higher than in retail beef or pork isolates from Ontario and Quebec.

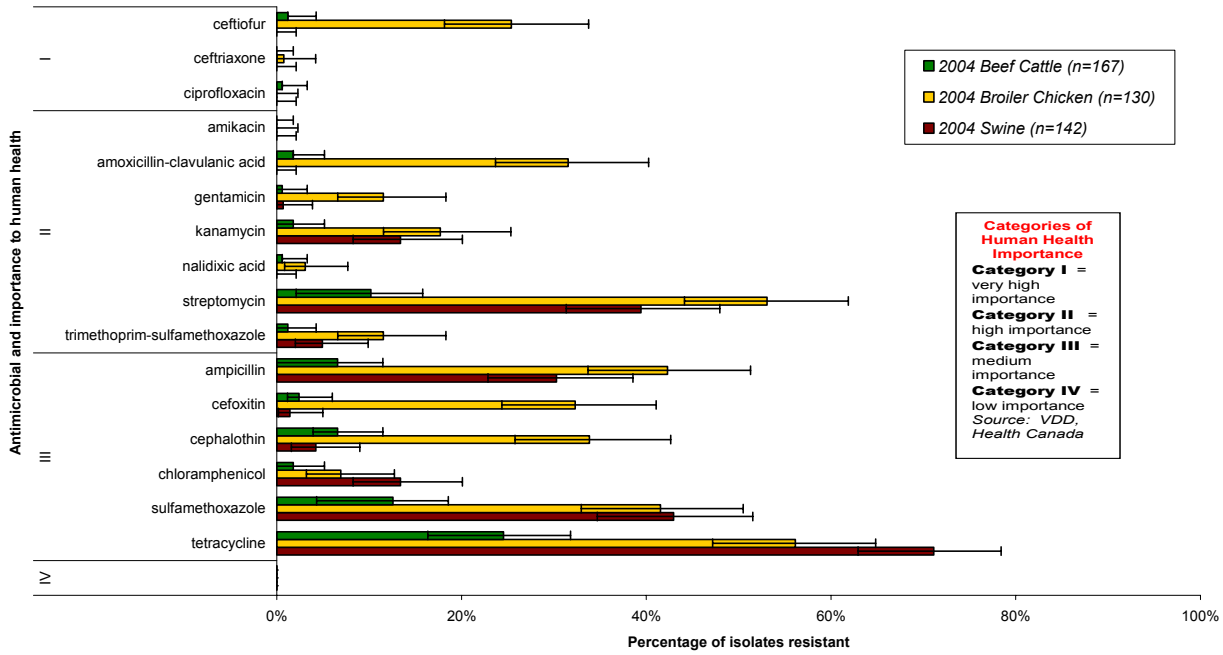


Figure 12. Individual antimicrobial drug resistance in *E. coli* from beef cattle (n=167), chicken (n=130), and swine (n=142) isolates in 2004; *Abattoir Surveillance*.

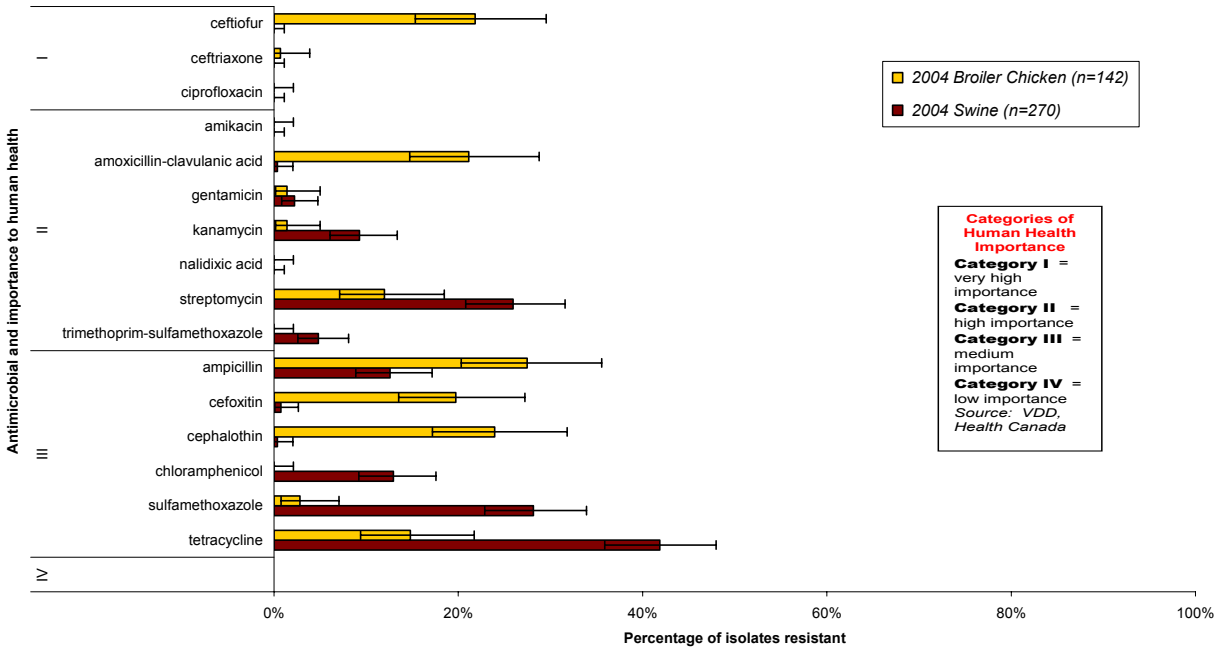


Figure 13. Individual antimicrobial drug resistance in *Salmonella* from chicken (n=142) and swine (n=270) isolates in 2004; *Abattoir Surveillance*.

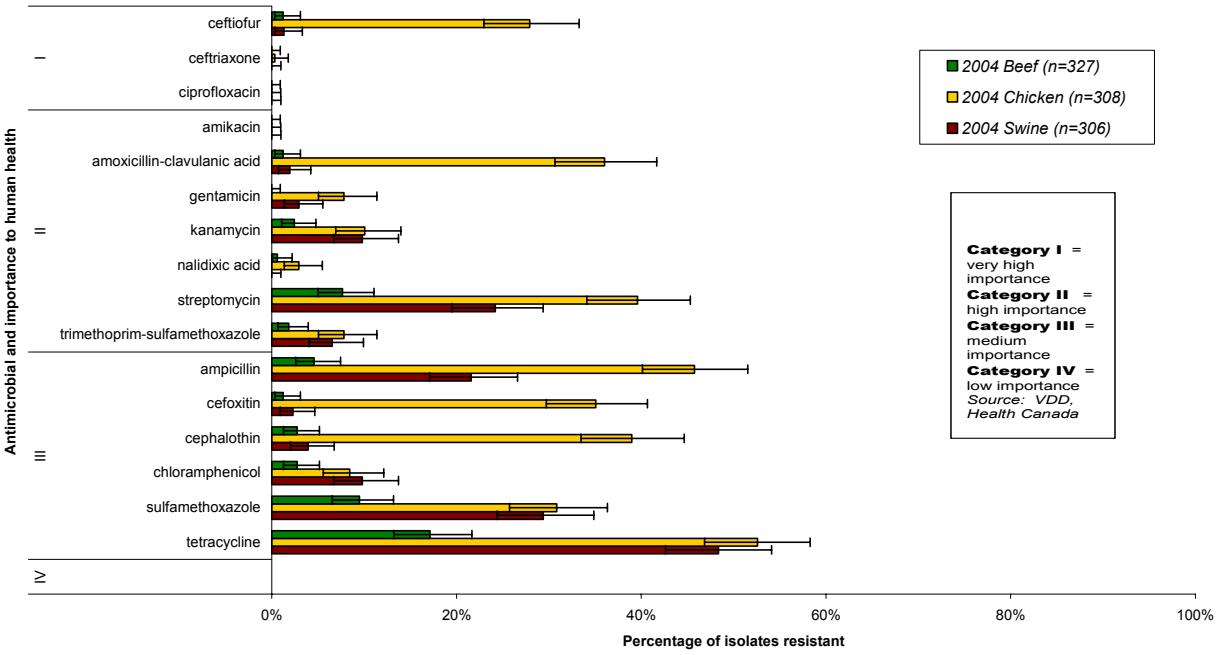


Figure 14. Individual antimicrobial drug resistance in *E. coli* from beef (n=327), chicken (n=308), and pork (n=306) isolates in 2004 from Ontario and Québec; *Retail Surveillance*.

Comparisons of *Salmonella* serovars and phage types across human, abattoir, and retail isolates

One objective of CIPARS is to compare antimicrobial resistance across bacterial strains obtained from humans, animals, and food of animal origin. Currently, *Salmonella* is the only bacteria available to make such comparisons. Table 22 describes the distribution of different serovars observed across CIPARS surveillance components[5]. A detailed table comparing serovars from 2003 and 2004 human isolates, abattoir (chicken and swine), and retail (chicken) isolates can be viewed on the CIPARS website (*http://www.phac-aspc.gc.ca/cipars-picra/index.html*).

S. Heidelberg

The frequency of *S*. Heidelberg among human samples decreased significantly between 2003 (613/3056, 20%) and 2004 (559/3147,18%). Among abattoir chicken samples, the frequency also decreased significantly from 50% (63/126) in 2003 to 35% (51/142) in 2004, as well as among retail chicken samples, from 72% (39/54) in 2003 to 56% (60/107) in 2004. The prevalence was 3% for swine abattoir isolates in both 2003 (12/395) and 2004 (8/270).

The most frequent phage type of human *S*. Heidelberg was PT19 with similar frequencies in both 2003 (211/613, 34%) and 2004 (191/559, 34%). It had similar frequencies across years among abattoir chicken isolates (2003: 9/63, 14%; 2004: 12/51, 23%), chicken retail isolates (2003: 4/39, 10%; 2004: 7/60, 12%) and swine abattoir isolates (2003: 2/12, 17%; 2004: 1/8, 12%). The prevalence of phage type 29 increased significantly among human *S*. Heidelberg samples between 2003 (68/613, 11%) and 2004 (124/559, 22%). Although the absolute numbers are different, the increases noted were not statistically significant among chicken abattoir samples (2003: 12/63, 19%; 2004: 15/51, 29%) and chicken retail samples (2003: 11/39, 28%; 2004: 23/60, 38%). No significant changes between 2003 and 2004 were observed between PT31 and PT41 in human, abattoir or retail isolates. The frequency of PT11 decreased significantly between 2003 and 2004 in both human isolates (2003: 44/613, 7%; 2004: 24/559, 4%) and in chicken abattoir isolates (2003: 15/63, 24%; 2004: 2/51, 4%). PT11 was not detected among the 39 retail isolates in 2003 but was identified in 5% (3/60) of isolates in 2004.

S. Typhimurium

In 2003 and 2004, *S.* Typhimurium was the most frequent serovar in human samples. It was also the most frequent serovar among swine abattoir isolates (Table 22). Between 2003 and 2004, there was a significant decrease in the relative frequency of *S.* Typhimurium among swine abattoir isolates from 28% (112/395) to 15% (41/270). This decrease did not translate into an overall decrease of the relative or absolute frequency in humans (2003: 610/3056, 20%; 2004: 597/3147, 19%). Most of the decrease among swine abattoir isolates was attributable to a significant decrease in frequency of PT208 that was observed in 19% (21/112) of the isolates in 2003 and 2% (1/41) of isolates in 2004. This phage type was observed in 4% (27/610) and 2% (13/597) of all human *S*. Typhimurium isolates in 2003 and 2004, respectively. A significant decrease in the frequency of PT104 among human samples was noted between 2003 (147/610, 24%) and 2004 (96/597, 16%) while there was no detectable change among swine abattoir isolates between 2003 (40/112, 36%) and 2004 (15/41, 37%). There was a significant increase in the frequencies of PT108 among human *S*. Typhimurium between 2003 (16/610, 3%) and 2004 (68/597, 11%), while this phage type was detected in 4% (4/112) of swine abattoir *S*. Typhimurium isolates in 2003 but was not detected among the 41 isolates recovered in 2004.

[5] *Comparisons with data from animal clinical isolates (majority come from diseased animals that do not enter the food chain) are not discussed in this section because they are not considered to be a common sources of human disease.*

The frequency of *S.* Heidelberg among human samples decreased significantly between 2003 (613/3056, 20%) and 2004 (559/3147,18%). Among abattoir chicken samples, the frequency also decreased significantly from 50% (63/126) in 2003 to 35% (51/142) in 2004, as well as among retail chicken samples, from 72% (39/54) in 2003 to 56% (60/107) in 2004.

Table 22. Distribution of *Salmonella* serovars isolated by the National Enterics Surveillance Program (human) and CIPARS (human, bovine, poultry and porcine) in 2004.

Serovar	Human		Bovine[2] n (%)			Chicken n (%)			Swine[2] n (%)			Turkey n (%)		
	NESP	CIPARS	Clinical	Abattoir	Retail	Clinical	Abattoir	Retail	Clinical	Abattoir	Retail	Clinical	Abattoir	Retail
Typhimurium	1107 (20.6)	597 (18.9)	48 (44.9)			2 (4.8)	4 (2.8)	4 (3.7)	121 (53.8)	41 (15.2)		2 (5.4)		
Enteritidis	991 (18.4)	550 (17.5)	1 (0.9)			6 (14.3)	9 (6.3)	3 (2.8)		1 (0.4)				
Heidelberg	942 (17.5)	559 (17.8)	4 (3.7)			22 (52.4)	51 (35.9)	60 (56.1)	7 (3.1)	8 (3.0)		6 (16.7)		
Thompson	153 (2.8)	95 (3.0)	1 (0.9)			2 (4.8)	4 (2.8)		1 (0.4)					
Newport	149 (2.8)	153 (4.9)[1]	19 (17.8)									1 (2.8)		
Hadar	149 (2.8)	85 (2.7)					5 (3.5)	8 (7.5)	1 (0.4)	1 (0.4)		2 (5.6)		
Typhi	129 (2.4)	125 (3.9)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
Agona	116 (2.2)	87 (2.8)					4 (2.8)	3 (2.8)	13 (5.8)	6 (2.2)				
Infantis	102 (1.9)	53 (1.7)					4 (2.8)	3 (2.8)	16 (7.1)	25 (9.3)		4 (11.1)		
Saintpaul	91 (1.7)	60 (1.9)										3 (8.3)		
Other serovars	1449 (26.9)	783 (24.8)[3]	34 (31.8)			10 (23.8)	61 (43.0)	26 (24.3)	66 (29.3)	188 (69.6)		18 (50.0)		
Total	**5378**	**3147**	**107**			**42**	**142**	**107**	**225**	**270**		**36**		

1 The total number of S. Newport and S. Typhi isolates includes all isolates recovered across Canada, whereas other Salmonella serovars are only a subset of isolates submitted to CIPARS from provincial laboratories (see Methods, Appendix B).

2 In 2004, CIPARS did not test retail beef, retail pork, retail turkey or abattoir beef samples or turkey for Salmonella.

3 Frequency not corrected for unequal submission between provinces.

Antimicrobial Resistance in Bacteria Contaminating Food or Animals – A Public Health Concern?

S. Enteritidis – A Need for Surveillance in Raw Eggs?

In 2003 and 2004, resistance to nalidixic acid was present in 19% (66/352) and 23% (124/550) of human *S*. Enteritidis isolates, respectively. As noted in Section I the importance of nalidixic acid resistance is that it may be associated with clinical failure or delayed response to fluoroquinolone therapy (NCCLS/CLSI - M100-S15). There was a significant increase in streptomycin resistance in human isolates between 2003 (5/352, 1%) and 2004 (22/550, 4%). Surveillance of raw eggs would allow for the evaluation of the role of agriculture on resistance observed in humans. Travel related information would also be needed to exclude cases acquired abroad, since *S.* Enteritidis is one of the most frequent *Salmonella* serovar worldwide.

S. Heidelberg – Increase in A2C-AMP pattern in Humans and Chickens

As published in CIPARS 2003, resistance to A2C-AMP in *S*. Heidelberg isolates was significantly higher in Québec than in Ontario among both human isolates (Ontario: 29/172, 17%; Québec: 52/167, 31%; p=0.002) and retail chicken meat isolates (Ontario: 2/19, 11%; Québec, 13/20, 65%; p<0.001). In 2003, resistance was higher in Québec's *S*. Heidelberg isolates from chicken meat than from humans (p=0.003). In Ontario, results from chicken meat and humans were not significantly different.

In 2004, resistance to A2C-AMP remained relatively stable in Québec's (Figure 15) *S*. Heidelberg isolates from both retail chicken (16/28, 57%) and humans (39/116, 34%) and remained higher in chicken than in human isolates (p=0.02). However in Ontario in 2004, resistance increased significantly in retail chicken (17/32, 53%, p=0.002) and human (67/186, 36%, p<0.0001) *S*. Heidelberg isolates (Figure 16). Similar to Québec, resistance to A2C-AMP in 2004 tended to be higher in Ontario chicken meat isolates than among human isolates (p=0.06). In 2004, there were no significant differences between Ontario and Québec in A2C-AMP resistance in either chicken or human *S*. Heidelberg isolates.

In 2004, a significant increase was also noted in A2C-AMP resistance in human *S*. Heidelberg isolates in British Columbia (2003: 13/49, 27%; 2004: 30/55, 55%) and Manitoba (2003: 1/44, 2%; 2004: 9/58, 16%) (Figure 17). In 2004, Alberta had the lowest prevalence of A2C-AMP resistance among human *S*. Heidelberg isolates. CIPARS did not conduct retail surveillance outside of Ontario and Québec in 2003 and 2004, thus comparisons between human and meat isolates could not be made.

A2C-AMP resistance also increased significantly between 2003 (4/63, 6%) and 2004 (23/51, 45%) among chicken abattoir *S*. Heidelberg isolates from across Canada. Although S. Heidelberg was also recovered from swine abattoir samples in both 2003 (12 isolates) and 2004 (8 isolates), none were resistant to A2C-AMP.

Box 5. Antimicrobial Resistant *Salmonella* Heidelberg in Canada.

As was observed in the two studies presented in Box 1 (Currie et al (2005) and MacDougall et al (2004)) and in Hennessey et al (2004), consumption of poultry products and shell eggs are considered risk factors for *S.* Heidelberg infection. Of concern is the increased severity of infections that could be attributed to infections with resistant organisms. In Canada, the CIPARS surveillance data for 2003-2004 has revealed a significant and increasing prevalence of AmpC resistance in *S.* Heidelberg isolated from human and chicken samples. In 2004, *ampC*-like resistance (pattern A2C-AMP) was found in 48% of retail chicken meat and 26% of human isolates of *S.* Heidelberg. Reduced susceptibility to the 3rd generation cephalosporin ceftriaxone has increased from 8% in 2003 to 26% in 2004 among human isolates of *S.* Heidelberg.

A leading hypothesis for the increase in *ampC*-like resistance observed in Canada is that ceftiofur use in poultry is a contributor to resistance in chickens and in humans via consumption or direct contact with poultry. This hypothesis seems to be biologically plausible given the routes of transmission and the similarity of ceftiofur to ceftriaxone. There is some evidence to suggest that this emergence is relatively recent in humans, within the past 5-6 years, but historical AMR data needs to be examined for verification.

As opposed to other parts of the world, *S.* Heidelberg is frequently involved in clinical infections in humans in Canada. The increase of *ampC*-like resistance among human isolates in Canada and the emergence of multi-resistant strains is a concern because of the possible reduced efficacy of several drugs and in particular of third generation cephalosporins in the treatment of extra-intestinal salmonellosis. Ceftriaxone, a third generation cephalosporin, is one of the last antimicrobial options for the treatment of extra-intestinal salmonellosis in children where fluoroquinolones cannot be administered.

References:

Currie A, MacDougall L, Aramini J, Gaulin C, Ahmed R, Isaacs S. 2005. Frozen chicken nuggets and strips and eggs are leading risk factors for *Salmonella* Heidelberg infections in Canada. Epidemiol. Infect. 133: 809-816.

Hennessy TW, Cheng LH, Kassenborg H, Ahuja SD, Mohle-Boetani J, Marcus R, *et al*. 2004. Egg consumption is the principal risk factor for sporadic *Salmonella* serotype Heidelberg infections: A case-control study in FoodNet sites. CID. 38 (Suppl 3): S237-43.

MacDougall L, Fyfe M, McIntyre L, Paccagnella A, Cordner K, Kerr A, Aramini J. 2004. Frozen chicken nuggets and strips – a newly identified risk factor for *Salmonella* Heidelberg infection in British Columbia, Canada. J. Food. Protect. 67: 1111-1115.

A2C resistance in S. Heidelberg PT29

The majority of human *S*. Heidelberg resistant to A2C-AMP identified in 2003 (48/130, 37%) and 2004 (113/175, 65%) were PT29. Phage type 29 was also the most frequently noted phage type among animal sources and was identified in 75% (3/4) and 65% (15/23) of abattoir chicken isolates resistant to A2C-AMP in 2003 and 2004, respectively. Phage type 29 was also identified in 60% (9/15) and 77% (23/30) of chicken retail meat A2C-AMP resistant isolates in 2003 and 2004, respectively.

It appears that chicken is one possible source of exposure for *S*. Heidelberg in humans. From CIPARS data, it is estimated that 3% and 4%[6] of the chicken meat samples purchased in 2003 and 2004, respectively, were contaminated with an A2C-AMP resistant PT29. When data are examined by province, the risk of purchasing A2C-AMP resistant PT29 contaminated chicken was 4% in both 2003 and 2004 in Québec, while it went from 1% in 2003 to 4% in 2004 in Ontario. A2C-AMP resistant PT29 was also identified in veterinary clinical isolates (bovine: 1 isolate in 2004; swine: 1 isolate in 2004; turkey: 1 isolate in 2003), indicating that other species can also occasionally harbour this strain. In 2002 and 2003, CIPARS estimated that the overall prevalence of *Salmonella* in retail pork and retail beef to be below one percent. Since *S*. Heidelberg is not a major serovar in swine and beef, the risk of exposure through those sources should be relatively low. Retail surveillance in turkey meat samples would help to better characterize *S*. Heidelberg prevalence and resistance in this commodity. CIPARS has undertaken molecular comparisons of S. Heidelberg with A2C-AMP pattern from various human, animal, and food sources to determine their degree of genetic relatedness.

The use of the third-generation cephalosporin, ceftiofur, was identified as one possible risk factor explaining the resistance observed in chickens in 2003 and 2004. There are currently no drug use data available that are sufficiently detailed in animals to explore this potential relationship.

Drug use in humans could also have triggered this resistance, however the oral consumption of third generation cephalosporins in humans in the provinces of Ontario and Quebec has decreased since January 2000 (Figure 27).

Despite the lack of clear evidence between the extra-label use of ceftiofur and AMR in chicken, certain chicken hatchery groups have taken action to ban the extra-label use of ceftiofur in hatching and day-old chickens. On-going CIPARS *Abattoir* and *Retail Surveillance* should be able to measure the impact of these actions on AMR. Passive surveillance of veterinary clinical isolates will also be used to ascertain the impact of this measure on clinical samples. (Box 5).

ACSSuT-A2C resistance in S. Heidelberg PT54

In 2004, the second most frequent phage type among human *S*. Heidelberg A2C-AMP resistant strains was PT54 (15/175, 9%). This particular strain raises concern because it is resistant to ACSSuT-A2C plus has reduced susceptibility or resistance to ceftriaxone. In 2004, 73% (11/15) of PT54 ACSSuT-A2C isolates were identified in British Columbia, and the remainder were identified in Québec (3/15) and Alberta (1/15). This PT54 ACSSuT-A2C strain was also identified in 2003 in British Columbia (9/11, including one isolate with additional resistance to ceftriaxone), in Alberta (1/11), and in Saskatchewan (1/11). *Salmonella* Heidelberg PT54 isolates with no A2C-AMP resistance were identified in humans in 2003 (3 isolates) and 2004 (5 isolates), but only one of these isolates was recovered in British Columbia.

CIPARS has not identified any animal or food source of PT54 ACSSuT-A2C. However, CIPARS' capacity to detect this particular strain among animal or food sources from British Columbia in 2003 and 2004 was low. CIPARS recovered only one *Salmonella* sample in 2003 and five samples in 2004 from chicken *Abattoir Surveillance* in British Columbia, and only three isolates were S. Heidelberg, none of which were PT54. Furthermore, CIPARS *Retail Surveillance*

[6] *(Salmonella prevalence in chicken meat) * (prevalence of S. Heidelberg among all Salmonella recovered) * (prevalence of PT29 A2C-AMP strains among all S. Heidelberg strains)*

was not national in scope in 2003 or 2004[7], nor did CIPARS' *Passive Surveillance* include any veterinary clinical isolates from British Columbia during this period.

As a result of these findings, CIPARS initiated a short investigation of AMR in *Salmonella* from retail chicken and turkey meat purchased in British Columbia in September and October 2005. Only five *Salmonella* isolates were recovered from 38 chicken samples, and none were recovered from 18 turkey samples. *Salmonella*. Only two of the chicken isolates were *S*. Heidelberg, both were PT 6. CIPARS also obtained clinical chicken and turkey *S. Heidelberg* isolates and their associated AMR results from the British Columbia Ministry of Agriculture and Lands and submitted those isolates for phage typing. Twenty-four isolates were received; nine isolates were from both chicken and turkey samples and the remainder were from various sources (porpoise, dog, fluff from a layer barn, environmental sample from a layer barn, and a cheetah). None of the 24 isolates were PT 54 or expressed the ACSSuT-A2C pattern. One turkey PT 19 isolates showed the A2C-AMP-STR-SMX-TCY pattern and one cheetah PT 5 isolate expressed the A2C-AMP-STR-SMX-TCY pattern.

In 2004, PT 54 ACSSuT-A2C represented 20% (11/55) of all human *S*. Heidelberg identified in British Columbia. If the prevalence of PT 54 ACSSuT-A2C contaminated meat samples was only one percent (risk similar as the estimated prevalence of A2C-AMP PT 29 contaminated chicken in Ontario in 2003), the chance of detecting at least one positive sample among the 38 chicken samples purchased was only 39%. On-going surveillance in British Columbia is required to obtain a larger number of chicken and turkey samples.

S. Newport - No Increase in Multi-Resistant Human Isolates but Remains a Concern in Cattle

S. Newport is a *Salmonella* serovar of public health interest in North America because of previous outbreaks of multiple resistant strains among humans in the United States (Gupta et al, 2003) and in Canada (CIPARS, 2003). The 2003 CIPARS annual report highlighted one outbreak in Ontario where bovine and human cases were associated. *S*. Newport was isolated from five percent (153/3147) of human isolates in 2004, a rate similar to 2003 (175/3056, 6%). In 2004, there were no reported animal-human related outbreaks in Canada. Among animals in 2004, *S.* Newport was recovered from 17% (19/114) of clinical bovine samples, a significant decrease compared to 2003 (63/234; 27%), and was also recovered from one of the 37 clinical turkey samples.

The proportion of human isolates resistant to five or more antimicrobials in 2004 (11%; 17/153) was similar to 2003 (13%; 22/175). In 2004, 8% (13/153) of human isolates were resistant to ACSSuT-A2C while 86% were susceptible to all antimicrobials tested. All but one clinical bovine *S.* Newport isolate showed resistance to either ACKSSuT-A2C or ACSSuT-A2C (17/114, 15%). Due to the risk of transmission from cattle to humans and the great number of antimicrobials in the resistance pattern, multi-resistant S. Newport remains a public health concern in Canada. This also highlights the need for effective isolation measures when *S*. Newport is identified from cattle and the need for appropriate public health messages.

S. Typhimurium – Greater Resistance in Swine than Humans and Low Salmonella *Prevalence in Pork Meat*

In 2004, differences in prevalence of resistance between swine and human samples were significant for ampicillin (swine: 31/41, 76%; human: 413/1053, 39%), chloramphenicol (swine: 27/41, 66%; human: 332/1053, 32%), kanamycin (18/41, 44%; 205/1053, 19%), streptomycin (swine: 28/41, 68%, human:393/1051, 38%), sulfamethoxazole (swine: 29/41, 71%, human: 449/1053, 43%), and tetracycline (swine: 33/41,80%; human: 456/1053, 43%)[8], with resistance always higher among isolates from healthy pigs than among

[7] *Retail Surveillance was initiated during the summer of 2003 in Ontario and Québec, and in December 2004 in Saskatchewan.*

[8] *Human rates were corrected for unequal submission rates across provincial laboratories.*

clinical human samples (Figure 18). The overall prevalence of *Salmonella* in pork chops estimated in 2003 by CIPARS was below one percent. The risk of infection via pork meat is therefore relatively small. *Salmonella* prevalence in live pigs is much higher (close to 40%). However, similarities in trends between 2003 and 2004 were rare among S. Typhimurium phage types, with the exception of PT208. Nevertheless, the fact that resistance among healthy slaughtered pigs is higher than among diseased humans remains a concern particularly for those in contact with live pigs. *Salmonella* Typhimurium has been identified from CIPARS *Passive Surveillance* of veterinary clinical isolates in swine, bovine, avian, equine, and several other species, and humans are likely exposed to a variety of sources. Molecular characterization is needed to ascertain the degree of genetic relatedness between *S.* Typhimurium from human samples and various animal sources, and to elucidate the contribution of the resistance observed in swine isolates to resistance among human isolates.

In 2004, resistance in S. Heidelberg to A2C-AMP increased significantly in retail chicken from Ontario (17/32, 53%) and humans (67/186, 36%). In both Ontario and Québec, *S.* Heidelberg resistance to A2C-AMP in 2004 was higher in chicken meat isolates than among human isolates. A2C-AMP resistance also increased significantly between 2003 (4/63, 6%) and 2004 (23/51, 45%) among chicken abattoir *S.* Heidelberg isolates from across Canada. The majority of human *S.* Heidelberg isolates resistant to A2C-AMP identified in 2004 (113/175, 65%) were PT29. Phage type 29 was also the most frequently noted phage type among animal sources and in 2004 was identified in 65% (15/23) and 77% (23/30) of abattoir chicken isolates and chicken retail meat isolates, respectively, that were resistant to A2C-AMP. In 2004, the second most frequent phage type among human *S.* Heidelberg A2C-AMP resistant strains was PT54 (15/175, 9%). This particular strain raises concern because it is resistant to ACSSuT-A2C plus has reduced susceptibility to ceftriaxone. In 2004, 73% (11/15) of PT54 ACSSuT-A2C isolates were identified in British Columbia, and the remainder were identified in Québec (3/15) and Alberta (1/15).

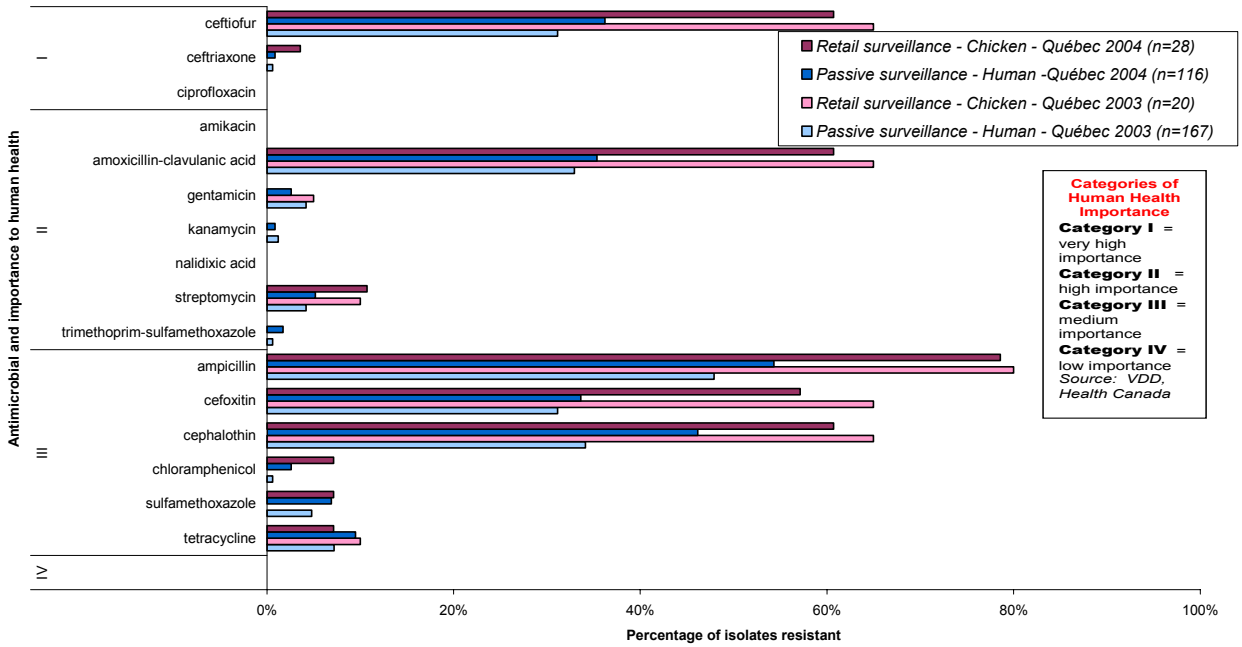


Figure 15. Individual antimicrobial drug resistance in *Salmonella* Heidelberg isolated from human salmonellosis cases in Québec *(Enhanced Passive Surveillance)* in 2003 (n=167) and 2004 (n=116), and from retail chicken in Québec *(Retail Surveillance)* in 2003 (n=20) and 2004 (n=28).

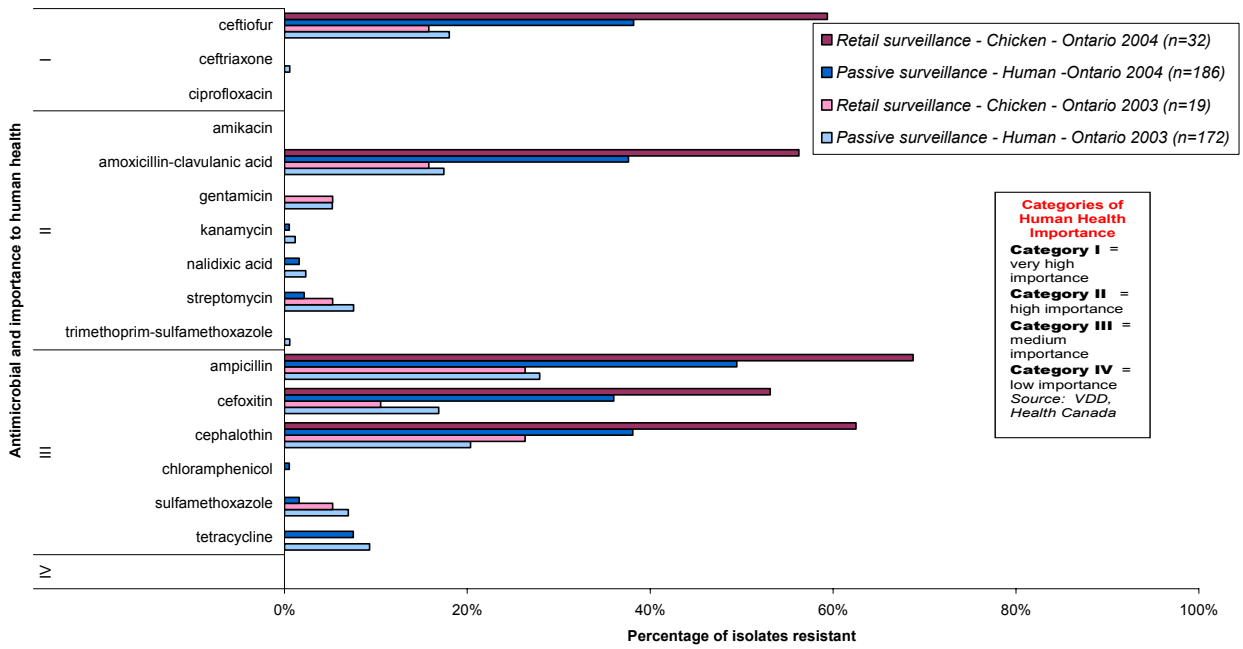
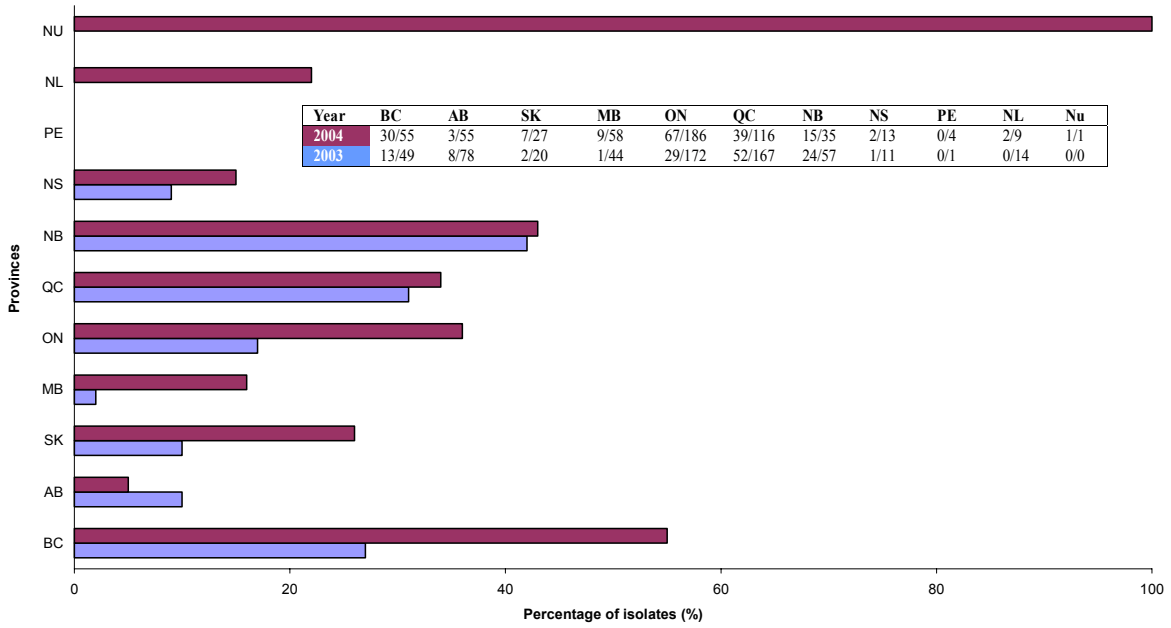


Figure 16. Individual antimicrobial drug resistance in *Salmonella* Heidelberg isolated from human salmonellosis cases in Ontario (*Enhanced Passive Surveillance*) in 2003 (n=172) and 2004 (n=186), and from retail chicken in Ontario (*Retail Surveillance*) in 2003 (n=19) and 2004 (n=32).



Year	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	Nu
2004	30/55	3/55	7/27	9/58	67/186	39/116	15/35	2/13	0/4	2/9	1/1
2003	13/49	8/78	2/20	1/44	29/172	52/167	24/57	1/11	0/1	0/14	0/0

Figure 17. Prevalence of the A2C-AMP pattern among *Salmonella* Heidelberg isolates in human in 2003 and 2004 across Canada.

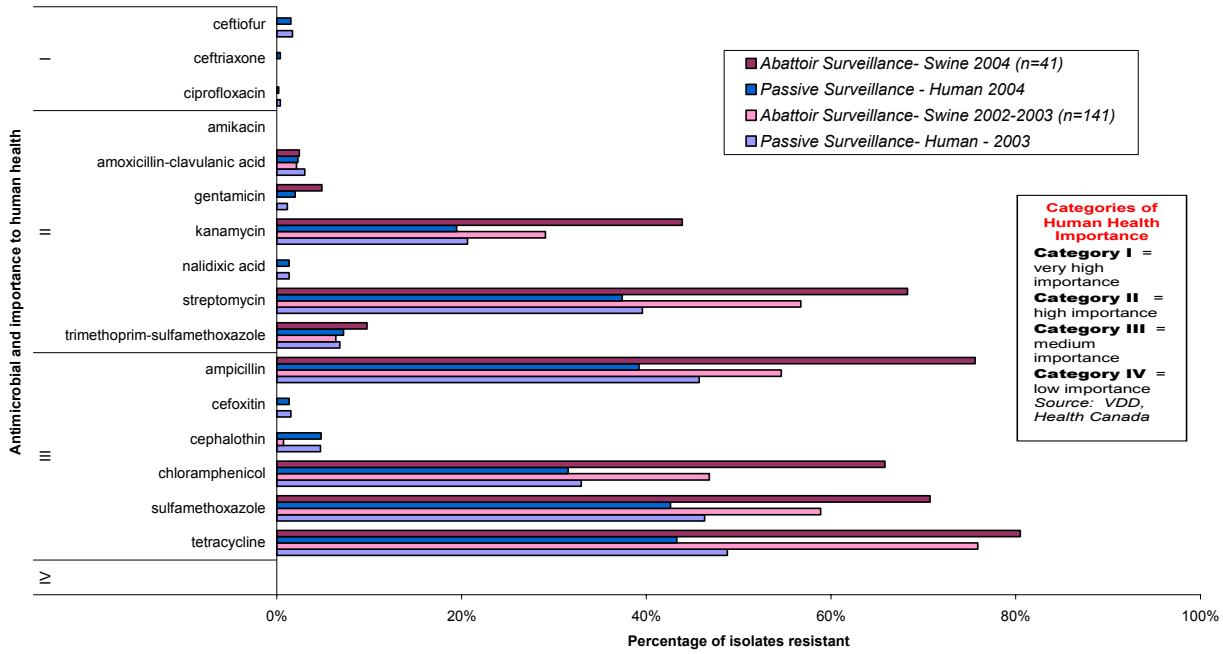


Figure 18. Individual antimicrobial drug resistance in *Salmonella* Typhimurium from swine abattoir surveillance in 2002/2003 (n=141) and in 2004 (n=41), and from human salmonellosis cases (*Enhanced Passive Surveillance*) in 2003 (estimated from 610 Canadian isolates) and in 2004 (estimated from 581 Canadian isolates).

Data Limitations

As in 2003, 2004 *Retail Surveillance* data were available only for the provinces of Ontario and Québec. In 2005, representative retail samples from Saskatchewan were collected. CIPARS intends to expand this program across the country to account for potential regional differences in AMR. Due to low prevalence of *Salmonella* and *Campylobacter* in meat other than chicken, the retail component does not evaluate the possible contribution of beef or pork or other types of meat to resistance in these enteropathogenic bacteria in humans.

At the abattoir level, CIPARS does not examine *Salmonella* in bovine samples because of its low prevalence in beef caecal samples. Following approval of fluoroquinolone drugs for cattle in Canada, *Campylobacter* has been added to the 2005 beef *Abattoir Surveillance* test panel. CIPARS is also considering other sources of *Salmonella* samples to evaluate resistance in healthy beef animals.

Due to data gaps, CIPARS has occasionally used abattoir data as a surrogate for human exposure data, but abattoir data may not accurately reflect human exposure (please refer to CIPARS 2003 annual report, *Discussion* section, *Limitations* for an in depth discussion on the subject). CIPARS intends to continually improve its retail component as resources become available.

The human component of CIPARS only includes AMR surveillance of clinical *Salmonella* isolates. CIPARS is actively exploring avenues to add AMR surveillance of other human enteric pathogens and commensal bacteria. Source attribution for human *Salmonella* is difficult because of the many possible origins such as from animals, food, and the environment. Further complicating this matter is the opportunity for human exposure during international travel; CIPARS does not currently obtain travel-related information for isolates from human *Salmonella* cases.

Molecular studies are required to adequately determine the level of genetic relatedness between abattoir, retail, animal clinical, and human clinical sources. CIPARS has undertaken a number of molecular studies in 2005 and intends to include molecular testing as part of on-going surveillance in the future.

The current lack of animal antimicrobial use data prevents exploration of links between drug use and AMR in animals. At the moment, we can only hypothesize possible use from imprecise knowledge of antimicrobial drug management methods in the various animal production sectors. The on-farm component of CIPARS will provide useful information in this regard and assist in the development of prudent use guidelines. Other efforts are also being made by CIPARS and several provinces to obtain national or provincial animal drug use data.

The absence of a reliable food and animal tracking system continues to limit the interpretation of CIPARS data. Without such a system, it is not possible to accurately determine the origin of meat samples purchased at the retail level. In certain circumstances, this absence of knowledge impairs the capacity of the animal industry to appropriately react. As soon as reliable information on the province or country of origin of the meat is available at the retail level, CIPARS will report and use this information. CIPARS is supportive of all efforts being made by the food industry and governments at the national and provincial levels to establish a reliable food-tracking system.

CIPARS and its partners are actively working towards addressing the limitations addressed above wherever possible through additional surveillance activities and research One partnership is with C-EnterNet, which is an integrated surveillance system that is focussed on reducing the burden of human enteric disease through sentinel site surveillance (Box 6).

Box 6. Overview of C-EnterNet, a national integrated enteric disease surveillance program

C-EnterNet is a multi-partner pilot initiative facilitated by the Public Health Agency of Canada and funded by Agriculture and Agri-Food Canada, Agricultural Policy Framework. It supports activities that will reduce the burden of enteric disease by comprehensive sentinel site surveillance implemented through local public health units. This initiative will result in effective evaluation and development of policies related to the safety of food and water. Its approach is in line with leading-edge work in public health, as called for in Canada by the recent Haines (meat safety), Naylor (SARS outbreak) and O'Connor (water safety) reports, the Auditor General and the Pan-Canadian Public Health Network. Such work focuses on the necessity of collaboration among jurisdictions and of integration of efforts, communication networks, rigorous systematization, and involvement of local public health units to inform policy at the local, regional and national levels.

The C-EnterNet model

The C-EnterNet model is similar to the Centers for Disease Control and Prevention (CDC) FoodNet sentinel site model - a leading-edge surveillance approach implemented to reduce the occurrence and impact of foodborne diseases in the United States. However, C-EnterNet's scientific mandate is broader; it includes simultaneous investigation of foodborne and waterborne diseases and exposure. Their sentinel site selection criteria ensure that cost efficiencies are achieved for sample collection and laboratory analysis, and that data results may be generalized for communities across Canada. Each sentinel site is established in a unique partnership with the local public health unit and includes a working network with the local water, agriculture and retail food sectors, as well as the provincial and federal institutions responsible for public health.

The C-EnterNet implementation

The C-EnterNet pilot site was launched June 2005 in the Region of Waterloo, Ontario. Enhanced investigations of sporadic cases and outbreaks as well as enhanced subtyping provide data that are integrated with laboratory results from food, farms, and water within the region. These activities have improved capacity locally and provincially, while providing the high quality data necessary for the determination of trends over time and source attribution.

C-EnterNet and CIPARS are coordinating activities and procedures where possible. For instance, C-EnterNet and CIPARS are using common laboratory tests (e.g. AMR panels) and are working towards integrated sample collection (particularly for the on-farm components). C-EnterNet' next steps are to report on the first year of data and to expand to additional sites as funding becomes available.

Section Two – Antimicrobial Use

Human Antimicrobial Use

In 2004, CIPARS obtained two datasets from Intercontinental Medical Statistics (IMS) Health through the Office of Public Health Practice of the Public Health Agency of Canada. These datasets contain human drug use data from 2000 to 2004. This report presents analyses from the Canadian CompuScript (CCS) dataset and the Canadian Disease and Therapeutic Index (CDTI) dataset. The CCS dataset provides information from Canadian retail pharmacies and the CDTI dataset contains information related to diagnostic data associated with antimicrobial drug mentions[9] occurring during patient visits. Additional information on IMS Health data collection and CIPARS analytic methodologies are described in Appendix B.3.

Currently, the World Health Organization (WHO) recommends that antimicrobial drug use be reported using Defined Daily Doses (DDD[10]). The number of DDDs /1000 inhabitant-days are presented for retrospective national and international comparisons[11]. 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 are presented. While CCS data are presented by Anatomical Therapeutic Chemical[12] (ATC) classes, the format of the CDTI data received precluded the transposition of these data into ATC classes.

Canadian CompuScript - Retail Pharmacy Dispensing Data

The CCS tracks the number of extended units, the size, and the cost of prescriptions dispensed by approximately 2700 Canadian retail pharmacies. IMS extrapolates this data to estimate the number of extended units, the cost, and the number of prescriptions dispensed by all retail pharmacies in Canada (approximately 7400 chain and independent stores in 2004). Although no hospital pharmacies are included in the CCS sample, CCS data includes a small volume of antimicrobials delivered in non-oral forms such as injectable drugs or products administered by inhalation. Inconsistencies related to non-oral drugs, which represent a very small volume of the CCS data, were judged too frequent to include in this analysis. Consequently, unlike previously published CIPARS reports, this 2004 report only describes drugs delivered by oral forms from retail pharmacies. The 'data' limitations' section outlines some further issues and inconsistencies with this dataset. In previous CIPARS reports, methenamine and linezolid were classified under "Other antimicrobials"; here they are reported separately to harmonise with reports from other surveillance programs such as DANMAP. The list of all antimicrobial drugs included in each ATC class are shown in Table 48 (Appendix A.5).

The total volume of oral antimicrobial drugs dispensed by Canadian retail pharmacies decreased from 211,035 kg in 2000 to 185,819 kg in 2004 (Table 23). Similarly, the total number of prescriptions per 1000 inhabitant per year decreased from 739 in 2000 to 661 in 2004 (Figure 19 and Table 49 (Appendix A.5)), while the number of DDDs per 1000 inhabitant-days decreased from 19.23 in 2000 to 17.35 in 2004 (Table 24). Despite a decrease in consumption, the amount of money spent by Canadians in purchasing oral drugs through retail pharmacies increased from $20,853 per 1000 inhabitants in 2000 to $21,053 per 1000 inhabitants in 2004 (Figure 19 and Table 50, Appendix A.5).

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

[10] *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/)].*

[11] *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 (e.g. number of days in calendar year x (population of Canada for given year/1,000 inhabitants).*

[12] *ATC classification system is maintained by the WHO Collaborating Centre for Drug Statistics Methodology (http://www.whocc.no/atcddd/). The 2005 ATC classification system was used here.*

In 2004, the five most frequently dispensed systemic antibacterial drug classes by proportion of total DDDs per 1000 inhabitant-days were: extended-spectrum penicillins (25.24%); macrolides (19.79%); tetracyclines (13.85%); fluoroquinolones (12.06%); and second-generation cephalosporins (5.42%) (Table 24). The consumption of most drug classes decreased between 2000 and 2004 (Figure 20 and Table 24). However increases were observed in fluoroquinolones (9.5 to 12.06%), combinations of penicillins, including β-lactamase inhibitors (2.64 to 3.01%), lincosamides (1.27 to 1.83%), first-generation cephalosporins (3.88 to 5.02%), and nitrofuran derivatives (2.17 to 2.85%) (Table 24). Linezolid, which was not used in 2000, showed an increase of 928% between 2001 and 2004. Despite this large relative increase between 2001 and 2004, the total consumption of linezolid remained low, representing only 0.02 prescriptions per 1000 inhabitant-years in 2004 (Table 51) or less than 0.01 percent of the total consumption of all oral drugs dispensed by retail pharmacies in Canada (Table 24). The proportion of the total consumption represented by macrolides increased from 18.92% to 19.79% between 2000 and 2004 (Table 24). However, this does not represent a true increase of consumption as the total number of DDDs/1000 inhabitant-days decreased form 3.64 to 3.42 between 2000 and 2002, increased to 3.57 DDDs in 2003, and decreased again to 3.43 DDDs/1000 inhabitant-days in 2004. In this case, the increase in relative consumption of macrolides is likely explained by the overall decrease in consumption of all antimicrobials. Antimicrobials of Very High Human Medicine Importance (Category I) represented a consistently increasing proportion of the total DDDs dispensed from 10.01% in 2000 compared to 12.42% in 2004 (Table 24). The third-generation cephalosporin class was the only class of Very High Human Medicine Importance (Category I) where a decrease in consumption was noted between 2000 and 2004 (Figure 20).

The fact that no decrease in the cost of oral antimicrobial drugs was noted despite the decrease in consumption could be attributable to a shift in physician prescribing practices, where new and often more expensive drugs tend to be favored over older drugs. In addition, changes towards newer molecules within drug classes also occurred. For example, between 2000 and 2004, the increased consumption of fluoroquinolones was mainly attributable to increases in consumption of moxifloxacin, levofloxacin, and gatifloxacin (Figure 21), often referred to as “respiratory quinolones” that offer Gram-positive coverage in addition to expanded Gram-negative coverage (CPS 2003). During this period, the use of ofloxacin and norfloxacin, two older generations of fluoroquinolones, decreased (Figure 21). Similarly, despite the absence of a marked increase in the overall consumption of macrolides, the consumption of azithromycin in DDDs per 1000 inhabitant-days increased from 0.53 in 2000 to 0.76 in 2004 while the consumption of erythromycin decreased from 0.88 DDDs per 1000 inhabitant-days in 2000 to 0.43 in 2004 (Figure 22).

Differences in 2004 in the total consumption of antimicrobials (expressed in DDDs/1000 inhabitant-days) were observed across Canada (Figure 23 and Table 51 (Appendix A.5)). Consumption was highest in the combined provinces of Prince Edward Island and Newfoundland, while Québec had the lowest overall antimicrobial consumption. Much of these inter-provincial variations are explained by differences in consumption of extended-spectrum penicillins (Figure 23). Some of the differences between provinces may also be due to sampling variations, especially in less populated provinces where antimicrobial drugs are consumed less frequently overall.

The estimation of the total amount of oral antimicrobials delivered in 2002 by retail pharmacies in Canada was compared to the total outpatient antimicrobial use in 26 European countries in 2002 and published by ESAC (European Surveillance of Antimicrobial Consumption) (Goossens *et al.*, 2005) (Figure 24). This analysis showed that the level of consumption in Canada in 2002 was similar to the level of consumption in Finland. Canada’s consumption represented approximately twice the level of consumption of people from the Netherlands (the country with the lowest level of consumption) and half the level estimated in France (the country with the highest level of consumption). While Canada ranked 14th out of the 27 countries classified by increasing level of total antimicrobial consumption, it ranked 23rd for its level of consumption of macrolides and lincosamides (there was no oral consumption of streptogramins in 2002), and 20th for its level of

consumption of quinolones (largely composed of fluoroquinolones).

Canadian Disease and Therapeutic Index – Diagnostic Data

The CDTI dataset represents a compilation of information from 652 office-based physicians in Canada (for 2004 data). It provides information on diseases associated with drug mentions during patient visits to those sampled physicians, as well as information related to the sex, age, region, and office location (office, hospital, unspecified) of the physician. The information gathered from these sampled physicians is then projected to the target population (see Methods section in Appendix B.3 for more details). These projected data were used for the analysis presented in this report.

From 2000 to 2004, respiratory disease was the principal ICD-9 diagnostic class with drug mentions (50.6%), followed by central nervous system disease (13.4%), genitourinary disease (12.0%), and skin and subcutaneous tissue disease (9.8%) (Figure 25 and Table 52 (Appendix A.5)). For respiratory disease, the main diagnoses were acute bronchitis (20.4%), acute unspecified sinusitis (15.2%), and acute pharyngitis (12.6%) (Table 53, Appendix A.5). Mentions of antimicrobial therapy for diseases of the central nervous system were mainly related to unspecified otitis media (86.9%) (Table 53, Appendix A.5). Unspecified urinary tract infection (47.3%) and acute cystitis (22%) were the main diagnosis codes related to genitourinary disease (Table 53, Appendix A.5). Skin and subcutaneous tissue diseases were related to various diagnostic codes, the most frequent being cellulitis and abscesses (17.2%) and unspecified acne (10.8%) (Table 53, Appendix A.5).

According to 2004 CDTI data, female patients visited office-based physicians more frequently (56%; projected number of visits=15,047,330) than did male patients (41%; projected number of visits=11,073,080). Among female patients, most visits were made by women between 20 and 39 years of age (29%; 4,296,690 projected visits) and between 40 and 59 years of age (27%; 4,077,280 projected visits). Among male patients, most visits were made by men between 40 to 59 years of age (25%; 2,759,880 projected visits) and between 20 to 39 years of age (23%; 2,553,920 projected visits). Within the top three ICD-9 diagnostic classes, differences in sex and age were noted. A greater proportion of visits with antimicrobial mentions were female patients with respiratory and genitourinary diseases (Figure 26). A greater proportion of respiratory disease was related to patients between 20 to 59 years of age (Figure 26). Children under nine years of age were the primary age-group seen for central nervous system diseases (mainly otitis media) (Figure 26). Visits with antimicrobial mentions related to a genitourinary disease were mainly in females between 20 and 59 years of age (Figure 26).

From 2000 to 2004, the primary antimicrobial classes (IMS USC5 classification system) mentioned during visits for respiratory disease were extended spectrum macrolides (31.6%), amoxicillin (24.6%), cephalosporins (13.7%) and oral quinolones (11.0%) (Table 25). The proportion of mentions of cephalosporins during respiratory disease related visits decreased between 2000 (16.6%) and 2004 (11.5%), while increases in drug mentions were noted for extended spectrum macrolides (2000: 27.0%; 2004: 36.0%) and oral quinolones (2000: 6.9%; 2004:13.0%.) (Table 25).

The antimicrobial drugs most frequently mentioned in visits associated with central nervous system diseases (mainly otitis) from 2000 and 2004 were amoxicillin (38.6%), cephalosporins (23.4%), and extended spectrum macrolides (18%) (Table 25). Between 2000 and 2004, drug mentions in visits associated with central nervous system diseases decreased for cephalosporins (2000: 26.5%; 2004: 21.5%), broad spectrum penicillins (2000: 10.4%; 2004: 7.1%), and trimethoprim combinations (2000: 5.9%; 2004: 1.5%) and increased for extended spectrum macrolides (2000: 13.9% ;2004: 22.6%) (Table 25).

From 2000 to 2004, the antimicrobials most frequently mentioned in visits associated with genitourinary disease were oral quinolones (56.5%) and trimethoprim combinations (25.6%) (Table 25). Between 2000 and 2004, oral fluoroquinolones increased (2000: 48.9%; 2004: 62.0%) and trimethoprim combinations decreased (2000: 31.7%; 2004: 20.9%)(Table 25). This observation agrees with CCS data where overall (irrespective of diagnosis) there

was increased consumption of fluoroquinolones and newer macrolides but decreased consumption of cephalosporins and combinations of sulfonamides and trimethoprim.

Data Limitations

The information in the CCS 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, a small proportion of 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 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. All non-oral drugs records were excluded because of the high frequency of inconsistencies in this field. Inconsistencies identified with oral antimicrobial drugs were corrected whenever possible. However, some less apparent inconsistencies for which there is no possible adjustment may remain. These corrections induced a slightly higher number of DDDs for certain drug categories, namely extended spectrum penicillins, third-generation cephalosporins, lincosamides, macrolides, β-lactams sensitives penicillins, intermediate acting sulfonamides, and tetracyclines.

Data from CCS measure systemic antimicrobial agents 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 a small volume of drugs dispensed to health care facilities such as nursing homes.

Data obtained from CCS are derived from a sample selection of participating pharmacies rather than from all participating pharmacies. These numbers therefore represent an estimate of Canadian drug consumption and should not be viewed as census data. Data in cells containing a smaller number of observations should always be interpreted with caution.

Pharmacies located in one important large retail store chain do not submit data to CCS. The impact of the absence of these retail pharmacies from the "Universe" for the estimation of the Canadian consumption of antimicrobial drugs through retail pharmacies is unknown. Internet pharmacies are excluded from sampled pharmacies whenever possible but a certain volume of internet sales outside Canada may remain. The magnitude of these possible biases is unknown. CIPARS collaborates with the British Columbia Center for Disease Control to compare CCS data from BC to data collected through its medical drug recording system, Pharmanet, a source judged more complete and precise than CCS since it includes all pharmacies from British Columbia. This exercise should provide information regarding the direction and magnitude of the bias.

CDTI data are derived from sampled office based physicians across the country. The primary limitation of this dataset is its small sample size and lack of certainty of estimates derived from a very small number of observations. It is recommended by IMS that CDTI data be interpreted with caution when the number of observations in one cell is bellow 100,000 drug mentions (ie. at 100,000, the 95% C.I. is 48,000 to 152,000) (Refer to *http://www.phac-aspc.gc.ca/cipars-picra/index.html* for further details). The level of detail obtained also precluded reclassification of antimicrobials into ATC classes. For the same reason, 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. CDTI records drug mentions during physician visits. As a result, a drug may or may not have been prescribed and if prescribed, may or may not have been filled. Also, CDTI data could include multiple visits from the same patient. The unit of analysis in this section is the number of visits with a drug mention, not the total number of visits (with or without drug mentions) and should not be used as a

surrogate estimate of the number of patients treated during a year.

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 in the two IMS databases, it is not possible to make these comparisons. CIPARS has acquired data from another IMS dataset, the Canadian Drugstore and Hospital Purchases Audit (CDH). Analyses of this dataset should provide some information on antimicrobials purchased by retail and hospital pharmacies. CIPARS intends to publish these data when analyses are completed.

Table 23. Total volume of active ingredients (in kilograms) of oral antimicrobials dispensed by retail pharmacies, Canada 2000-2004

Human health importance	ATC class		Total amount of active ingredients per year (Kg)					Percent of total (%)				
			2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
I	J01DD	Third-generation cephalosporins	441.47	412.56	372.50	321.45	275.37	0.21	0.20	0.19	0.17	0.15
	J01MA	Fluoroquinolones	17,387.35	17,569.37	17,718.15	18,469.28	18,738.69	8.24	8.69	9.19	9.58	10.08
	J01XA	Glycopeptides	25.90	28.25	32.23	40.56	70.36	0.01	0.01	0.02	0.02	0.04
	J01XX08	Linezolid		1.55	4.91	10.82	17.29	0.18	<0.01	<0.01	<0.01	<0.01
II	J01CA	Penicillins with extended spectrum	57,566.37	56,004.37	53,404.23	53,132.75	51,471.46	27.28	27.69	27.71	27.57	27.70
	J01CF	Beta-lactamase resistant penicillins	8,351.94	8,004.64	7,376.34	7,135.18	6,596.63	3.96	3.96	3.83	3.70	3.55
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	7,314.70	7,443.40	7,249.64	7,601.53	7,587.85	3.47	3.68	3.76	3.94	4.08
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	29,783.84	27,065.78	24,548.61	23,018.83	20,511.55	14.11	13.38	12.74	11.94	11.04
	J01FA	Macrolides	25,163.98	23,844.04	21,665.44	22,138.28	21,168.20	11.92	11.79	11.24	11.49	11.39
	J01FF	Lincosamides	3,289.35	3,590.12	3,896.00	4,272.26	4,441.95	1.56	1.77	2.02	2.22	2.39
	J01GB	Aminoglycosides	29.66	0.36	0.04	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	76.31	62.19	52.12	45.35	41.87	0.04	0.03	0.03	0.02	0.02
	J01RA	Sulfonamide combinations (excl. trimethoprim)	2,745.17	1,910.05	1,251.28	843.14	548.87	1.30	0.94	0.65	0.44	0.30
III	J01AA	Tetracyclines	14,112.37	13,169.24	12,595.12	11,902.77	11,050.90	6.69	6.51	6.54	6.18	5.95
	J01BA	Amphenicols	0.78	0.99	0.20		0.06	<0.01	<0.01	<0.01		<0.01
	J01CE	Beta-lactamase sensitive penicillins	15,079.86	14,253.92	13,722.26	13,802.13	12,916.80	7.15	7.05	7.12	7.16	6.95
	J01DB	First-generation cephalosporins	16,693.30	17,295.99	18,358.43	19,683.24	20,312.94	7.91	8.55	9.53	10.21	10.93
	J01DC	Second-generation cephalosporins	11,099.40	9,857.59	8,712.26	8,570.41	8,277.23	5.26	4.87	4.52	4.45	4.45
	J01EA	Trimethoprim and derivatives	315.71	297.29	310.34	307.34	288.32	0.15	0.15	0.16	0.16	0.16
	J01EB	Short-acting sulfonamides	105.38	13.45	0.88	1.04	1.02	0.05	<0.01	<0.01	<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides	28.08	4.51	4.77	5.55	4.61	0.01	<0.01	<0.01	<0.01	<0.01
IV	J01XC	Steroid antibacterials	34.79	39.06	35.54	37.27	36.64	0.02	0.02	0.02	0.02	0.02
	J01XE	Nitrofuran derivatives	935.24	981.97	1,019.51	1,073.19	1,152.40	0.44	0.49	0.53	0.56	0.62
	J01XX	Other antibacterials	64.76	74.26	48.00	35.71	26.28	0.03	0.04	0.02	0.02	0.01
	J01XX05	Methenamine	389.51	356.69	350.35	296.88	282.20	0.18	0.18	0.18	0.15	0.15
	J01	**Total**	**211,035.23**	**202,281.64**	**192,729.16**	**192,744.98**	**185,819.48**	**100**	**100**	**100**	**100**	**100**

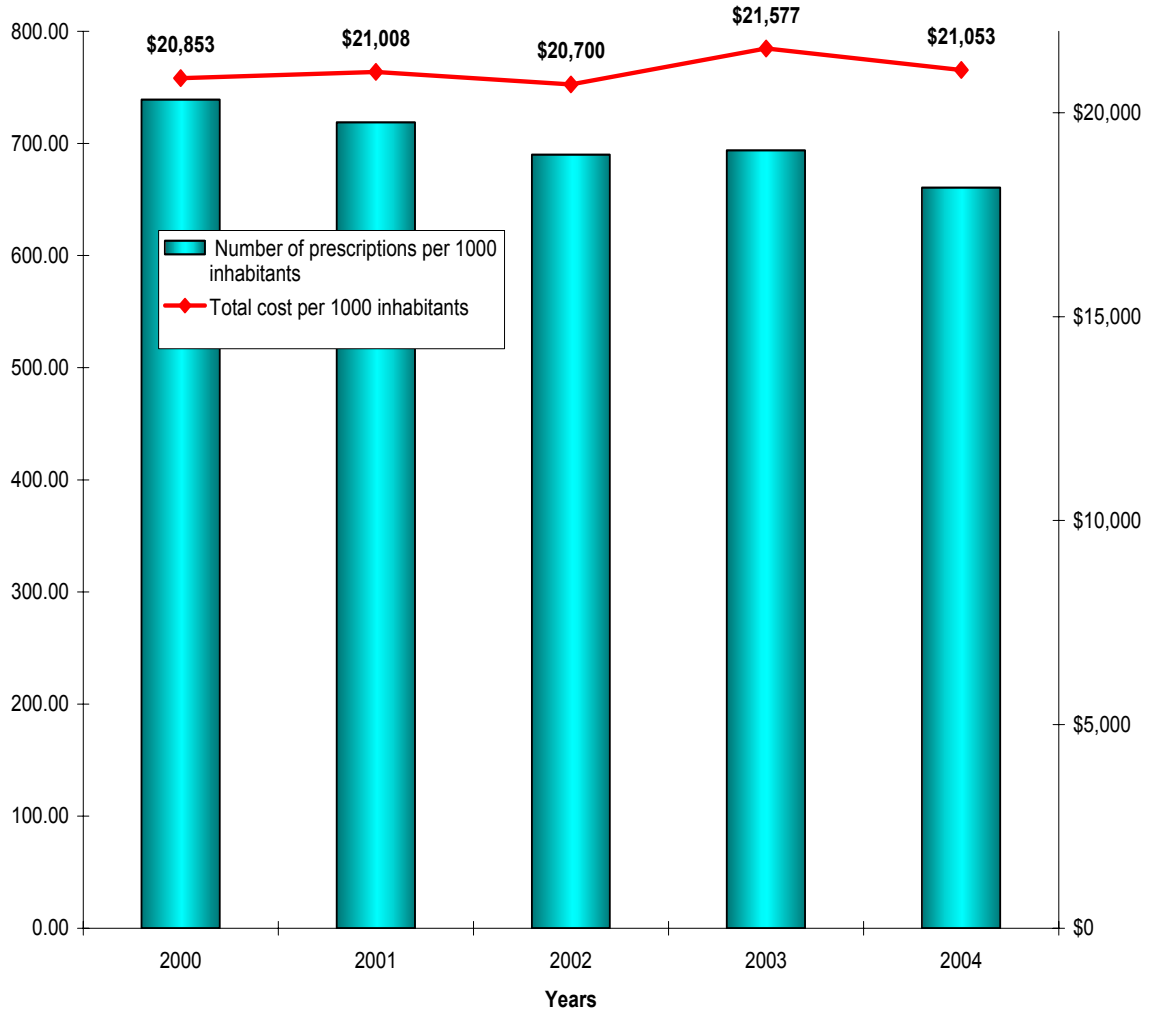

Figure 19. Total number of prescriptions and total cost per 1000 inhabitants per year, Canada 2000-2004.

Table 24. Defined daily doses of oral antimicrobials dispensed by retail pharmacies per 1000 inhabitant-days, Canada 2000-2004.

Human Health Importance	ATC class		Total number of DDDs/1000-inhabitant-days per year					Percent of consumption (%)				
			2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
I	J01DD	Third-generation cephalosporins	0.10	0.09	0.08	0.07	0.06	0.51	0.49	0.46	0.39	0.34
	J01MA	Fluoroquinolones	1.83	1.93	1.99	2.08	2.09	9.50	10.33	11.10	11.57	12.06
	J01XA	Glycopeptides	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
	J01XX08	Linezolid		<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01
II	J01CA	Penicillins with extended spectrum	5.07	4.90	4.63	4.57	4.38	26.37	26.18	25.87	25.39	25.24
	J01CF	Beta-lactamase resistant penicillins	0.37	0.35	0.32	0.31	0.28	1.94	1.89	1.81	1.72	1.63
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	0.51	0.52	0.50	0.52	0.52	2.64	2.76	2.80	2.92	3.01
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	1.39	1.25	1.12	1.04	0.92	7.23	6.69	6.28	5.80	5.29
	J01FA	Macrolides	3.64	3.62	3.42	3.57	3.43	18.92	19.36	19.13	19.86	19.79
	J01FF	Lincosamides	0.24	0.27	0.28	0.31	0.32	1.27	1.42	1.59	1.72	1.83
	J01GB	Aminoglycosides	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	0.03	0.02	0.01	<0.01	<0.01	0.16	0.11	0.08	0.05	0.03
III	J01AA	Tetracyclines	2.72	2.62	2.54	2.50	2.40	14.13	13.99	14.22	13.90	13.85
	J01BA	Amphenicols	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01		<0.01
	J01CE	Beta-lactamase sensitive penicillins	0.67	0.63	0.60	0.60	0.55	3.50	3.37	3.36	3.33	3.19
	J01DB	First-generation cephalosporins	0.75	0.77	0.80	0.85	0.87	3.88	4.09	4.49	4.75	5.02
	J01DC	Second-generation cephalosporins	1.39	1.22	1.05	1.00	0.94	7.24	6.52	5.84	5.56	5.42
	J01EA	Trimethoprim and derivatives	0.07	0.07	0.07	0.07	0.06	0.37	0.35	0.38	0.37	0.36
	J01EB	Short-acting sulfonamides	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
IV	J01XC	Steroid antibacterials	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01
	J01XE	Nitrofuran derivatives	0.42	0.44	0.45	0.47	0.49	2.17	2.32	2.50	2.59	2.85
	J01XX	Other antibacterials	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01
	J01XX05	Methenamine	0.01	0.01	0.01	<0.01	<0.01	0.06	0.06	0.06	0.05	0.05
	J01	**Total**	**19.23**	**18.72**	**17.89**	**17.99**	**17.35**	**100**	**100**	**100**	**100**	**100**

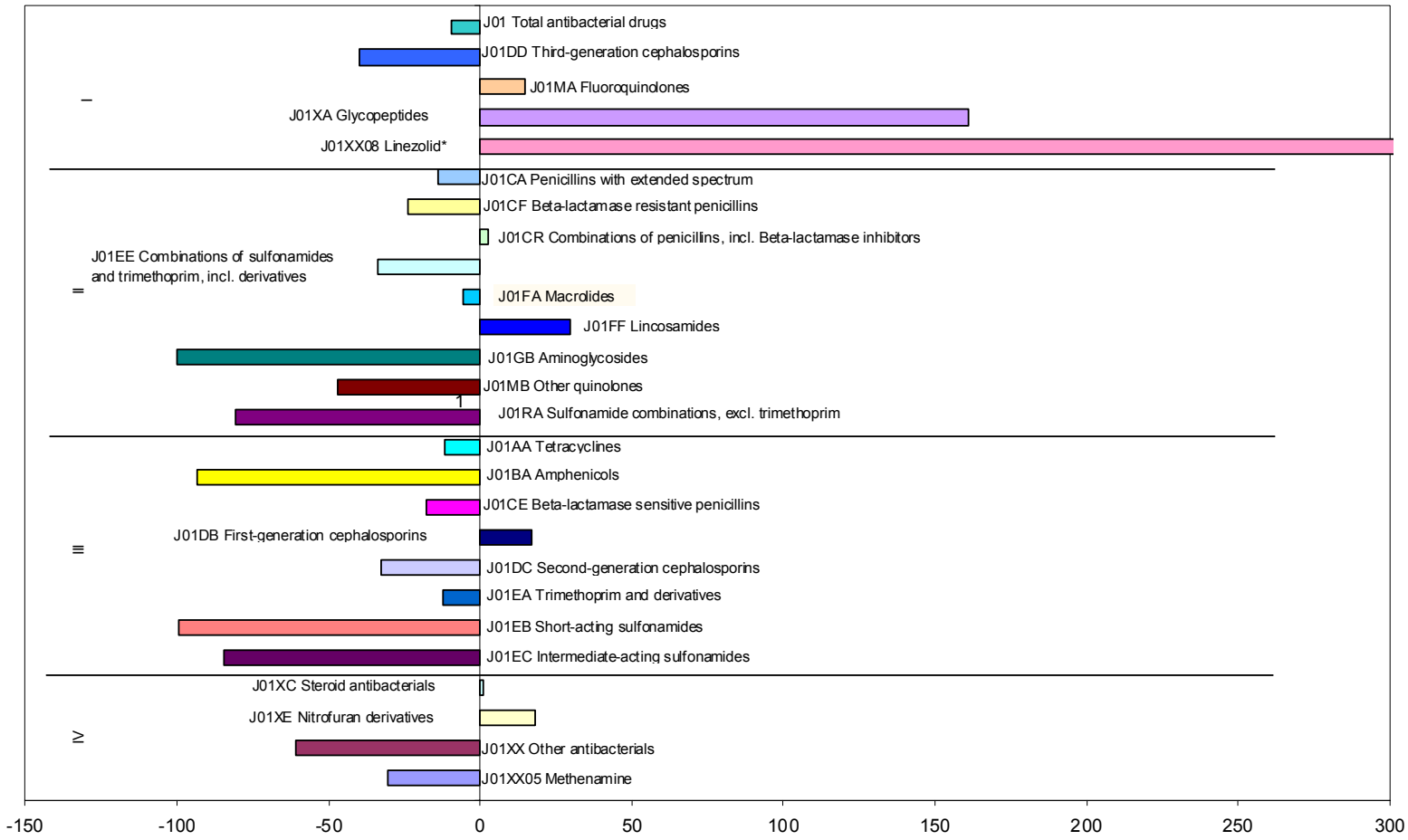

Figure 20. Percent difference between 2000 and 2004 of total DDDs per 1000-inhabitant-days per ATC classes, Canada.

** There was no prescription for J01XX08- Linezolid in 2000. Between 2001 and 2004, the consumption of linezolid increased by 928% from 0.0001 to 0.0012 DDDs/ 1000-inhabitant-days.*

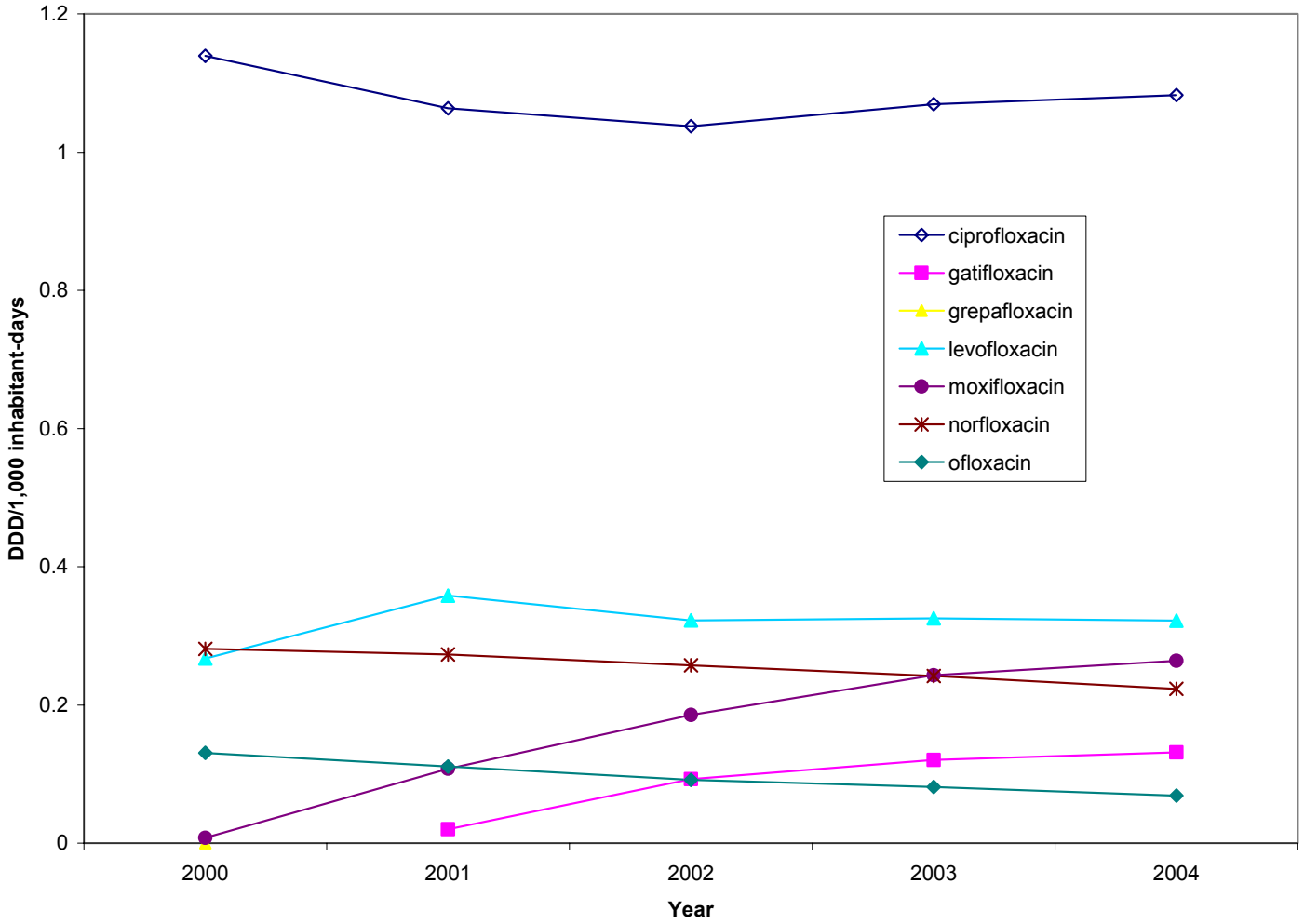

Figure 21. Consumption of oral fluoroquinolones in DDDs per 1000 inhabitant-days, Canada 2000-2004.

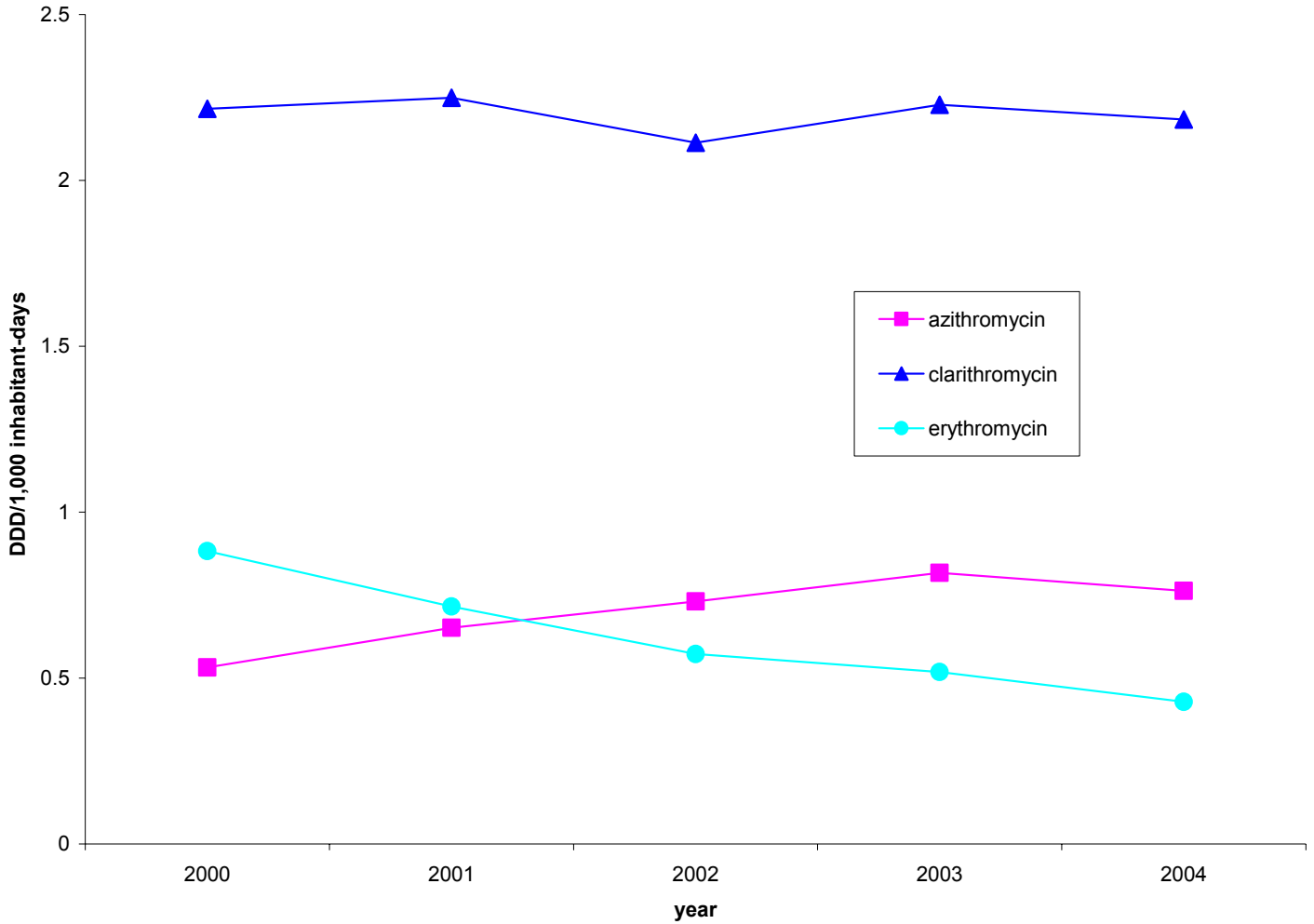

Figure 22. Consumption of oral macrolides in DDDs per 1000 inhabitant-days, Canada 2000-2004.

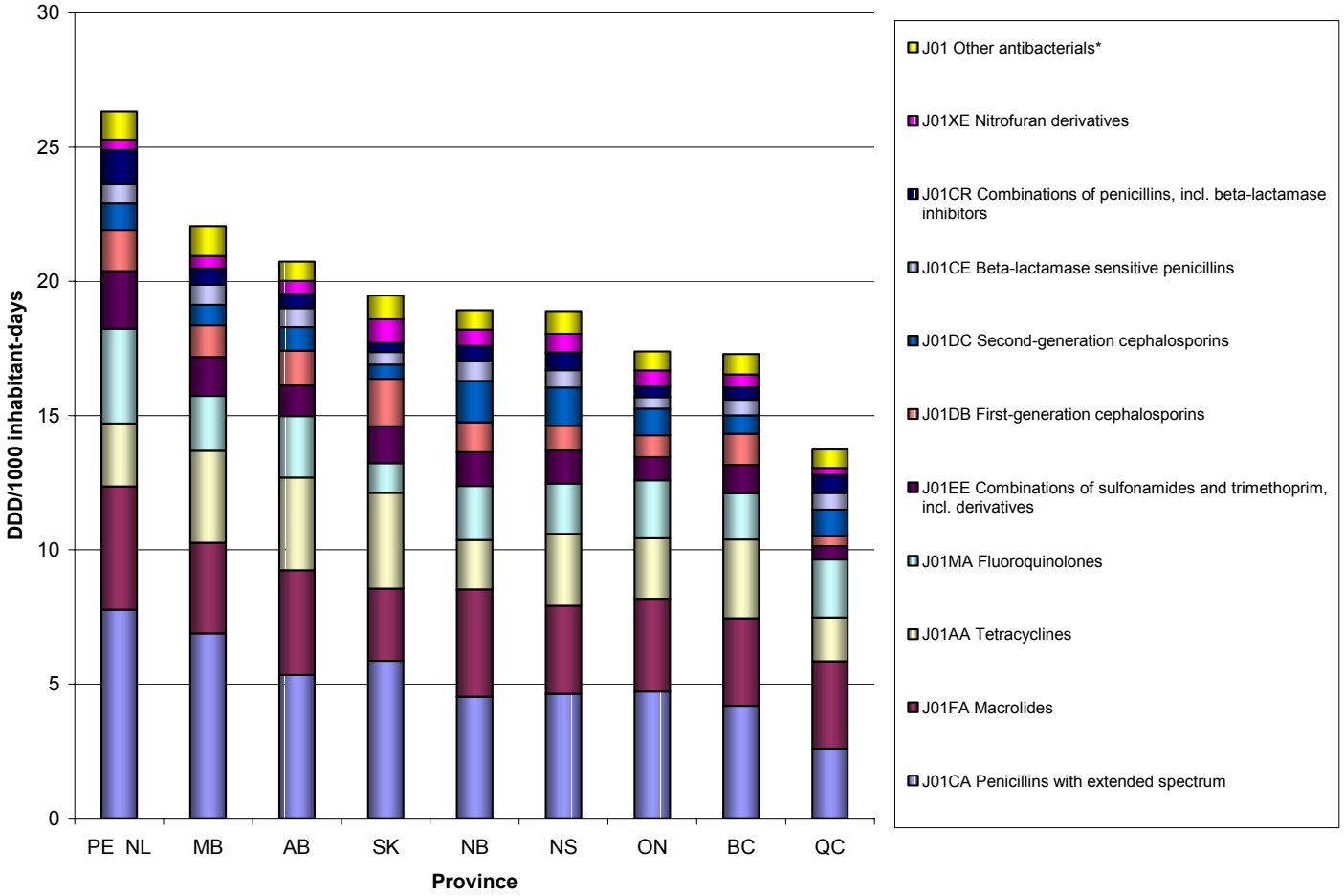

Figure 23. Antimicrobial consumption by province in Canada, 2004.

**Other antibacterials: J01BA-Amphenicols, J01CF- β-lactamase resistant penicillins, J01DD-Third-generation cephalosporins, J01EA-Trimethoprim and derivatives, J01EB-Short-acting sulfonamides, J01EC-Intermediate-acting sulfonamides, J01FF-Lincosamides, J01GB-Aminoglycosides, J01MB-Other quinolones, J01RA-Sulfonamide combinations (excl. trimethoprim), J01XA-Glycopeptides, J01XC-Steroid antibacterials, J01XX-Other antibacterials, J01XX05-Methenamine, J01XX08-Linezolid*

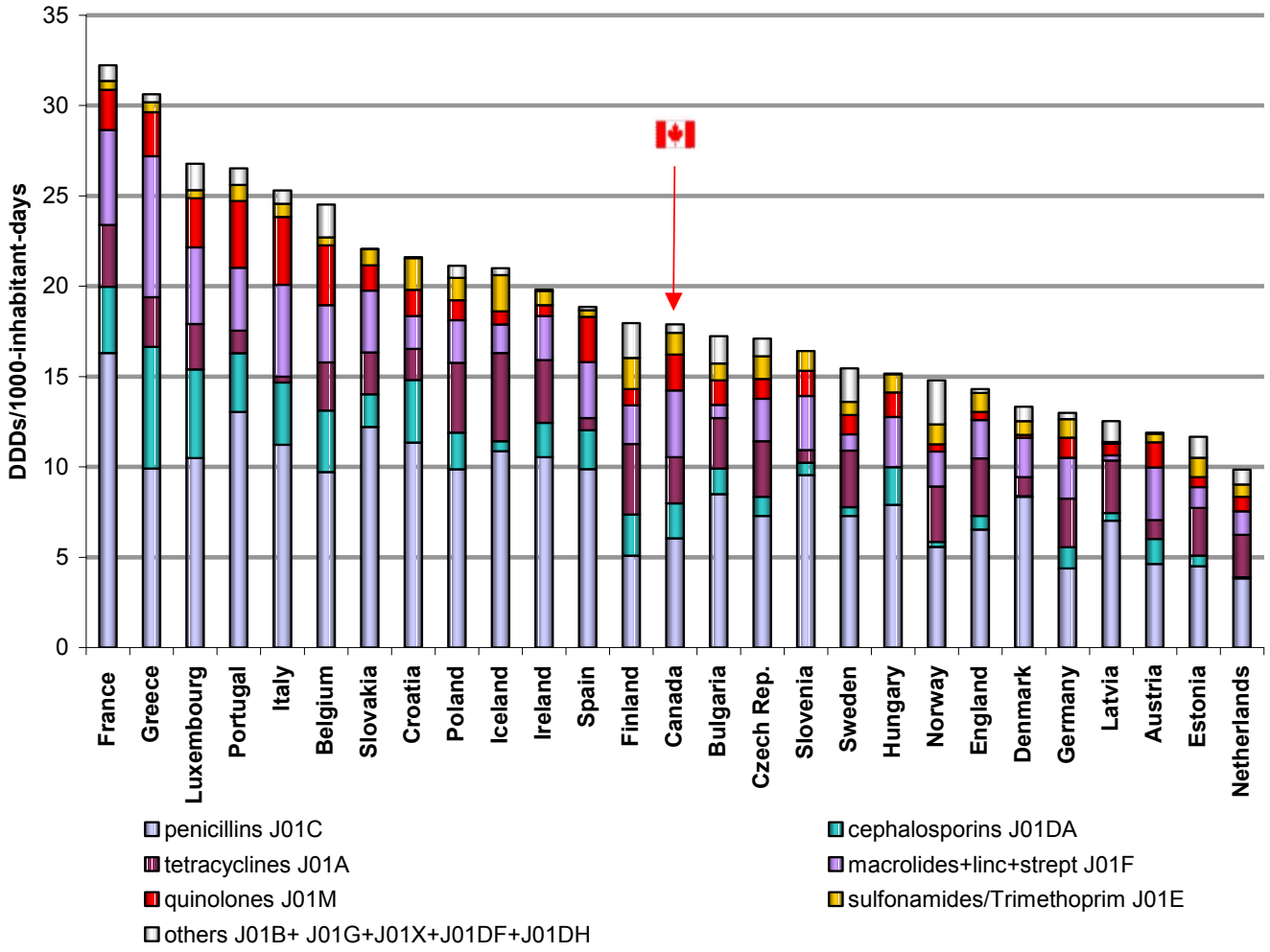

Figure 24. Total Outpatient Antibiotic Use in 26 European Countries (ESAC) and Total Oral Antibiotic Delivered by Retail Pharmacies in Canada in 2002

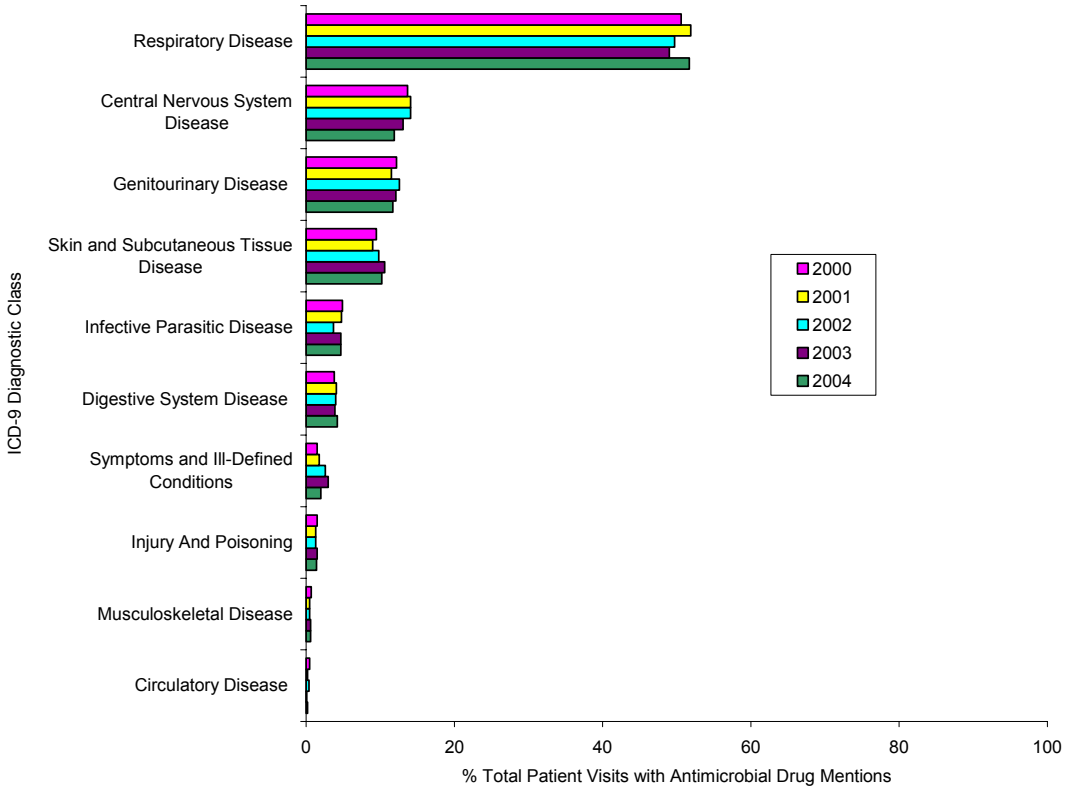

Figure 25. Percentage of patient visits to physicians with mention of antimicrobial therapy, by ICD-9 diagnostic class and year.

Note: The category for central nervous systems disease is largely comprised of otitis media cases (Table 53).

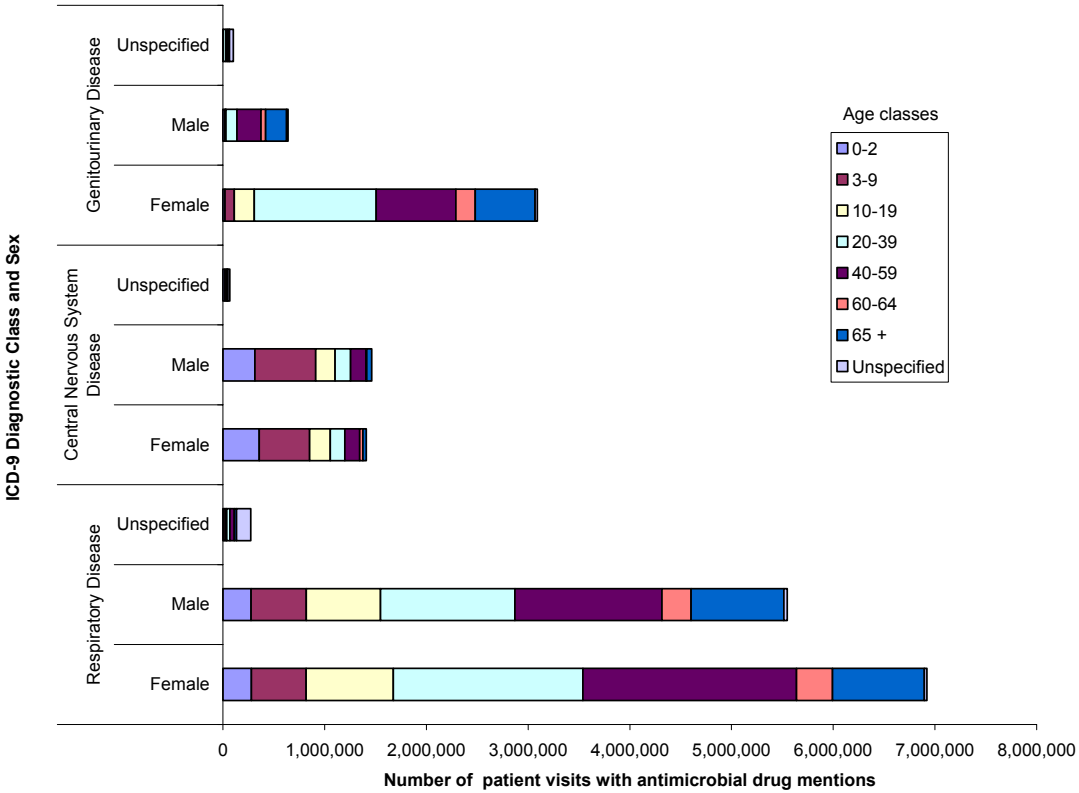

Figure 26. Number of patient visits with mention of an antimicrobial among the top three ICD-9 diagnostic classes, by sex and age class, CDTI data, Canada 2004.

Table 25. Number of visits with drug mentions by ICD-9 Diagnostic Class and IMS Antimicrobial Class, Canada 2000-2004.

ICD-9 Diagnostic class	2000 to 2004		2000		2001		2002		2003		2004	
IMS Antimicrobial class	n	%	n	%	n	%	n	%	n	%	n	%
Disease of respiratory system												
Macrolides extended spectrum	20,699,420	31.6	3,632,410	27.0	4,304,780	29.1	4,060,220	31.8	4,126,470	35.1	4,575,540	36.0
Amoxicillin	16,101,880	24.6	3,471,280	25.8	3,528,950	23.8	3,064,100	24.0	2,916,830	24.8	3,120,720	24.5
Cephalosporin	8,995,550	13.7	2,228,590	16.6	2,213,750	14.9	1,779,750	13.9	1,305,160	11.1	1,468,300	11.5
Quinolones oral	7,205,220	11.0	931,090	6.9	1,505,170	10.2	1,538,930	12.1	1,575,260	13.4	1,654,770	13.0
Penicillin other broad spectrum	3,804,010	5.8	779,220	5.8	881,050	5.9	714,440	5.6	731,390	6.2	697,910	5.5
Other antimicrobials	8,689,890	13.0	2,395,560	17.9	2,376,850	15.9	1,605,750	12.4	1,111,030	9.6	1,200,700	9.5
Total	65,495,970	100	13,438,150	100	14,810,550	100	12,763,190	100	11,766,140	100	12,717,940	100
Central nervous system total												
Amoxicillin	6,691,920	38.6	1,281,180	35.1	1,615,350	40.2	1,393,790	38.6	1,202,620	38.4	1,198,980	40.8
Cephalosporin	4,057,000	23.4	965,500	26.5	841,440	21.0	915,560	25.3	704,450	22.5	630,050	21.5
Macrolides extended spectrum	3,129,580	18.0	508,480	13.9	605,160	15.1	699,140	19.4	653,940	20.9	662,860	22.6
Penicillin other broad spectrum	1,548,560	8.9	380,250	10.4	401,690	10.0	239,210	6.6	318,370	10.2	209,040	7.1
Trimethoprim combinaisons	710,700	4.1	214,910	5.9	283,910	7.1	102,860	2.8	65,040	2.1	43,980	1.5
Other antimicrobials	1,208,660	6.8	297,320	8.2	267,160	6.7	261,610	7.1	190,460	6.1	192,110	6.7
Total	17,346,420	100	3,647,640	100	4,014,710	100	3,612,170	100	3,134,880	100	2,937,020	100
Disease of genitourinary system												
Quinolones oral	8,783,310	56.5	1,583,690	48.9	1,548,270	47.2	1,913,360	59.1	1,947,440	67.0	1,790,550	62.0
Trimethoprim combinaisons	3,974,790	25.6	1,025,970	31.7	1,101,600	33.6	775,790	24.0	469,190	16.1	602,240	20.9
Cephalosporin	883,100	5.7	206,780	6.4	179,880	5.5	185,560	5.7	155,400	5.3	155,480	5.4
Amoxicillin	609,120	3.9	144,420	4.5	121,140	3.7	139,870	4.3	114,270	3.9	89,420	3.1
Tetracycline congeners	233,460	1.5	51,060	1.6	62,450	1.9	42,630	1.3	39,540	1.4	37,780	1.3
Other antimicrobials	1,066,870	6.9	228,050	6.9	264,430	8.0	178,730	5.5	182,770	6.2	212,890	7.5
Total	15,550,650	100	3,239,970	100	3,277,770	100	3,235,940	100	2,908,610	100	2,888,360	100
Disease of skin/subcutaneous tissue												
Cephalosporin	3,425,850	27.1	692,200	27.5	663,070	25.9	675,730	27.0	657,280	25.9	737,570	29.5
Penicillin anti-Staph	2,605,120	20.6	543,280	21.5	518,190	20.2	442,990	17.7	594,070	23.4	506,590	20.3
Tetracycline congeners	2,165,390	17.2	452,670	18.0	386,530	15.1	446,930	17.8	432,710	17.1	446,550	17.9
Tetracycline	1,089,980	8.6	220,390	8.7	286,720	11.2	224,880	9.0	208,080	8.2	149,910	6.0
Other anti-infectious broad and medium spectrum	640,160	5.1	143,620	5.7	114,080	4.5	145,330	5.8	117,070	4.6	120,060	4.8
Other antimicrobials	2,697,390	21.3	469,200	18.6	593,560	23.1	570,650	22.8	526,370	20.6	537,610	21.6
Total	12,623,890	100	2,521,360	100	2,562,150	100	2,506,510	100	2,535,580	100	2,498,290	100
Other ICD-9 diagnostic classes												
Total	18,368,270		3,703,420		3,868,810		3,578,660		3,646,860		3,570,520	
All ICD-9 diagnostic classes												
Total	**129,385,200**		**26,550,540**		**28,533,990**		**25,696,470**		**23,992,070**		**24,612,130**	

Animal Antimicrobial Use

In Canada there is no existing mechanism by which comprehensive antimicrobial consumption data for food producing animals are collected, analysed, and reported. A program for monitoring antimicrobial use on farm is being developed, as a part of the CIPARS *On-Farm Surveillance*. Also, several provinces (e.g. British Columbia, Québec) are considering, or have implemented, programs to monitor antimicrobial use in various sectors of the antimicrobial drug distribution system.

In addition, the Canadian Animal Health Institute (CAHI) agreed to survey its members on the kilograms of active ingredient distributed in Canada. CAHI is a trade association representing companies that make and distribute drugs for companion, sporting, and food animals in Canada. CAHI estimates that its member sales represent over 90% of licensed product sales in the country. The data represent antimicrobial distribution by the CAHI member companies into various segments of the antimicrobial distribution system in a given year.

Thus, the data do not directly represent the use of antimicrobials in animals in a given calendar year. Although the amounts distributed should approximately correspond to the amounts consumed, especially over several years of reporting, some antimicrobials may be distributed but not used in the same calendar year because of the inherent time lag between distribution and use, as well as stockpiling at various points in the distribution system. Furthermore, the data does not reflect antimicrobials sold by nonCAHI members, product used under Health Canada's personal use provision or active pharmaceutical ingredients used in veterinary medicine.

The CAHI data were undergoing validation and review at the time of printing and will be made available on the Public Health Agency website later in 2006 (http://www.phac-aspc.gc.ca/cipars-picra/index.html).

Appendix A: Additional Information

A.1 Categorization of Antimicrobial Products Based on Importance in Human Medicine[1]

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

[1] *These categories were used in the 2003 CIPARS report and were originally taken from the Veterinary Drugs Directorate's draft Guidelines on the Microbiological Safety Studies for the Evaluation of Veterinary New Drug Submissions (Septmber 2003). In September 2005, VDD released revised guidelines that had several differences from the proposed guidelines CIPARS followed in 2003. These revised guidelines were not adopted for the 2004 CIPARS report because data analyses were completed by the time the guidelines were released. The 2005 CIPARS report will use the revised guidelines. Please direct comments in regards to these guidelines to VDD.*

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.

Table 26 and Table 27 outline human and livestock population demographics and general health care availability.

As specific demographic data were not available for all categories in 2004, 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 2003 and 2004, quantity of food produced, per capita consumption of the various commodities, imports and exports, and veterinary services are shown in Table 28 and Table 29.

Human Demographic Information

Table 26. Population demographics and health care availability.

	Post-censal population estimates Jan 1, 2004	Post-censal population estimates Jan 1, 2003[2]	change in 2004	Population density per square Km (2004)[3a]	Health care – summary of discharges (2003-2004)[4]	Number of physicians per 100,000 population (2004)[5,6]
Canada	31,788,635	31,475,999	0.99	3.50	3,083,545	189
British Columbia	4, 173,596	4,127,454	1.12	4.51	696,698	196
Alberta	3,179,066	3,132,484	1.49	4.95	350,830	185
Manitoba	1,164,962	1,158,360	0.57	2.10	145,581	177
Saskatchewan	994,443	994,905	-0.05	1.68	236,855	154
Ontario	12,312,421	12,156,595	1.28	13.42	1,129,775	177
Québec	7,516,950	7,462,432	0.73	5.51	NA	213
New Brunswick	750,741	750,439	0.04	10.51	156,302	168
Nova Scotia	937,220	935,180	0.22	17.57	197,717	213
Prince Edward Island	137,620	137,334	0.21	24.31	28,354	152
Newfoundland and Labrador	518,809	519,560	-0.14	1.39	125,456	192
Yukon Territory	30,927	30,569	1.17	0.07	4,413	195
Northwest Territories	42,629	41,630	2.40	0.04	9,025	119
Nunavut	29,251	29,057	0.67	0.02	2,539	24

1. Statistics Canada-The Daily. (2005), Demographic statistics - Canada's population. http://www.statcan.ca/Daily/English/040322/d040322e.htm and

http://www.statcan.ca/Daily/English/050324/d050324c.htm. *Accessed April 2005.*

2. Statistics Canada-The Daily. (2004). Demographic statistics - Canada's population. http://www.statcan.ca/Daily/English/040623/d040623b.htm, *Accessed April 2005.*

3. Population density per square km in 2004 was calculated based on the population January 1, 2004 and the land area in square kilometres reported in Statistics Canada, Census of Population Products http://www.statcan.ca/english/Pgdb/phys01.htm. *Accessed April 2005.*

4. Canadian Institute for Health Information. http://secure.cihi.ca/cihiweb/en/downloads/DAD_Background_Documentation_0304_e.pdf. *Accessed April 2005.*

5. Canadian Institute for Health Information. http://secure.cihi.ca/cihiweb/en/AR14_2002_tab5_e.html. *Accessed October 2005.*

6. British Columbia data in 2004 do not reflect the annual update from the College of Physicians and Surgeons of British Columbia.

Animal Demographic Information

Table 27. Canadian livestock–demographics, production, and per-capita consumption.

Farmed Species	Number of farms 2001	Number of animals Jan. 1, 2003	Number of animals Jan 1, 2004	Percentage change in 2004 [(2004-2003)/2003] *100	Product produced metric tonnes 2003	Per-capita consumption Kg/person 2004[12]
Cattle	122,066[1]	13,487,600[6]	14,660,000[6]	8.69	[6]cattle total cold dressed weight[b] = 1,148,705 [6]calves total cold dressed weight[b] = 41,544	beef = 13.62 veal = 0.52
beef cows	90,066[1]	4,752,100[6]	5,339,800[6]	12.37		
dairy cows	21,911[1]	1,065,300[6]	1,068,800[6]	0.33	[9]kilolitres milk and cream = 7,522,676	fluid milk = 63.22 (litres/person) cream[13] = 1.8 (litres/person) cheese = 8.81
heifers (≥1 year)	83,914[1]					
heifers for beef replacement	59,662[1]	648,300[6]	824,200[6]	27.13		
heifers for dairy replacement	20, 439[1]	512,000[6]	536,700[6]	4.82		
steers (≥>=1 year)	32,884[1]	1,178,600[6]	1,732,400[6]	46.99		
calves (<1 year)	110,397[1]	4,311,900[6]	5,695,800[6]	32.09		
bulls (≥1 year)	78,816[1]	239,400[6]	285,700[6]	19.34		
Swine	15,472[2]	14,671,900[7]	14,623,000[7]	-0.33	[7]total cold trimmed weight = 1,882,444[b]	pork = 11.60
sows and bred gilts	8,542[2]	1,526,700[7]	1,578,100[7]	3.37		
boars	7,615[2]	41,700[7, a]	39,200[7]	-6.00		
pigs < 20Kg		4,345,200[7]	4,548,000[7]	4.67		
20-60Kg		4,430,400[7]	4,266,700[7]	-3.69		
pigs > 60Kg		4,327,900[7]	4,191,000[7]	-3.16		
Poultry					poultry meat[10] = 1,100,000	poultry meat = 13.51
hens and chickens	26,484[3]	*2001 data* 126,159,529[3]			eggs[10] = 576,500,000 dozen	eggs 12.76 dozen/person
broilers, roasters, and Cornish hens	10,875[3]	*2001 data* 87,437,798[3]				chicken meat = 10.73 stewing hens = 0.61
turkeys	4,176[3]	*2001 data* 8,115,942[3]			turkey meat[10] = 147,800, 000 Kg	turkey meat = 2.18

Farmed Species	Number of farms 2001	Number of animals Jan. 1, 2003	Number of animals Jan 1, 2004	Percentage change in 2004 [(2004-2003)/2003]	Product produced metric tonnes 2003	Per-capita consumption Kg/person 2004[12]
Ovine	13,232[4]	975,600[8]	997,000[8]	2.19	total cold dressed weight[8] = 16,325[b]	mutton/lamb meat = 0.46
ewes	12,510[4]	612,800[8]	622,200[8]	1.53		
rams	9, 926[4]	28,800[8]	27,700[8]	-3.82		
replacement lambs		96,000[8]	94,000[8]	-2.08		
market lambs		238,000[8]	253,100[8]	6.34		
Fish[14]						fish meat[14] = 6.88
salmon trout steelhead	*2001 data* salmon[5] =300 trout[5] =900				salmon[11] = 105,050[c] trout[11] = 5,661[c] steelhead[11] = 1,150[c] all shellfish[11] = 35,521[c]	fresh and frozen seafish[14] = 2.89 freshwater[14] = 0.31 processed seafish[14] = 2.45 shellfish[14] = 1.23

1. Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95F0301XIE/tables/html/Table19Can.htm. *Accessed April 2005.*

2. Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95F0301XIE/tables/html/Table20Can.htm. *Accessed April 2005.*

3. Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95F0301XIE/tables/html/Table23Can.htm. *Accessed April 2005.*

4. Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95F0301XIE/tables/html/Table21Can.htm. *Accessed April 2005.*

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-XIE2004002.pdf. *Accessed April 2005.*

7. Statistics Canada, Census of Agriculture- Cat. No. 23-010-XIE. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2005001.pdf. *Accessed April 2005.*

8. Statistics Canada, Census of Agriculture- Cat. No. 23-011-XIE. http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2004002.pdf. *Accessed April 2005.*

9. Statistics Canada. (2005). Milk production and utilization, computed annual total Kilolitres-CANSIM (Table 003-0011). http://cansim2.statcan.ca/CII/Dir/0030011_E.htm. *Accessed May 2005*

10. Statistics Canada, The Daily- Production of Poultry and Eggs. http://www.statcan.ca/Daily/English/040526/d040526f.htm. *Accessed April 2005.*

11. Statistics Canada, Aquaculture Statistics- Cat. No. 23-222-XIE. http://www.statcan.ca/english/freepub/23-222-XIE/23-222-XIE2003000.pdf. *Accessed April 2005.*

12. Statistics Canada , Food Statistics- Cat. No. 21-020-XIE. http://www.statcan.ca/english/freepub/21-020-XIE/21-020-XIE2004001.pdf. *Accessed October 2005.*

13. Statistics Canada, Food Consumption in Canada 2003. http://www.statcan.ca/english/ads/23F0001XCB/highlight.htm. *Accessed May 2005.*

14. Fish consumption statistics were not available for 2004, as a result statistics shown here are from the 2003 Food Statistic report.

a. Boars ≥6months.

b. Not including edible offal.

c.Excludes confidential data.

Table 28. The number of births, slaughtered animals, international imports and exports, and on-farm deaths of Canadian cattle, swine and ovine in 2004.

	Cattle[1]	Swine[2]	Ovine[3]
Births	5,571,000	33,125,000 [b]	894,700
Slaughter	4,439,600	22,888,700	781,900
% change of slaughter in 2004[a]	25.69%	1.90%	6.93%
International imports	10,500	6,100	500
% change of imports in 2004 [a]	-81.77%	41.86%	25.00%
International exports	0	8,555,400	0
% change of exports in 2004 [a]	-100.00%	14.95%	-100.00%
Deaths and condemnations	711,900	1,635,000	130,000
% change of deaths and condemnations 2004/2003 [a]	12.09%	4.86%	2.44%

Note: Statistics from the 2003 CIPARS report are slightly different that those reported here. These changes were made to reflect updates in the 2004 Census of Agriculture report.

1 Statistics Canada, Census of Agriculture- Cat. No. 23-012-XIE. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2004002.pdf *Accessed June 2005; 2 Statistics Canada, Census of Agriculture- Cat. No. 23-010-XIE.* http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2005001.pdf *Accessed June 2005; 3 Statistics Canada, Census of Agriculture- Cat. No. 23-011-XIE.* http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2004002.pdf *Accessed June 2005.*

*a Percent change was calculated by [(2004-2003)/2003]*100*

b Number of pigs born during the quarter that were either on hand at the end of the quarter or had been sold

Table 29. Veterinary services in Canada, 2004.

Province	Total # veterinary practices	Total # large animal practices
Alberta	330	195
British Columbia	442	155
Manitoba	104	66
North West Territories	1	0
New Brunswick	56	18
Nova Scotia	74	42
Newfoundland	14	3
Ontario	1101	428
Prince Edward Island	13	11
Québec	505	157
Saskatchewan	118	85
Yukon	2	1

Note: Large animal practices included any practices that had a large animal component.

Source: Email correspondence, June 2005, with Canadian Veterinary Medical Association.

A.3 Human Antimicrobial Resistance

Table 30. Details regarding human *Salmonella* isolates from Enhanced Passive Surveillance for 2004 (N=3147).

Gender n/N (%)	Age distribution n/N (%)	Province n/N (%)
Male: 1462 /3147 (46%)	Less than 5 years: 479/3147 (15%)	British Columbia: 403/3147 (11%)
Female: 1460 /3147 (46%)	5 to 12 years: 355/3147 (11%)	Alberta: 334/3147 (11%)
Unknown: 225/3147 (7%)	13 to 17 years: 166/3147 (5%)	Saskatchewan: 132/3147 (4%)
	18 to 29 years: 538/3147 (17%)	Manitoba: 172/3147 (5%)
	30 to 49 years: 722/3147 (23%)	Ontario: 1291/3147 (41%)
	50 to 69 years: 467/3147 (15%)	Québec: 497/3147 (16%)
	70+ years: 234/3147 (7%)	New Brunswick: 157/3147 (5%)
		Nova Scotia: 112/3147 (4%)
		Prince Edward Island: 17/3147 (<1%)
		Newfoundland and Labrador: 31/3147 (1%)
		Nunavut: 1/3147 (<1%)

Table 31. Details regarding specimen source of the main human serovars.

Specimen source	Enteritidis N=550 n (%)	Heidelberg N=559 n (%)	Newport n (%)	Typhi N=125 n (%)	Typhimurium N=597 n (%)	Other serovars N=1163 n (%)	Total N=3147 n (%)
Stool	419 (77)	349 (62)	112 (73)	29 (23)	448 (75)	743 (64)	2100 (64)
Blood	10 (2)	45 (8)	4 (3)	59 (47)	9 (2)	62 (5)	189 (6)
Urine	5 (1)	15 (3)	5 (3)	2 (2)	5 (<1)	70 (6)	102 (3)
Aspirate	1 (<1)						1 (<1)
Swab	1 (<1)		1 (<1)		1 (<1)	1 (<1)	4 (<1)
Fluid				1 (<1)	1 (<1)		2 (<1)
Anatomy						3 (<1)	3 (<1)
Abscess/Tissue					1 (<1)	1 (<1)	2 (<1)
Unknown	114 (21)	150 (27)	31 (26)	34 (27)	132 (22)	283 (24)	744 (24)

Table 32. Distribution of MICs and resistance in *Salmonella* recovered from humans, *Enhanced Passive Surveillance* 2004.

*	Antimicrobial	Serovar	n	MIC Percentiles		%R	Distribution (%) of MICs																
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
	Ceftiofur	Enteritidis	550	0.5	1	0.4				0.4	0.7	80.4	17.6	0.5			0.4						
	Ceftiofur	Heidelberg	559	0.5	>8	32.7				0.2	0.2	62.3	3.9	0.4	0.4	0.7	32						
	Ceftiofur	Newport	153	0.5	2	9.2						86.9	2.6	1.3		0.7	8.5						
	Ceftiofur	Typhi	125	0.5	0.5	0				0.8	28.8	67.2	3.2										
	Ceftiofur	Typhimurium	597	0.5	1	1.5					0.2	80.9	16.1	1.2	0.2	0.2	1.3						
	Ceftiofur	Other serovars	1163	0.5	1	1.7				0.2	0.6	80.1	17	0.3	0.2	0.3	1.4						
	Ceftriaxone	Enteritidis	550	≤0.25	≤0.25	0					98.7	0.5		0.2		0.2	0.2	0.2					
	Ceftriaxone	Heidelberg	559	≤0.25	16	0.9					65.7	0.9		0.5	0.5	5.9	21.5	4.1	0.9				
I	Ceftriaxone	Newport	153	≤0.25	≤0.25	2					90.8						2	5.2	1.3	0.7			
	Ceftriaxone	Typhi	125	≤0.25	≤0.25	0					100												
	Ceftriaxone	Typhimurium	597	≤0.25	≤0.25	0.3					97.8	0.8			0.2	0.2	0.5	0.2	0.3				
	Ceftriaxone	Other serovars	1163	≤0.25	≤0.25	0.2					98	0.2	0.1		0.2	0.2	1	0.2	0.1	0.1			
	Ciprofloxacin	Enteritidis	550	≤0.015	0.12	0	75.3	1.8	0.9	18.5	3.5												
	Ciprofloxacin	Heidelberg	559	≤0.015	≤0.015	0	97.1	1.8	0.4	0.5	0.2												
	Ciprofloxacin	Newport	153	≤0.015	≤0.015	0	98			1.3	0.7												
	Ciprofloxacin	Typhi	125	0.12	0.25	0	35.2		9.6	19.2	36												
	Ciprofloxacin	Typhimurium	597	≤0.015	≤0.015	0.2	96.8	1.3	0.5	0.7	0.2	0.2	0.2			0.2							
	Ciprofloxacin	Other serovars	1163	≤0.015	0.03	0.1	89.3	2.1	0.1	2	3.5	3			0.1								
	Amikacin	Enteritidis	550	1	1	0						29,1	60,9	9,5	0,2	0,4							
	Amikacin	Heidelberg	559	1	2	0						6.1	75.7	15.7	2.3	0.2							
	Amikacin	Newport	153	1	2	0						2.6	73.9	22.2	0.7	0.7							
	Amikacin	Typhi	125	1	1	0						23.2	73.6	2.4	0.8								
	Amikacin	Typhimurium	597	1	2	0						0.8	69.3	23.6	5.7	0.5							
	Amikacin	Other serovars	1163	1	2	0.1						6.4	67.2	24.3	1.7	0.3				0.1			
	Amoxicillin-clavulanic acid	Enteritidis	550	≤1	≤1	0.7							92.2	3.8	0.4	2.5	0.4	0.5	0.2				
	Amoxicillin-clavulanic acid	Heidelberg	559	≤1	>32	32.2							52.1	2.5	0.4	5.5	7.3	14.1	18.1				
	Amoxicillin-clavulanic acid	Newport	153	≤1	8	9.2							87.6	1.3	0.7	1.3		3.3	5.9				
	Amoxicillin-clavulanic acid	Typhi	125	≤1	8	0							83.2		5.6	11.2							
	Amoxicillin-clavulanic acid	Typhimurium	597	≤1	16	2.4							60.3	2.2	0.7	13.2	21.3	1.2	1.2				
	Amoxicillin-clavulanic acid	Other serovars	1163	≤1	2	1.6							86.2	5.4	0.9	3.4	2.4	0.6	1				
	Gentamicin	Enteritidis	550	≤0.25	0.5	0.6					84.7	12.7	0.9	0.2		0.9	0.4	0.2					
	Gentamicin	Heidelberg	559	≤0.25	0.5	1.3					69.9	24.2	3.6	0.5	0.4	0.2	0.9	0.4					
II	Gentamicin	Newport	153	≤0.25	0.5	1.4					66	30.1	2	0.7			0.7	0.7					
	Gentamicin	Typhi	125	≤0.25	≤0.25	0					95.2	4		0.8									
	Gentamicin	Typhimurium	597	0.5	1	2.3																	
	Gentamicin	Other serovars	1163	≤0.25	0.5	1.7					60.8	32.9	3.4	0.7	0.1	0.4	1	0.7					
	Kanamycin	Enteritidis	550	≤8	≤8	0.4										99.6			0.4				
	Kanamycin	Heidelberg	559	≤8	≤8	1.1										98.4	0.5		0.2	0.9			
	Kanamycin	Newport	153	≤8	≤8	2										97.4	0.7		0.7	1.3			
	Kanamycin	Typhi	125	≤8	≤8	0.8										99.2				0.8			
	Kanamycin	Typhimurium	597	≤8	>64	18.8										80.6	0.5	0.2		18.8			
	Kanamycin	Other serovars	1163	≤8	≤8	2.2										97.1	0.4	0.3		2.2			
	Nalidixic Acid	Enteritidis	550	4	>32	22.6							0.2	5.6	68.5	2.4	0.7	0.2	22.4				
	Nalidixic Acid	Heidelberg	559	4	8	1.3								0.5	88.6	9.7		0.2	1.1				
	Nalidixic Acid	Newport	153	4	4	1.3								24.2	71.9	2	0.7		1.3				
	Nalidixic Acid	Typhi	125	>32	>32	56.8							0.8	27.2	12	3.2		0.8	56				
	Nalidixic Acid	Typhimurium	597	4	4	1.3								22.6	72.7	2.8	0.5	0.3	1				
	Nalidixic Acid	Other serovars	1163	4	8	8.4						0.1	0.1	21.3	65.9	3.4	0.8	0.7	7.7				

*	Antimicrobial	Serovar	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
	Streptomycin	Enteritidis	550	≤32	≤32	4												96	2	2			
	Streptomycin	Heidelberg	559	≤32	≤32	8.4												91.6	2.1	6.3			
	Streptomycin	Newport	153	≤32	>64	11.8												88.2		11.8			
	Streptomycin	Typhi	125	≤32	>64	16												84	0.8	15.2			
	Streptomycin	Typhimurium	597	≤32	>64	35.2												64.8	20.6	14.6			
	Streptomycin	Other serovars	1163	≤32	64	11.6												88.4	6.6	5			
II	Sulphamethoxazole	Enteritidis	550	≤0.12	0.25	1.1				83.5	14.5	0.9			0.2	0.9							
	Sulphamethoxazole	Heidelberg	559	≤0.12	0.25	1.3				83.2	14.7	0.5		0.4		1.3							
	Sulphamethoxazole	Newport	153	≤0.12	0.25	1.3				79.7	19					1.3							
	Sulphamethoxazole	Typhi	125	≤0.12	>4	16				77.6	6.4					16							
	Sulphamethoxazole	Typhimurium	597	≤0.12	0.25	7.1				54.4	36.7	1.7	0.2		0.2	6.9							
	Sulphamethoxazole	Other serovars	1163	≤0.12	0.25	3.1				78.1	17.9	0.9				3.1							
	Ampicillin	Enteritidis	550	≤1	2	3.8							64	29.5	2.2	0.4	0.2	0.2	3.6				
	Ampicillin	Heidelberg	559	2	>32	45.1							27.9	24.7	1.6	0.5	0.2		45.1				
	Ampicillin	Newport	153	≤1	>32	11.1							64.7	23.5	0.7				11.1				
	Ampicillin	Typhi	125	≤1	>32	16							66.4	16.8	0.8				16				
	Ampicillin	Typhimurium	597	2	>32	37.3							41.5	19.4	1.2	0.2	0.3	0.3	37				
	Ampicillin	Other serovars	1163	≤1	4	7.9							63.3	24.9	3	0.8	0.1	0.1	7.8				
	Cefoxitin	Enteritidis	550	2	2	0.2							20.5	73.6	4	1.1	0.5	0.2					
	Cefoxitin	Heidelberg	559	2	>16	31.5							43.1	21.5	2.7	0.4	0.9	27.2	4.3				
	Cefoxitin	Newport	153	2	4	9.2							27.5	60.1	3.3			7.2	2				
	Cefoxitin	Typhi	125	4	4	0						1.6	42.4	4	47.2	4.8							
	Cefoxitin	Typhimurium	597	2	4	1.3							16.8	72.4	7.2	1.8	0.5	0.8	0.5				
	Cefoxitin	Other serovars	1163	2	4	1.4						0.3	23.4	45.7	26.7	2.1	0.3	1.1	0.3				
	Cephalothin	Enteritidis	180	≤2	4	1.7								83.9	12.2	1.7	0.6		1.7				
	Cephalothin	Heidelberg	137	4	>32	34.3								41.6	8.8	2.9	12.4	2.9	31.4				
	Cephalothin	Newport	25	≤2	>32	24								68	8				24				
	Cephalothin	Typhi	30	≤2	8	0								70	16.7	10	3.3						
	Cephalothin	Typhimurium	131	≤2	8	4.6								55	30.5	9.9		2.3	2.3				
III	Cephalothin	Other serovars	280	≤2	4	2.5								71.4	22.1	2.5	1.4	0.4	2.1				
	Chloramphenicol	Enteritidis	550	4	8	1.5								0.4	57.3	40.4	0.5	0.2	1.3				
	Chloramphenicol	Heidelberg	559	8	8	4.3									20.9	73.7	1.1	0.2	4.1				
	Chloramphenicol	Newport	153	4	>32	10.5									77.8	11.8			10.5				
	Chloramphenicol	Typhi	125	4	>32	16								1.6	79.2	3.2			16				
	Chloramphenicol	Typhimurium	597	8	>32	29.8								0.8	44.4	24.3	0.7	0.2	29.6				
	Chloramphenicol	Other serovars	1163	8	8	3.7								1	48.4	45.1	1.7	0.2	3.5				
	Sulphamethoxazole	Enteritidis	550	32	64	4.5											37.1	49.1	9.1		0.2	2.9	1.6
	Sulphamethoxazole	Heidelberg	559	32	64	7.5											37.7	51.7	3			3.6	3.9
	Sulphamethoxazole	Newport	153	64	512	11.7											15	24.8	46.4	0.7	1.3	6.5	5.2
	Sulphamethoxazole	Typhi	125	≤16	512	16											52	24	5.6	2.4		12.8	3.2
	Sulphamethoxazole	Typhimurium	597	32	>512	40.9											12.9	44.1	1.5	0.7		28.3	12.6
	Sulphamethoxazole	Other serovars	1163	32	128	9.7											32.5	40.4	16.6	0.6	0.2	6.3	3.4
	Tetracycline	Enteritidis	550	≤4	≤ 4	4.5									94.5	0.9	0.2	0.5	3.8				
	Tetracycline	Heidelberg	559	≤4	>32	15.9									83.7	0.4	0.9	1.6	13.4				
	Tetracycline	Newport	153	≤4	32	12.5									85.6	2	0.7	2	9.8				
	Tetracycline	Typhi	125	≤4	>32	15.2									84.8				15.2				
	Tetracycline	Typhimurium	597	≤4	>32	41.3									57.1	1.5	17.6	7.5	16.2				
	Tetracycline	Other serovars	1163	≤4	32	18.5									80.2	1.3	2.3	7.5	8.7				
IV																							

2002 and 2004 NARMS Sensititre plate (refer to material and method for ranges). Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

A.4 Agri-Food Antimicrobial Resistance

Table 33. Distribution of MICs and resistance in generic *E. coli* recovered from beef cattle; *Abattoir Surveillance* 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs																
			MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.50	1	2	4	8	16	32	64	128	256	512	>512
I	Ceftiofur	167	0.25	0.5	1.2				6.0	62.3	28.7	1.2		0.6	**1.2**							
	Ceftriaxone	167	≤0.25	≤0.25	0					97.6	0.6	0.6			1.2							
	Ciprofloxacin	167	≤0.015	≤0.015	0.6	97.6	1.8								**0.6**							
II	Amikacin	167	2	2	0							41.9	52.7	4.8	0.6							
	Amoxicillin-clavulanic acid	167	4	8	1.8							4.8	28.7	56.3	8.4		**1.2**	**0.6**				
	Gentamicin	167	0.5	1	0.6					12.6	54.5	29.9	0.6		1.8		**0.6**					
	Kanamycin	167	≤8	≤8	1.8										94.6	1.8	1.8		**1.8**			
	Nalidixic Acid	167	2	4	0.6							2.4	61.7	35.3				**0.6**				
	Streptomycin	167	≤32	64	10.2												89.8	7.2	3.0			
	Trimethoprim-sulphamethoxazole	167	≤0.12	≤0.12	1.2				91.0	5.4	1.8	0.6			**1.2**							
III	Ampicillin	167	4	4	6.6							6.0	37.7	47.3	2.4			**6.6**				
	Cefoxitin	167	4	8	2.4							1.2	18.6	53.3	19.8	4.8	**2.4**					
	Cephalothin	167	8	16	6.6								3.6	9.6	53.9	26.3	**2.4**	**4.2**				
	Chloramphenicol	167	8	8	1.8								1.8	30.5	62.3	3.6	**0.6**	**1.2**				
	Sulphamethoxazole	167	≤16	>512	12.6											77.2	7.8	2.4				**12.6**
	Tetracycline	167	≤4	>32	24.6									74.3	1.2	**6.0**	**1.8**	**16.8**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 34. Distribution of MICs and resistance in generic *E. coli* recovered from swine; *Abattoir Surveillance* 2004.

I	Ceftiofur	142	0.25	0.5	0				5.6	68.3	26.1											
	Ceftriaxone	142	≤0.25	≤0.25	0					97.9	0.7		1.4									
	Ciprofloxacin	142	≤0.015	≤0.015	0	99.3	0.7															
II	Amikacin	142	2	4	0						0.7	30.3	58.5	10.6								
	Amoxicillin-clavulanic acid	142	4	8	0							2.1	34.5	33.8	26.8	2.8						
	Gentamicin	142	0.5	1	0.7					7.0	57.0	33.8	0.7		0.7	**0.7**						
	Kanamycin	142	≤8	>64	13.4										83.1	2.1	1.4	**0.7**	**12.7**			
	Nalidixic Acid	142	2	4	0							1.4	68.3	30.3								
	Streptomycin	142	≤32	>64	39.4												60.6	**17.6**	**21.8**			
	Trimethoprim-sulphamethoxazole	142	≤0.12	0.5	4.9				60.6	18.3	12.7	2.1	1.4		**4.9**							
III	Ampicillin	142	4	>32	30.3							3.5	33.1	28.9	3.5	0.7		**30.3**				
	Cefoxitin	142	4	8	1.4								22.5	59.9	15.5	0.7	**1.4**					
	Cephalothin	142	8	16	4.2								2.8	21.1	47.2	24.6	**3.5**	**0.7**				
	Chloramphenicol	142	8	32	13.4								2.1	28.2	50.0	6.3	**9.9**	**3.5**				
	Sulphamethoxazole	142	32	>512	43.0											44.4	7.7	4.9				**43.0**
	Tetracycline	142	>32	>32	71.1									28.2	0.7	**1.4**	**2.1**	**67.6**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 35. Distribution of MICs and resistance in *Salmonella* recovered from swine; *Abattoir Surveillance* 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs																
			MIC_{50}	MIC_{90}		≤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	270	1	1	0				0.4	1.1	48.1	44.1	6.3									
	Ceftriaxone	270	≤ 0.25	≤ 0.25	0					100												
	Ciprofloxacin	270	≤ 0.015	0.03	0	81.5	15.2	3.3														
II	Amikacin	270	1	2	0						16.3	49.3	31.9	2.2	0.4							
	Amoxicillin-clavulanic acid	270	≤ 1	8	0.4							76.3	10.4	1.1	3.3	8.5	**0.4**					
	Gentamicin	270	≤ 0.25	1	2.2					62.6	8.1	26.7	0.4			**1.5**	**0.7**					
	Kanamycin	270	≤ 8	≤8	9.3										90.0	0.7		**0.7**	**8.5**			
	Nalidixic Acid	270	4	8	0						0.4		7.8	78.5	12.2	1.1						
	Streptomycin	270	≤ 32	>64	25.9												74.1	**10.7**	**15.2**			
	Trimethoprim-sulphamethoxazole	270	≤ 0.12	0.5	4.8				70.4	18.9	5.9				**4.8**							
III	Ampicillin	270	≤ 1	>32	12.6							61.1	20.0	6.3				**12.6**				
	Cefoxitin	270	4	8	0.7							8.1	40.0	36.7	10.7	3.7	**0.7**					
	Cephalothin	270	4	8	0.4								42.2	40.7	14.1	2.6	**0.4**					
	Chloramphenicol	270	8	>32	13.0								2.2	22.6	51.9	10.4	**1.1**	**11.9**				
	Sulphamethoxazole	270	64	> 512	28.1											14.8	20.7	30.4	4.4	1.5		**28.1**
	Tetracycline	270	≤ 4	>32	41.9									57.4	0.7	**3.0**	**5.9**	**33.0**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 36. Distribution of MICs and resistance in generic *E. coli* recovered from broiler chickens; *Abattoir Surveillance* 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs															
			MIC_{50}	MIC_{90}		≤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	130	0.5	>8	25.4				3.8	39.2	25.4	3.1		3.1	**10.8**	**14.6**						
	Ceftriaxone	130	≤0.25	16	0.8					68.5	2.3	0.8		1.5	9.2	15.4	1.5	**0.8**				
	Ciprofloxacin	130	≤0.015	≤0.015	0	92.3	4.6	0.8	0.8	1.5												
II	Amikacin	130	2	4	0						3.1	24.6	58.5	13.8								
	Amoxicillin-clavulanic acid	130	4	>32	31.5							3.1	20.8	34.6	8.5	1.5	**17.7**	**13.8**				
	Gentamicin	130	0.5	16	11.6					7.7	45.4	33.8		0.8	0.8	**3.1**	**8.5**					
	Kanamycin	130	≤8	>64	17.7										75.4	6.2	0.8	**1.5**	**16.2**			
	Nalidixic Acid	130	2	4	3.1							3.8	63.8	29.2			**0.8**	**2.3**				
	Streptomycin	130	64	>64	53.0												46.9	**19.2**	**33.8**			
	Trimethoprim-sulphamethoxazole	130	≤0.12	4	11.5				62.3	13.1	10.0	1.5	1.5	**1.5**	**10.0**							
III	Ampicillin	130	4	>32	42.3							6.2	20.0	27.7	3.1	0.8		**42.3**				
	Cefoxitin	130	8	>16	32.3								9.2	34.6	23.1	0.8	**32.3**					
	Cephalothin	130	16	>32	33.8								1.5	10.8	28.5	25.4	**1.5**	**32.3**				
	Chloramphenicol	130	8	16	6.9								0.8	33.1	54.6	4.6		**6.9**				
	Sulphamethoxazole	130	32	>512	41.5											41.5	12.3	4.6				**41.5**
	Tetracycline	130	>32	>32	56.2									43.1	0.8		**3.8**	**52.3**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 37. Distribution of MICs and resistance in *Salmonella* recovered from broiler chickens; *Abattoir Surveillance* 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs															
			MIC_{50}	MIC_{90}		≤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	142	0.5	>8	21.8					2.1	61.3	13.4	1.4			**21.8**						
	Ceftriaxone	142	≤0.25	16	0.7					78.2					7.7	9.9	3.5	**0.7**				
	Ciprofloxacin	142	≤0.015	≤0.015	0	90.8	7.7	1.4														
II	Amikacin	142	1	2	0						24.6	58.5	16.2		0.7							
	Amoxicillin-clavulanic Acid	142	≤1	>32	21.1							69.7	2.8	1.4	1.4	3.5	**2.1**	**19.0**				
	Gentamicin	142	≤0.25	1	1.4					81.0	4.2	12.7	0.7			**0.7**	**0.7**					
	Kanamycin	142	≤8	≤8	1.4										97.9	0.7			**1.4**			
	Nalidixic Acid	142	4	4	0								17.6	74.6	7.7							
	Streptomycin	142	≤32	64	12.0												88.0	**8.5**	**3.5**			
	Trimethoprim-sulphamethoxazole	142	≤0.12	≤0.12	0				93.0	7.0												
III	Ampicillin	142	≤1	>32	27.5							63.4	7.7	1.4				**27.5**				
	Cefoxitin	142	2	>16	19.7							15.5	48.6	13.4	1.4	1.4	**19.7**					
	Cephalothin	142	≤2	>32	23.9								57.7	12.7	3.5	2.1	**2.1**	**21.8**				
	Chloramphenicol	142	8	8	0								2.1	39.4	57.0	1.4						
	Sulphamethoxazole	142	32	64	2.8											31.0	38.0	24.6	3.5			**2.8**
	Tetracycline	142	≤4	>32	14.8									84.5	0.7		**2.8**	**12.0**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 38. Distribution of MICs and resistance in generic *E. coli* recovered from beef in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤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	Ontario	190	0.25	0.5	0.5				9.5	72.6	17.4					**0.5**						
		Québec	137	0.25	0.5	2.2				12.4	71.5	13.9				**1.5**	**0.7**						
	Ceftriaxone	Ontario	190	≤0.25	≤0.25	0					99.5						0.5						
		Québec	137	≤0.25	≤0.25	0					97.1			0.7		1.5	0.7						
	Ciprofloxacin	Ontario	190	≤0.015	≤0.015	0	98.9	0.5		0.5													
		Québec	137	≤0.015	≤0.015	0	98.5	0.7			0.7												
II	Amikacin	Ontario	190	2	2	0							37.4	53.7	8.9								
		Québec	137	2	4	0							27.0	61.3	11.7								
	Amoxicillin-clavulanic acid	Ontario	190	4	4	0.5							6.3	26.3	60.5	5.8	0.5		**0.5**				
		Québec	137	4	4	2.2							3.6	35.8	56.2	2.2		**0.7**	**1.5**				
	Gentamicin	Ontario	190	0.5	1	0					4.2	54.2	41.1	0.5									
		Québec	137	0.5	1	0					6.6	43.8	48.2	0.7	0.7								
	Kanamycin	Ontario	190	≤8	≤8	3.2										95.3	1.6			**3.2**			
		Québec	137	≤8	≤8	1.5										97.8	0.7			**1.5**			
	Nalidixic Acid	Ontario	190	2	4	0.5							3.7	61.1	34.2	0.5			**0.5**				
		Québec	137	2	4	0.7							5.8	63.5	29.2	0.7			**0.7**				
	Streptomycin	Ontario	190	≤32	≤32	6.3												93.7	**2.6**	**3.7**			
		Québec	137	≤32	≤32	9.5												90.5	**3.6**	**5.8**			
	Trimethoprim-sulphamethoxazole	Ontario	190	≤0.12	0.25	1.6				88.4	6.8	3.2				**1.6**							
		Québec	137	≤0.12	0.25	2.2				88.3	7.3	2.2				**2.2**							
III	Ampicillin	Ontario	190	0.4	4	5.3							6.3	43.7	42.1	2.6			**5.3**				
		Québec	137	4	4	3.6							8.0	40.9	45.3	2.2		**0.7**	**2.9**				
	Cefoxitin	Ontario	190	4	8	0.5							1.1	25.3	61.6	11.6		**0.5**					
		Québec	137	4	8	2.2							1.5	24.8	61.3	9.5	0.7	**2.2**					
	Cephalothin	Ontario	190	8	16	1.0								3.7	17.9	62.1	15.3	**0.5**	**0.5**				
		Québec	137	8	16	5.1								1.5	22.6	54.0	16.8	**2.2**	**2.9**				
	Chloramphenicol	Ontario	190	8	8	2.1								4.2	40.5	51.1	2.1		**2.1**				
		Québec	137	4	8	3.6								4.4	49.6	40.1	2.2		**3.6**				
	Sulphamethoxazole	Ontario	190	≤16	>512	10.5											78.9	10.5					**10.5**
		Québec	137	≤16	32	8.0											78.1	13.9					**8.0**
	Tetracycline	Ontario	190	≤4	>32	18.9									78.9	2.1	**2.6**	**2.6**	**13.7**				
		Québec	137	≤4	>32	14.6									77.4	8.0			**14.6**				
IV																							

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 39. Distribution of MICs and resistance in generic *E. coli* recovered from pork in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs																
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
	Ceftiofur	Ontario	198	0.25	0.5	1.0				12.1	69.7	16.7			0.5	**1.0**							
		Québec	108	0.25	0.5	1.9				10.2	54.6	29.6	1.9	1.9		**1.9**							
I	Ceftriaxone	Ontario	198	≤0.25	≤0.25	0					98.5					1.5							
		Québec	108	≤0.25	≤0.25	0					94.4	0.9	0.9			3.7							
	Ciprofloxacin	Ontario	198	≤0.015	≤0.015	0	100																
		Québec	108	≤0.015	0.03	0	88.9	9.3	1.9														
	Amikacin	Ontario	198	2	4	0							24.7	62.6	12.1	0.5							
		Québec	108	2	4	0							29.6	50.9	19.4								
	Amoxicillin-clavulanic acid	Ontario	198	4	8	1.5							3.0	31.8	44.9	17.7	1.0	**0.5**	**1.0**				
		Québec	108	4	8	2.8							2.8	24.1	59.3	10.2	0.9	**1.9**	**0.9**				
	Gentamicin	Ontario	198	0.5	1	3.0					3.0	56.1	36.9	1.0			**1.5**	**1.5**					
		Québec	108	1	1	2.8					8.3	39.8	44.4	4.6			**1.9**	**0.9**					
II	Kanamycin	Ontario	198	≤8	>64	12.6										84.8	2.0	0.5		**12.6**			
		Québec	108	≤8	≤8	4.6										93.5	1.9		**0.9**	**3.7**			
	Nalidixic Acid	Ontario	198	2	4	0							3.5	63.1	32.8	0.5							
		Québec	108	2	4	0							2.8	58.3	35.2	3.7							
	Streptomycin	Ontario	198	≤32	>64	26.2												73.7	**14.1**	**12.1**			
		Québec	108	≤32	>64	20.4												79.6	**9.3**	**11.1**			
	Trimethoprim-sulphamethoxazole	Ontario	198	≤0.12	0.5	6.6				68.7	15.2	7.1	2.0	0.5		**6.6**							
		Québec	108	≤0.12	0.5	6.5				74.1	12.0	6.5	0.9			**6.5**							
	Ampicillin	Ontario	198	4	>32	23.2							7.6	35.9	32.3	1.0			**23.2**				
		Québec	108	4	>32	18.5							7.4	30.6	32.4	9.3	1.9		**18.5**				
	Cefoxitin	Ontario	198	4	8	1.5							0.5	22.2	63.1	12.6		**1.5**					
		Québec	108	4	16	3.7								23.1	52.8	11.1	9.3	**3.7**					
III	Cephalothin	Ontario	198	8	16	3.0								1.5	22.2	54.5	18.7	**1.5**	**1.5**				
		Québec	108	8	16	5.6								2.8	24.1	43.5	24.1	**1.9**	**3.7**				
	Chloramphenicol	Ontario	198	8	32	10.6								0.5	44.4	41.9	2.5	**8.6**	**2.0**				
		Québec	108	8	16	8.3								3.7	37.0	41.7	9.3	**8.3**					

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
III	Sulphamethoxazole	Ontario	198	≤16	>512	32.8											57.6	9.1	0.5				**32.8**
		Québec	108	≤16	>512	23.1											63.0	13.0	0.9				**23.1**
	Tetracycline	Ontario	198	>32	>32	54.5									44.4	1.0	**0.5**	**2.0**	**52.0**				
		Québec	108	≤4	>32	37.1									61.1	1.9		**2.8**	**34.3**				
IV																							

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 40. Distribution of MICs and resistance in generic *E. coli* recovered from chicken in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.50	1	2	4	8	16	32	64	128	256	512	> 512
	Ceftiofur	Ontario	150	0.25	8	21.3				4.0	48.7	18.0	4.0	1.3	2.7	**14.0**	**7.3**						
		Québec	158	0.5	>8	34.2				5.1	38.0	12.7	4.4		5.7	**21.5**	**12.7**						
I	Ceftriaxone	Ontario	150	≤0.25	8	0					71.3	1.3	3.3		1.3	12.7	10.0						
		Québec	158	≤0.25	16	0.6					54.4	1.9	3.2	0.6	3.2	21.5	12.0	2.5	**0.6**				
	Ciprofloxacin	Ontario	150	≤0.015	≤0.015	0	98.7	0.7		0.7													
		Québec	158	≤0.015	≤0.015	0	91.8	3.2		3.8	1.3												
	Amikacin	Ontario	150	2	4	0						1.3	28.0	60.0	10.7								
		Québec	158	2	4	0						0.6	23.4	63.9	12.0								
	Amoxicillin-cavulanic acid	Ontario	150	4	>32	29.3							6.0	25.3	32.7	4.7	2.0	**18.7**	**10.7**				
		Québec	158	6	>32	42.4							3.2	19.6	27.2	6.3	1.3	**21.5**	**20.9**				
	Gentamicin	Ontario	150	1	1	5.3					4.7	42.7	43.3	2.0	0.7	1.3	**2.7**	**2.7**					
		Québec	158	1	8	10.1					3.8	45.6	37.3	0.6		2.5	**3.8**	**6.3**					
II	Kanamycin	Ontario	150	≤8	>64	11.3										86.0	2.7		**0.7**	**10.7**			
		Québec	158	≤8	16	8.9										88.0	3.2			**8.9**			
	Nalidixic Acid	Ontario	150	2	4	0.7						0.7	2.0	63.3	33.3				**0.7**				
		Québec	158	2	4	5.1							8.9	60.8	25.3			**1.3**	**3.8**				
	Streptomycin	Ontario	150	≤32	>64	33.3												66.7	**11.3**	**22.0**			
		Québec	158	≤32	>64	45.6												54.4	**8.9**	**36.7**			
	Trimethoprim-sulphamethoxazole	Ontario	150	≤0.12	0.5	4.0				72.7	14.0	8.7	0.7			**4.0**							
		Québec	158	≤0.12	>4	11.4				62.0	15.8	8.2	2.5			**11.4**							
	Ampicillin	Ontario	150	4	>32	39.3							8.7	27.3	22.7	2.0			**39.3**				
		Québec	158	>32	>32	51.9							5.7	25.9	13.3	2.5	0.6		**51.9**				
	Cefoxitin	Ontario	150	4	>16	26.7							2.0	13.3	45.3	10.7	2.0	**26.7**					
		Québec	158	8	>16	43.0							0.6	13.9	29.7	12.0	0.6	**43.0**					
	Cephalothin	Ontario	150	8	>32	30.7								1.3	14.7	41.3	12.0	**0.7**	**30.0**				
		Québec	158	16	>32	46.8								1.3	9.5	32.3	10.1	**0.6**	**46.2**				
III	Chloramphenicol	Ontario	150	8	8	5.3								2.0	38.7	53.3	0.7		**5.3**				
		Québec	158	8	>32	11.4								3.2	39.9	43.7	1.9	**0.6**	**10.8**				
	Sulphamethoxazole	Ontario	150	≤16	>512	25.3											66.0	6.0	2.0	0.7			**25.3**
		Québec	158	≤16	>512	36.1											51.3	11.4		1.3			**36.1**
	Tetracycline	Ontario	150	32	>32	52.0									46.7	1.3		**2.7**	**49.3**				
		Québec	158	32	>32	53.2									45.6	1.3	**0.6**	**8.9**	**43.7**				
IV																							

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 41. Distribution of MICs and resistance in *Salmonella* recovered from chicken in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
	Ceftiofur	Ontario	55	1	>8	45.5						40.0	14.5			**3.6**	**41.8**						
		Québec	52	0.5	>8	40.4				1.9	1.9	48.1	7.7				**40.4**						
I	Ceftriaxone	Ontario	55	≤ 0.25	16	0					54.5					21.8	18.2	5.5					
		Québec	52	≤ 0.25	16	1.9					59.6					23.1	9.6	5.8	**1.9**				
	Ciprofloxacin	Ontario	55	≤ 0.015	0.03	0	87.3	12.7															
		Québec	52	≤ 0.015	0.03	0	84.6	15.4															
	Amikacin	Ontario	55	1	2	0						27.3	61.8	9.1	1.8								
		Québec	52	1	2	0						36.5	51.9	11.5									
	Amoxicillin-clavulanic Acid	Ontario	55	8	>32	43.6							49.1			1.8	5.5	**9.1**	**34.5**				
		Québec	52	2	>32	40.4							48.1	1.9	1.9	5.8	1.9	**5.8**	**34.6**				
	Gentamicin	Ontario	55	≤ 0.25	1	0					80.0	1.8	18.2										
		Québec	52	≤ 0.25	1	1.9					80.8	1.9	15.4				**1.9**						
II	Kanamycin	Ontario	55	≤ 8	≤ 8	0										100							
		Québec	52	≤ 8	≤ 8	0										100							
	Nalidixic Acid	Ontario	55	4	8	0								5.5	69.1	25.5							
		Québec	52	4	8	0								7.7	71.2	21.2							
	Streptomycin	Ontario	55	≤ 32	≤ 32	3.6												96.4	**3.6**				
		Québec	52	≤ 32	>64	23.1												76.9	**13.5**	**9.6**			
	Trimethoprim-sulphamethoxazole	Ontario	55	≤ 0.12	0.25	1.8				85.5	10.9			1.8		**1.8**							
		Québec	52	≤ 0.12	0.25	0				86.5	7.7	1.9	1.9	1.9									
	Ampicillin	Ontario	55	>32	>32	50.9							45.5	3.6					**50.9**				
		Québec	52	2	>32	50.0							48.1	1.9					**50.0**				
	Cefoxitin	Ontario	55	4	>16	40.0							5.5	40.0	9.1		5.5	**40.0**					
		Québec	52	2	>16	38.5							11.5	42.3	5.8		1.9	**38.5**					
	Cephalothin	Ontario	55	4	>32	47.3								41.8	9.1		1.8	**1.8**	**45.5**				
		Québec	52	4	>32	40.4								48.1	5.8		5.8		**40.4**				
III	Chloramphenicol	Ontario	55	8	8	0								3.6	23.6	72.7							
		Québec	52	8	8	3.8								1.9	36.5	53.8	3.8		**3.8**				
	Sulphamethoxazole	Ontario	55	32	64	1.8											36.4	29.1	27.3	5.5			**1.8**
		Québec	52	32	64	7.7											36.5	46.2	9.6				**7.7**
	Tetracycline	Ontario	55	≤ 4	≤ 4	3.6									96.4			**3.6**					
		Québec	52	≤ 4	>32	23.1									76.9			**11.5**	**11.5**				
IV																							

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 42. Distribution of MICs and resistance in *Campylobacter* spp. recovered from chicken in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs																
				MIC_{50}	MIC_{90}		≤0.002	0.004	0.008	0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
I	Ciprofloxacin	Ontario	140	0.032	0.125	2.1	0.7		1.4	15.7	47.1	23.6	7.1	1.4		0.7									
		Québec	158	0.032	0.125	2.5		0.6		15.8	47.5	17.7	10.1	5.7											
II	Azithromycin	Ontario	140	0.064	0.5	7.9				3.6	24.3	35.7	22.1	4.3	1.4	0.7									
		Québec	158	0.064	>256	15.8				3.2	26.6	36.1	12.0	5.1	1.3										
	Clindamycin	Ontario	140	0.125	1	7.1				3.6	15.0	26.4	28.6	9.3	5.0	3.6	1.4								
		Québec	158	0.125	4	13.3				1.9	13.9	24.1	25.9	10.8	8.2		1.9								
	Erythromycin	Ontario	140	0.5	0.4	7.1				0.7	0.7	2.1	13.6	31.4	28.6	9.3	3.6	2.9							
		Québec	158	0.5	>256	15.8					0.6	0.6	12.0	32.9	27.8	7.0	3.2								
	Gentamicin	Ontario	140	0.25	0.5	0.0				2.1	0.7	3.6	14.3	45.7	24.3	7.1	1.4	0.7							
		Québec	158	0.25	0.5	0.0						1.9	19.6	50.6	24.7	1.9	0.6	0.6							
	Nalidixic Acid	Ontario	140	0.1	4	2.9				0.7	1.4		1.4	6.4	20.0	40.7	13.6	7.1	4.3	1.4					
		Québec	158	0.1	4	2.5							0.6	6.3	22.8	41.1	15.8	7.0	3.8						
III	Chloramphenicol	Ontario	140	0.5	2	0.0				2.1	2.1	2.9	5.7	21.4	35.7	17.1	7.1	3.6	1.4	0.7					
		Québec	158	0.5	0.2	0.0				0.6	1.3	1.9	5.7	17.1	43.7	19.6	8.2	1.9							
	Tetracycline	Ontario	140	2	>256	47.1				0.7	10.7	18.6	10.7	7.9	0.7		1.4		2.1						
		Québec	158	>256	>256	79.1					5.1	6.3	3.2	2.5	2.5				1.3						
IV																									

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 43. Distribution of MICs and resistance in *Enterococcus* recovered from chicken in Ontario and Québec; *Retail Surveillance* 2004.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
				MIC50	MIC90		≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048
I	Ciprofloxacin	Ontario	158	1	1	0	1.9	6.3	38.6	51.9	1.3										
		Québec	162	1	1	0	3.1	3.1	43.8	47.5	2.5										
	Linezolid	Ontario	158	2	2	0			0.6	45.6	53.8										
		Québec	162	2	2	0			1.2	45.1	53.7										
	Quinupristin-dalfopristin	Ontario	15	8	16	80.0				6.7	13.3	**20.0**	**26.7**	**33.3**							
		Québec	10	8	16	90.0					10.0	**30.0**	**30.0**	**20.0**	**10.0**						
	Vancomycin	Ontario	158	1	2	0			6.3	70.9	22.2	0.6									
		Québec	162	1	2	0			4.3	67.3	27.8	0.6									
II	Erythromycin	Ontario	158	2	>8	39.2			36.1	7.6	16.5	0.6	**0.6**	**38.6**							
		Québec	162	2	>8	46.3			37.0	9.3	7.4		**0.6**	**45.7**							
	Gentamicin	Ontario	158	≤128	≤128	3.8											96.2		**1.3**	**1.3**	**1.3**
		Québec	162	≤128	≤128	4.9											95.1		**1.2**	**1.2**	**2.5**
	Kanamycin	Ontario	158	≤128	>1024	12.7											85.4	1.3		0.6	**12.7**
		Québec	162	≤128	>1024	16.0											79.0	0.6	1.9	2.5	**16.0**
	Lincomycin	Ontario	15	>32	>32	93.3				6.7			**6.7**	**20.0**	**13.3**	**53.3**					
		Québec	10	>32	>32	100								**20.0**		**80.0**					
	Streptomycin	Ontario	158	≤512	>2048	22.2													77.8		**6.3**	**15.8**
		Québec	162	≤512	>2048	22.2													77.8	**1.9**	**5.6**	**14.8**
	Tylosin tartrate	Ontario	158	2	>32	41.1			3.8	27.8	25.9	1.3		**0.6**		**40.5**					
		Québec	162	2	>32	46.9		0.6	1.9	26.5	22.2	1.9	**0.6**			**46.3**					
III	Chloramphenicol	Ontario	158	8	8	0					1.9	41.1	56.3	0.6							
		Québec	162	8	8	0						33.3	66.7								
	Penicillin	Ontario	158	4	4	1.3			3.8	1.9	20.3	71.5	1.3	**1.3**							
		Québec	162	4	4	2.5			0.6	0.6	19.8	75.9	0.6	**1.9**	**0.6**						
	Tetracycline	Ontario	158	>32	>32	84.8						14.6	0.6	**2.5**	**7.6**	**74.7**					
		Québec	162	>32	>32	86.4						12.3	1.2	**0.6**	**6.2**	**79.6**					
IV	Bacitracin	Ontario	158	>128	>128	86.7							1.9		3.2	8.2	**9.5**	**77.2**			
		Québec	162	>128	>128	84.6								1.2	1.2	13.0	**17.3**	**67.3**			
	Flavomycin	Ontario	158	≤1	2	5.1				87.3	3.8	1.9	1.9			**5.1**					
		Québec	162	≤1	2	4.3				88.3	5.6		1.9	**0.6**		**3.7**					
	Nitrofurantoin	Ontario	158	8	32	1.3					0.6	1.3	75.3	10.1	7.0	4.4	**1.3**				
		Québec	162	8	16	3.1					0.6		80.2	11.7	1.2	3.1	**3.1**				
	Salinomycin	Ontario	158	≤1	4	0				57.6	13.3	22.8	6.3								
		Québec	162	≤1	4	0				65.4	13.0	16.7	4.9								

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 44. Distribution of MICs and resistance in *Salmonella* recovered from cattle; *Passive Surveillance* of Animal Clinical Isolates, 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs															
			MIC_{50}	MIC_{90}		≤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	>8	19.6						63.6	16.8				**19.6**						
	Ceftriaxone	107	≤0.25	16	0					80.4					0.9	15.0	3.7					
	Ciprofloxacin	107	≤0.015	≤0.015	0	98.1	0.9	0.9														
II	Amikacin	107	1	2	0						3.7	73.8	20.6	0.9		0.9						
	Amoxicillin-Clavulanic Acid	107	4	>32	20.6							48.6		1.9	6.5	22.4	**2.8**	**17.8**				
	Gentamicin	107	≤0.25	1	0					55.1	9.3	33.6	0.9		0.9							
	Kanamycin	107	≤8	>64	29.0										70.1		0.9		**29.0**			
	Nalidixic Acid	107	4	4	0								12.1	86.9	0.9							
	Streptomycin	107	≤32	>64	49.5												50.5	**23.4**	**26.2**			
	Trimethoprim-Sulphamethoxazole	107	≤0.12	0.25	6.5				57.9	33.6	1.9				**6.5**							
III	Ampicillin	107	8	>32	49.5							42.1	6.5	0.9	0.9			**49.5**				
	Cefoxitin	107	2	>16	20.6							6.5	61.7	8.4	2.8		**20.6**					
	Cephalothin	107	4	>32	20.6								49.5	22.4	4.7	2.8	**0.9**	**19.6**				
	Chloramphenicol	107	8	>32	42.1									20.6	37.4			**42.1**				
	Sulphamethoxazole	107	512	>512	50.5											8.4	15.9	21.5	3.7		**1.9**	**48.6**
	Tetracycline	107	16	>32	51.4									48.6		**1.9**	**17.8**	**31.8**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 45. Distribution of MICs and resistance in *Salmonella* recovered from swine; *Passive Surveillance* of Animal Clinical Isolates, 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs															
			MIC_{50}	MIC_{90}		≤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	225	0.5	1	1.8				0.4	0.9	58.2	33.3	5.3			1.8						
	Ceftriaxone	225	≤0.25	≤0.25	0					97.8			0.4			1.8						
	Ciprofloxacin	225	≤0.015	≤0.015	0	91.1	7.1	0.9	0.9													
II	Amikacin	225	1	2	0						7.1	51.1	39.6	2.2								
	Amoxicillin-clavulanic acid	225	4	16	2.7							43.6	6.2	4.9	9.8	32.9	1.8	0.9				
	Gentamicin	225	≤0.25	1	5.3					55.6	8.0	28.9	0.4		1.8	4.0	1.3					
	Kanamycin	225	≤8	>64	30.2										69.8			0.9	29.3			
	Nalidixic Acid	225	4	4	0								12.4	77.8	8.9	0.9						
	Streptomycin	225	64	>64	53.3												46.7	34.2	19.1			
	Trimethoprim-sulphamethoxazole	225	0.25	>4	19.6				38.7	33.8	5.8	1.8	0.4		19.6							
III	Ampicillin	225	32	>32	50.2							38.2	6.2	4.9	0.4		0.9	49.3				
	Cefoxitin	225	2	4	1.8						0.4	2.7	55.6	33.3	4.0	2.2	1.8					
	Cephalothin	225	4	8	3.1								36.9	42.2	15.6	2.2	0.9	2.2				
	Chloramphenicol	225	8	>32	32.9								0.4	9.3	50.7	6.7		32.9				
	Sulphamethoxazole	225	>512	>512	67.1											6.2	9.8	14.7	2.2		0.4	66.7
	Tetracycline	225	>32	>32	75.1									24.9		2.7	17.3	55.1				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 46. Distribution of MICs and resistance in *Salmonella* recovered chickens; *Passive Surveillance* of Animal Clinical Isolates, 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs															
			MIC_{50}	MIC_{90}		≤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	42	0.5	>8	21.4				2.4	2.4	59.5	11.9	2.4			**21.4**						
	Ceftriaxone	42	≤0.25	16	0					78.6					2.4	19.0						
	Ciprofloxacin	42	≤0.015	≤0.015	0	92.9	4.8	2.4														
II	Amikacin	42	1	2	0						9.5	71.4	14.3	4.8								
	Amoxicillin-clavulanic acid	42	≤1	>32	21.4							64.3	4.8		4.8	4.8	**2.4**	**19.0**				
	Gentamicin	42	≤0.25	1	2.4					66.7	7.1	21.4			2.4		**2.4**					
	Kanamycin	42	≤8	≤8	9.5										90.5			**2.4**	**7.1**			
	Nalidixic Acid	42	4	8	0								4.8	83.3	9.5	2.4						
	Streptomycin	42	≤32	>64	11.9												88.1	**7.1**	**4.8**			
	Trimethoprim-sulphamethoxazole	42	≤0.12	0.25	2.4				83.3	14.3					**2.4**							
III	Ampicillin	42	≤1	>32	31.0							52.4	14.3	2.4				**31.0**				
	Cefoxitin	42	2	>16	21.4							19.0	42.9	9.5	4.8	2.4	**21.4**					
	Cephalothin	42	≤2	>32	23.8								59.5	9.5	2.4	4.8	**2.4**	**21.4**				
	Chloramphenicol	42	8	8	7.1								2.4	23.8	64.3	2.4		**7.1**				
	Sulphamethoxazole	42	32	256	9.5											42.9	26.2	16.7	2.4	2.4	**2.4**	**7.1**
	Tetracycline	42	≤4	>32	11.9									88.1			**2.4**	**9.5**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

Table 47. Distribution of MICs and resistance in *Salmonella* recovered turkeys; *Passive Surveillance* of Animal Clinical Isolates, 2004.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs																
			MIC_{50}	MIC_{90}		≤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	>8	16.7						50.0	33.3				**16.7**						
	Ceftriaxone	36	≤0.25	32	2.8					83.3					2.8	2.8	8.3	**2.8**				
	Ciprofloxacin	36	≤0.015	≤0.015	0	100																
II	Amikacin	36	1	2	0						8.3	61.1	22.2	8.3								
	Amoxicillin-cavulanic acid	36	≤1	>32	16.7							55.6			5.6	22.2	**2.8**	**13.9**				
	Gentamicin	36	2	>16	44.4					22.2	5.6	16.7	5.6		5.6	**5.6**	**38.9**					
	Kanamycin	36	≤8	>64	38.9										55.6	5.6		**13.9**	**25.0**			
	Nalidixic Acid	36	4	4	0							2.8	8.3	88.9								
	Streptomycin	36	64	>64	55.6												44.4	**27.8**	**27.8**			
	Trimethoprim-sulphamethoxazole	36	≤0.12	0.25	0				75.0	25.0												
III	Ampicillin	36	2	>32	44.4							47.2	8.3					**44.4**				
	Cefoxitin	36	4	>16	16.7							8.3	36.1	38.9			**16.7**					
	Cephalothin	36	4	>32	38.9								41.7	16.7	2.8		**19.4**	**19.4**				
	Chloramphenicol	36	8	>32	11.1									27.8	61.1			**11.1**				
	Sulphamethoxazole	36	64	>512	36.1											16.7	30.6	16.7				**36.1**
	Tetracycline	36	≤4	>32	38.9									61.1			**5.6**	**33.3**				
IV																						

Note: Roman numerals I-IV indicate the ranking of human importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Vertical solid black bars indicate the breakpoints for resistance, vertical dotted bars indicate the breakpoints for susceptiblity. Numbers in red bold font indicate the percentage of resistant isolates. Numbers in the solid shaded area are the percentage of isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. Numbers in the smallest dilution of the range tested are susceptible to this level or to lower concentration of antimicrobial.

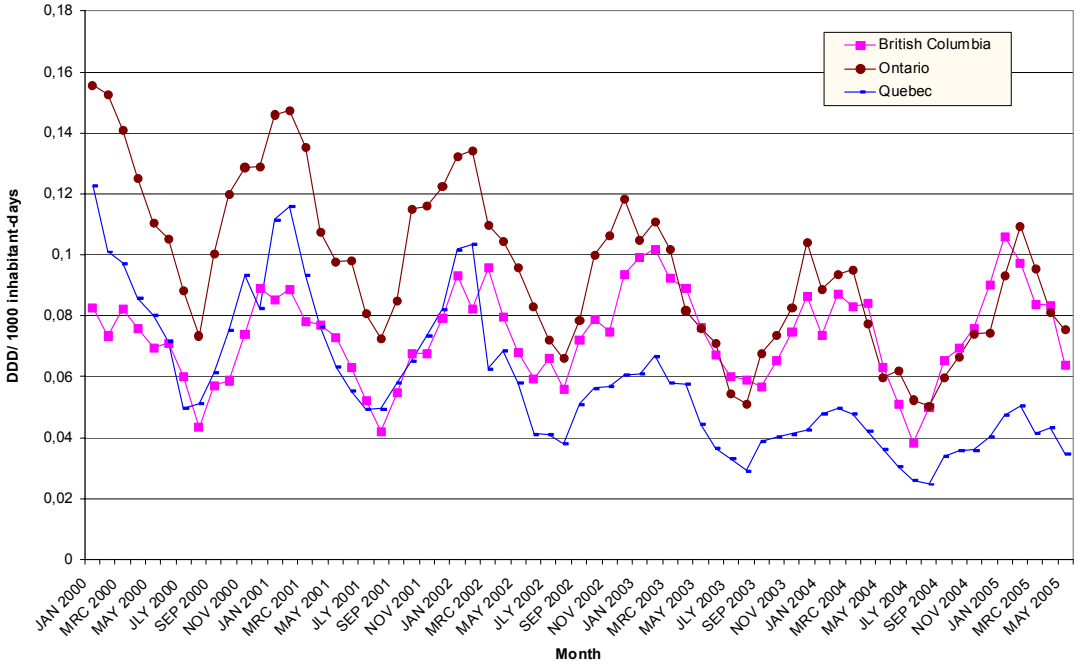

Figure 27. DDDs of third generation cephalosporins per 1000-inhabitant-days dispensed by retail pharmacies.

A.5 Antimicrobial Use - Human

Table 48. List of antimicrobial drugs included in each ATC class from CCS data, Canada 2000-2004.

Human health importance	ATC CLASS		Antimicrobial
I	J01DD	Third-generation cephalosporins	cefixime
	J01MA	Fluoroquinolones	ciprofloxacin, gatifloxacin, grepafloxacin, levofloxacin, moxifloxacin, norfloxacin, ofloxacin, trovafloxacin
	J01XA	Glycopeptides	vancomycin
	J01XX08	Linezolid	linezolid
II	J01CA	Penicillins with extended spectrum	amoxicillin, ampicillin, bacampicillin, pivampicillin, pivmecillinam,
	J01CF	Beta-lactamase resistant penicillins	cloxacillin, dicloxacillin, flucloxacillin
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	amoxicillin-clavulanic acid
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	sulfadiazine-trimethoprim, sulfamethoxazole-trimethoprim
	J01FA	Macrolides	azithromycin, clarithromycin, erythromycin, spiramycin, telithromycin
	J01FF	Lincosamides	clindamycin, lincomycin
	J01GB	Aminoglycosides	neomycin
	J01MB	Other quinolones	nalidixic acid
	J01RA	Sulfonamide combinations (excl. trimethoprim)	erythromycin-sulfisoxazole
III	J01AA	Tetracyclines	demeclocycline, doxycycline, minocycline, tetracycline
	J01BA	Amphenicols	chloramphenicol
	J01CE	Beta-lactamase sensitive penicillins	penicillin g, penicillin v
	J01DB	First-generation cephalosporins	cefadroxil, cephalexin, cephradine
	J01DC	Second-generation cephalosporins	cefaclor, cefprozil, cefuroxime axetil
	J01EA	Trimethoprim and derivatives	trimethoprim
	J01EB	Short-acting sulfonamides	sulfamethizole, sulfapyridine, sulfisoxazole
	J01EC	Intermediate-acting sulfonamides	phenazopyridine-sulfamethoxazole, sulfadiazine, sulfadiazine-trimethoprim, sulfamethoxazole
IV	J01XC	Steroid antibacterials	fusidic acid
	J01XE	Nitrofuran derivatives	nitrofurantoin
	J01XX	Other antibacterials	fosfomycin
	J01XX05	Methenamine	methenamine, methenamine-sodium-tartaric acid

Table 49. Total number of prescriptions of oral antimicrobials dispensed by retail pharmacies per 1000 inhabitants, Canada 2000-2004.

Human health importance	ATC class		Total number of prescriptions filled per 1000-inhabitants per year					Percent of prescriptions (%)				
			2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
I	J01DD	Third-generation cephalosporins	5.66	5.28	4.83	4.23	3.68	0.77	0.73	0.70	0.61	0.56
	J01MA	Fluoroquinolones	76.23	81.03	85.73	91.74	94.22	10.31	11.27	12.43	13.22	14.26
	J01XA	Glycopeptides	0.14	0.14	0.16	0.19	0.34	0.02	0.02	0.02	0.03	0.05
	J01XX08	Linezolid		<0.01	0.01	0.02	0.04		<0.01	<0.01	<0.01	<0.01
II	J01CA	Penicillins with extended spectrum	193.18	183.54	171.05	169.81	156.08	26.14	25.53	24.79	24.48	23.63
	J01CF	Beta-lactamase resistant penicillins	19.78	18.38	16.78	15.61	14.17	2.68	2.56	2.43	2.25	2.15
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	18.66	18.41	17.54	17.69	16.98	2.53	2.56	2.54	2.55	2.57
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	56.52	50.62	44.56	41.05	37.12	7.65	7.04	6.46	5.92	5.62
	J01FA	Macrolides	146.55	149.72	145.48	149.00	138.51	19.83	20.82	21.09	21.48	20.97
	J01FF	Lincosamides	15.92	16.74	17.63	18.48	18.85	2.15	2.33	2.55	2.66	2.85
	J01GB	Aminoglycosides	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	0.08	0.06	0.05	0.04	0.05	0.01	<0.01	<0.01	<0.01	<0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	3.50	2.43	1.58	1.05	0.67	0.47	0.34	0.23	0.15	0.10
III	J01AA	Tetracyclines	43.47	41.16	39.31	38.41	36.71	5.88	5.73	5.70	5.54	5.56
	J01BA	Amphenicols	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01		<0.01
	J01CE	Beta-lactamase sensitive penicillins	45.42	42.10	39.85	39.62	36.59	6.15	5.86	5.78	5.71	5.54
	J01DB	First-generation cephalosporins	41.03	41.70	43.07	45.23	45.65	5.55	5.80	6.24	6.52	6.91
	J01DC	Second-generation cephalosporins	55.09	48.95	43.06	41.41	39.37	7.46	6.81	6.24	5.97	5.96
	J01EA	Trimethoprim and derivatives	2.22	2.12	2.13	2.16	2.02	0.30	0.29	0.31	0.31	0.31
	J01EB	Short-acting sulfonamides	0.07	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
IV	J01XC	Steroid antibacterials	0.06	0.06	0.05	0.05	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
	J01XE	Nitrofuran derivatives	14.61	15.76	16.41	17.48	19.13	1.98	2.19	2.38	2.52	2.90
	J01XX	Other antibacterials	0.44	0.47	0.29	0.21	0.14	0.06	0.07	0.04	0.03	0.02
	J01XX05	Methenamine	0.27	0.28	0.29	0.28	0.25	0.04	0.04	0.04	0.04	0.04
	J01	**Total**	**738.98**	**718.97**	**689.86**	**693.81**	**660.61**	**100**	**100**	**100**	**100**	**100**

Table 50. Total cost of oral antimicrobials dispensed by retail pharmacies per 1000 inhabitants, Canada 2000-2004.

Human health importance	ATC class		Total cost by 1000-inhabitants per year ($)					Percent of total (%)				
			2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
I	J01DD	Third-generation cephalosporins	212.26	196.78	179.57	155.33	133.22	1.02	0.94	0.87	0.72	0.63
	J01MA	Fluoroquinolones	4,285.71	4,555.96	4,758.29	5,078.69	4,859.20	20.55	21.69	22.99	23.54	23.08
	J01XA	Glycopeptides	51.03	54.88	62.08	76.38	131.23	0.24	0.26	0.30	0.35	0.62
	J01XX08	Linezolid		6.36	19.53	43.61	71.59		0.03	0.09	0.20	0.34
II	J01CA	Penicillins with extended spectrum	2,662.57	2,559.11	2,416.25	2,456.31	2,295.16	12.77	12.18	11.67	11.38	10.90
	J01CF	Beta-lactamase resistant penicillins	287.70	272.68	251.58	242.19	226.14	1.38	1.30	1.22	1.12	1.07
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	758.68	741.82	644.84	632.84	584.65	3.64	3.53	3.12	2.93	2.78
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	632.11	571.05	511.01	481.11	438.79	3.03	2.72	2.47	2.23	2.08
	J01FA	Macrolides	5,800.28	6,177.44	6,219.24	6,639.65	6,521.81	27.81	29.41	30.05	30.77	30.98
	J01FF	Lincosamides	666.80	605.60	635.04	654.75	675.26	3.20	2.88	3.07	3.03	3.21
	J01GB	Aminoglycosides	0.93	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	3.62	3.01	2.53	2.27	2.16	0.02	0.01	0.01	0.01	0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	95.14	66.22	43.47	29.38	19.60	0.46	0.32	0.21	0.14	0.09
III	J01AA	Tetracyclines	1,456.11	1,451.83	1,485.89	1,524.95	1,512.46	6.98	6.91	7.18	7.07	7.18
	J01BA	Amphenicols	0.02	0.05	<0.01		<0.01	<0.01	<0.01	<0.01		<0.01
	J01CE	Beta-lactamase sensitive penicillins	497.32	467.30	452.74	463.27	435.95	2.38	2.22	2.19	2.15	2.07
	J01DB	First-generation cephalosporins	736.71	756.44	798.94	863.21	890.36	3.53	3.60	3.86	4.00	4.23
	J01DC	Second-generation cephalosporins	2,335.89	2,134.36	1,820.11	1,807.37	1,797.76	11.20	10.16	8.79	8.38	8.54
	J01EA	Trimethoprim and derivatives	47.67	43.68	41.75	39.62	35.03	0.23	0.21	0.20	0.18	0.17
	J01EB	Short-acting sulfonamides	2.79	0.35	0.03	0.02	0.02	0.01	<0.01	<0.01	<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides	0.45	0.40	0.32	0.48	0.22	<0.01	<0.01	<0.01	<0.01	<0.01
IV	J01XC	Steroid antibacterials	6.14	6.74	6.04	6.30	6.24	0.03	0.03	0.03	0.03	0.03
	J01XE	Nitrofuran derivatives	290.94	312.33	332.83	364.93	404.48	1.40	1.49	1.61	1.69	1.92
	J01XX	Other antibacterials	14.71	16.06	10.39	7.60	5.52	0.07	0.08	0.05	0.04	0.03
	J01XX05	Methenamine	7.64	7.27	7.14	6.59	6.31	0.04	0.03	0.03	0.03	0.03
	J01	**Total**	**20,853.20**	**21,007.78**	**20,699.63**	**21,576.86**	**21,053.14**	**100**	**100**	**100**	**100**	**100**

Table 51. Defined daily doses of oral antimicrobials dispensed by retail pharmacies per 1000 inhabitant-days in selected Canadian provinces, 2004.

Human health importance	ATC class		Total number of DDDs per 1000 inhabitant-days per year									
			PE & NL	MB	AB	SK	NB	NS	ON	BC	QC	Canada
I	J01DD	Third-generation cephalosporins	0.13	0.04	0.04	0.01	0.07	0.11	0.07	0.07	0.04	0.06
	J01MA	Fluoroquinolones	3.53	2.05	2.29	1.10	2.00	1.88	2.16	1.72	2.15	2.09
	J01XA	Glycopeptides	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01XX08	Linezolid	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
II	J01CA	Penicillins with extended spectrum	7.77	6.89	5.34	5.87	4.52	4.63	4.72	4.19	2.60	4.38
	J01CF	Beta-lactamase resistant penicillins	0.58	0.73	0.21	0.37	0.22	0.40	0.26	0.31	0.22	0.28
	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	1.25	0.61	0.54	0.34	0.57	0.67	0.40	0.46	0.67	0.52
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	2.15	1.45	1.15	1.37	1.26	1.23	0.86	1.06	0.51	0.92
	J01FA	Macrolides	4.59	3.37	3.90	2.69	4.00	3.28	3.46	3.26	3.25	3.43
	J01FF	Lincosamides	0.21	0.33	0.40	0.33	0.34	0.27	0.31	0.29	0.32	0.32
	J01GB	Aminoglycosides							<0.01			<0.01
	J01MB	Other quinolones	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	0.02	<0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01
III	J01AA	Tetracyclines	2.35	3.42	3.45	3.57	1.84	2.68	2.25	2.93	1.63	2.40
	J01BA	Amphenicols							<0.01			<0.01
	J01CE	Beta-lactamase sensitive penicillins	0.71	0.75	0.70	0.46	0.74	0.65	0.43	0.58	0.62	0.55
	J01DB	First-generation cephalosporins	1.51	1.18	1.29	1.77	1.12	0.92	0.82	1.16	0.37	0.87
	J01DC	Second-generation cephalosporins	1.03	0.76	0.87	0.53	1.53	1.42	0.99	0.69	0.99	0.94
	J01EA	Trimethoprim and derivatives	0.10	0.01	0.05	0.14	0.04	0.03	0.06	0.06	0.07	0.06
	J01EB	Short-acting sulfonamides				<0.01			<0.01		<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides		<0.01	<0.01		<0.01		<0.01		<0.01	<0.01
IV	J01XC	Steroid antibacterials	<0.01		<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01XE	Nitrofuran derivatives	0.39	0.46	0.48	0.88	0.61	0.69	0.59	0.49	0.26	0.49
	J01XX	Other antibacterials	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01XX05	Methenamine	<0.01	<0.01	0.02	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01
	J01	**Total**	**26.33**	**22.07**	**20.73**	**19.47**	**18.92**	**18.88**	**17.40**	**17.30**	**13.74**	**17.35**

Table 52. Number of visits with drug mentions by ICD-9 Diagnostic Class, Canada 2000-2004.

ICD-9 Diagnostic class	2000 to 2004		2000		2001		2002		2003		2004	
	N of mentions	% of total	N of mentions	% of total	N of mentions	% of total	N of mentions	% of total	N of mentions	% of total	N of mentions	% of total
Respiratory disease	65,495,970	50.6	13,438,150	50.6	14,810,550	51.9	12,763,190	49.7	11,766,140	49.0	12,717,940	51.7
Central nervous system disease	17,346,420	13.4	3,647,640	13.7	4,014,710	14.1	3,612,170	14.1	3,134,880	13.1	2,937,020	11.9
Genitourinary disease	15,550,650	12.0	3,239,970	12.2	3,277,770	11.5	3,235,940	12.6	2,908,610	12.1	2,888,360	11.7
Skin and subcutaneous tissue disease	12,623,890	9.8	2,521,360	9.5	2,562,150	9.0	2,506,510	9.8	2,535,580	10.6	2,498,290	10.2
Infectious and parasitic disease	5,897,490	4.6	1,302,090	4.9	1,359,140	4.8	943,130	3.7	1,137,220	4.7	1,155,910	4.7
Digestive disease	5,142,410	4.0	996,840	3.8	1,156,180	4.1	1,020,190	4.0	941,150	3.9	1,028,050	4.2
Symptoms and ill-defined conditions	2,793,310	2.2	395,840	1.5	500,120	1.8	679,530	2.6	724,870	3.0	492,950	2.0
Injury and poisoning	1,814,110	1.4	407,800	1.5	365,930	1.3	328,670	1.3	355,930	1.5	355,780	1.4
Musculoskeletal disease	770,400	0.6	183,210	0.7	153,860	0.5	138,290	0.5	137,400	0.6	157,640	0.6
Supplementary classification	395,120	0.3	58,310	0.2	55,020	0.2	87,130	0.3	100,350	0.4	94,310	0.4
Neoplasm	367,410	0.3	67,690	0.3	50,870	0.2	110,450	0.4	56,020	0.2	82,380	0.3
Circulatory disease	361,150	0.3	131,510	0.5	55,400	0.2	95,200	0.4	30,920	0.1	48,120	0.2
Complication of pregnancy,childbirth, and puerperium	270,390	0.2	44,770	0.2	50,350	0.2	62,980	0.2	66,810	0.3	45,480	0.2
Disease of blood and blood forming organs	178,090	0.1	55,060	0.2	27,170	0.1	46,840	0.2	20,480	0.1	28,540	0.1
Endocrine, nutritional, metabolic, and immunologic disease	167,010	0.1	31,840	0.1	27,580	0.1	32,550	0.1	47,800	0.2	27,240	0.1
Perinatal condition	144,440	0.1	15,630	0.1	46,960	0.2	27,600	0.1	21,440	0.1	32,810	0.1
Congenital anomalies	61,970	0.0	12,830	0.0	20,230	0.1	6,100	0.0	6,470	0.0	16,340	0.1
Mental disorders	4,970	0.0									4,970	0.0
Total	**129,385,200**	**100**	**26,550,540**	**100**	**28,533,990**	**100**	**25,696,470**	**100**	**23,992,070**	**100**	**24,612,130**	**100**

Table 53. Number of visits with drug mentions by ICD-9 Diagnostic Class and Diagnostic Code, Canada 2000-2004.

ICD-9 Diagnostic class	2002 to 2004		2000		2001		2002		2003		2004	
code	n	%	n	%	n	%	n	%	n	%	n	%
Disease of Respiratory System												
4660 Bronchitis acute	13,366,010	20.4	2,820,350	21.0	3,004,780	20.3	2,634,610	20.6	2,356,000	20.0	2,550,270	20.1
4619 Sinusitis acute unspecified	9,961,210	15.2	1,923,370	14.3	2,117,780	14.3	1,937,860	15.2	1,862,830	15.8	2,119,370	16.7
4620 Pharyngitis acute	8,252,760	12.6	1,556,100	11.6	1,832,730	12.4	1,487,260	11.7	1,672,190	14.2	1,704,480	13.4
4659 Acute upper respiratory infection site unspecified	6,670,050	10.2	1,345,470	10.0	1,664,430	11.2	1,458,890	11.4	1,080,310	9.2	1,120,950	8.8
4630 Tonsillitis acute	5,843,510	8.9	1,361,060	10.1	1,226,180	8.3	1,252,440	9.8	986,090	8.4	1,017,740	8.0
Other diagnostic code	21,402,430	32.3	4,431,800	33.1	4,964,650	32.9	3,992,130	31.1	3,808,720	31.6	4,205,130	33.0
Total	65,495,970	100	13,438,150	100	14,810,550	100	12,763,190	100	11,766,140	100	12,717,940	100
Central Nervous System												
3829 Unspecified otitis media	15,072,500	86.9	3,229,320	88.5	3,506,190	87.3	3,146,330	87.1	2,725,330	86.9	2,465,330	83.9
3801 Infective otitis externa	628,200	3.6	119,120	3.3	145,820	3.6	116,830	3.2	113,090	3.6	133,340	4.5
3887 Otalgia	305,760	1.8	18,540	0.5	59,820	1.5	69,100	1.9	55,680	1.8	102,620	3.5
3810 Acute nonsuppurative otitis Media	261,410	1.5	54,170	1.5	68,450	1.7	53,430	1.5	37,530	1.2	47,830	1.6
3731 Hordeolum and deep infection of eyelid	191,090	1.1	25,710	0.7	49,390	1.2	37,510	1.0	20,600	0.7	57,880	2.0
Other diagnostic code	887,460	4.8	200,780	5.2	185,040	4.5	188,970	5.3	182,650	6.0	130,020	4.7
Total	17,346,420	100	3,647,640	100	4,014,710	100	3,612,170	100	3,134,880	100	2,937,020	100
Disease of Genitourinary System												
5990 Urinary inferior tract site unspecified	7,361,500	47.3	1,419,100	43.8	1,485,270	45.3	1,526,120	47.2	1,490,050	51.2	1,440,960	49.9
5950 acute cystitis	3,416,540	22.0	775,030	23.9	697,370	21.3	709,850	21.9	641,910	22.1	592,380	20.5
5959 Cystitis unspecified	670,730	4.3	160,390	5.0	124,110	3.8	137,860	4.3	74,290	2.6	174,080	6.0
6010 Acute prostatitis	623,110	4.0	133,670	4.1	185,280	5.7	121,260	3.7	101,640	3.5	81,260	2.8
6110 Inflammatory disease of breast	392,670	2.5	57,920	1.8	99,790	3.0	81,510	2.5	85,030	2.9	68,420	2.4
Other diagnostic code	3,086,100	19.7	693,860	21.9	685,950	20.9	659,340	20.9	515,690	17.8	531,260	18.6
Total	15,550,650	100	3,239,970	100	3,277,770	100	3,235,940	101	2,908,610	100	2,888,360	100
Disease of Skin/Subcutaneous Tissue												
6829 Cellulitis and abscess unspecified site	2,174,910	17.2	349,920	13.9	403,130	15.7	462,630	18.5	485,150	19.1	474,080	19.0
7061 Acne unspecified	1,361,240	10.8	222,490	8.8	288,250	11.3	327,930	13.1	271,020	10.7	251,550	10.1
7065 Acne stage 2	786,080	6.2	193,950	7.7	133,680	5.2	142,920	5.7	140,790	5.6	174,740	7.0
6840 Impetigo	759,450	6.0	186,460	7.4	159,540	6.2	167,860	6.7	115,500	4.6	130,090	5.2
6869 Localized infection of skin and subcutaneous tissue unspecified	693,370	5.5	132,070	5.2	178,350	7.0	155,190	6.2	110,760	4.4	117,000	4.7
Other diagnostic code	6,848,840	54.1	1,436,470	57.2	1,399,200	54.7	1,249,980	50.0	1,412,360	55.7	1,350,830	54.3
Total	12,623,890	100	2,521,360	100	2,562,150	100	2,506,510	100	2,535,580	100	2,498,290	100
Other ICD-9 Diagnostic class												
Total	18,368,270		3,703,420		3,868,810		3,578,660		3,646,860		3,570,520	
All ICD-9 Diagnostic classes												
Total	**129,385,200**		**26,550,540**		**28,533,990**		**25,696,470**		**23,992,070**		**24,612,130**	

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 Summary 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.

In the past, PPHLs have forwarded a certain number of *Salmonella* isolates to the Enteric Diseases Program, National Microbiology Laboratory (NML), Winnipeg (previously known as the National Laboratory for Enteric Pathogens) for serotyping or phage typing. At the end of year 2002, a letter of agreement by which provinces agreed to forward all or a subset 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. To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak and non-outbreak) received passively by PPHLs in New Brunswick, Newfoundland, Nova Scotia, Manitoba, Prince Edward Island, and Saskatchewan were forwarded to the NML. More populated provinces (Alberta, British Columbia, Ontario, and Québec) forwarded isolates they received from the first to the 15th of each month. 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 multiple drug 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 collected, the outbreak identification if applicable, the patient age and/or date of birth, the patient gender, and the province of residence. The provision of data on travel history, antibiotic use, hospitalization status of the patient during specimen collection, and date of onset were optional and were not usually provided to the NML in 2004.

Although many outbreaks are identified by PPHLs prior to isolate submission, some outbreaks are identified after the isolates have been forwarded to the NML.

Bacterial Isolation Methods

Hospital-based and private laboratories isolated and identified *Salmonella* according to approved methods (Kauffman, 1966; Ewing, 1986; Le Minor, 2001; Le Minor and Popoff, 2001; Murray et al, 2005).

Serotyping and Phage Typing

The NML Identification/Serotyping Phage typing and Antimicrobial Resistance units at the NML have actively participated in WHO GSS EQAS proficiency program for *Salmonella* in 2001, 2002, 2003 & 2004. In addition, the 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. The NML has had a proficiency panel strain exchange with LFZ

(*Salmonella* and *E. coli*) in 2002, 2003, and 2004.

The Identification and Serotyping, and Phage Typing units at the NML have attained ISO 151189 accreditation.

Serotyping: In general, hospital-based and private laboratories forwarded their *Salmonella* isolates to their PPHL for serotyping. Isolates received at the NML without a *Salmonella* serovar name were serotyped by the NML (Le Minor and Popoff, 2001). If problems arose during phage typing on a designated *Salmonella* serotype, the serotype was confirmed by the NML.

Phage typing: All *Salmonella* Heidelberg, S. Typhimurium, S. Enteriditis, S. Hadar, S. Newport, S. Typhi, S. Paratyphi, S. Infantis, S. Thompson, S. Oranienburg, and S. Panama were phage typed 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°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°C to attain a bacterial growth turbidity equivalent to 0.5 McFarland Standard. Difco Phage Agar (DPA) plates were flooded with approximately 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 AMR 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 in each abattoir is divided by five, leading to a given number of collection periods. For each collection period, the five caecal samples are collected within five days, at the slaughterhouse's convenience, provided the five animals/samples come from different lots. Sampling from different lots is important to maximize diversity and avoid bias due to over-representation of particular producers. Collection periods are uniformly distributed over the year, leading to an abattoir-specific schedule for collecting caecal contents. 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.

Fifty-one federally inspected slaughter plants (28 poultry plants, 20 swine plants, and 9 beef plants, from across Canada, participated in the 2004 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*. 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.

Retail Surveillance

Retail food represents a logical sampling node for AMR 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 AMR of bacteria found in food at retail. This surveillance framework can be modified (e.g. food commodities, bacteria, regions) as necessary and function as a research platform to investigate specific questions regarding antimicrobial resistance in the agri-food sector.

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). For ground beef in the first year of sampling (2003), only lean ground beef was selected, but in 2004 this was 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 type of meat cuts were chosen based on its high prevalence with regards to the targeted bacteria and its low cost of purchase (Ravel, 2002).

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. Retail surveillance data that are presented in this report represent the first full year of retail sampling and these data were

collected in two provinces including Ontario and Québec. 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

In preparation for program expansion beyond two provinces, pilot projects were conducted in British Columbia, New Brunswick, Nova Scotia, and Prince Edward Island, where two census divisions were sampled in each province.

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 two divisions are sampled on each sampling day. In each division a slate of four stores is selected prior to the sampling day 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 2004, 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

In 2004, Personal Digital Assistants (PDAs) were piloted in Ontario as an efficient method to electronically capture the store and sample data listed above while maximizing data integrity.

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 diagnostic isolates included in the passive veterinary component were received by the *Salmonella* Typing Laboratory at LFZ (Guelph, Ontario). These isolates came from veterinary diagnostic laboratories from across the country and the isolation methodology may vary for each laboratory. Since the samples were submitted for diagnostic purposes, private practitioners and/or producers collect the samples. 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 (see Box 3 for further details). Data collection began in January 2006 and will be presented in subsequent CIPARS reports.

Bacterial Isolation Methods

Active Surveillance (Abattoir, Retail)

Primary isolation of *E. coli, Salmonella*, *Enterococcus* spp., and *Campylobacter* spp., and antimicrobial susceptibility testing of *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.

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 broiler and swine 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)

Escherichia coli were isolated from the caecal contents of broilers, swine and beef samples. 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, hippurate, and indoxyl acetate hydrolysis.

Retail Surveillance (Enterococcus 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 screened 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. 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, Phage Typing, and Antimicrobial Susceptibility Testing Methods

All food and animal *Salmonella* isolates were submitted to the LFZ, Guelph, Ontario. The serotyping and phage typing tests 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 phage typing in 2003 and successfully completed a phage typing proficiency panel provided by NML originating from the Central Public Health Laboratory, Colindale, England.

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 (2001) were used to name the serovars. Quebec passive isolates were serotyped by the *Institut national de santé animale* laboratory located in St-Hyacinthe, Quebec using standard methods.

Phage typing: The standard phage typing technique described by Anderson and Williams (1956) was followed. *Salmonella* Enteritidis strains were phage typed 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 phage typing 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 phage typing scheme and phages were supplied by NML (Demczuk *et al*, 2003). Isolates that reacted with the phages but did not conform to any recognized phage type 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. *Escherichia coli*, *Enterococcus,* and *Campylobacter* were tested by LFZ-Saint-Hyacinthe. Two test panels were used to assess AMR in human isolates. The first test panel, CMV7CNCD, was used from January to April 2004 on 847 isolates. This panel included amoxicillin-clavulanic acid, amikacin, ampicillin, cephalothin, chloramphenicol, ciprofloxacin, ceftriaxone, cefoxitin, gentamicin, kanamycin, nalidixic acid, sulfamethoxazole, streptomycin, trimethroprim-sulfamethoxazole, tetracycline, and ceftiofur. The second test panel, CMV1AGNF, was used on 2007 isolates collected from April to December 2004. Antimicrobials on this test panel were the same as those included on the previous panel (CMV7CNCD) except that cephalothin was removed and sulfamethoxazole was replaced by sulfisoxazole (the same acronym SMX is used in the AMR pattern definition).

MIC values for *Salmonella*, *E. coli,* and *Enterococcus* were determined by the broth microdilution method (NCCLS/CLSI - M7-A5). Broth microdilution method was performed using the Sensititre™ ARIS Automated Microbiology System (Trek™ Diagnostic Systems Ltd). Sensititre™ is a commercially available microwell broth dilution technique using dehydrated antimicrobials in the wells of microtitre plates. 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 CMV6CNCD 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 CMV6CNCD panels as outlined by the CLSI (NCCLS/CLSI - M100-S12). *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), (NCCLS/CLSI – M7-A6).

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 was 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 CLSI standards (NCCLS/CLSI – M31-A2).

Quality control testing was performed on 170 *E. coli* isolates (

Table **54**). Amikacin, ampicillin, and streptomycin had 99.4% of tests fall within expected MIC range. The remainder had all tests within the expected MIC range. Forty-five *Enterococcus faecalis* isolates were evaluated and all antimicrobials, except amoxicillin/clavulanic acid (95.6%), chloramphenicol (95.6%), and tetracycline (91.1%) had all tests fall within expected MIC range (

Table **54**).

Table 54. Quality control testing for *E. coli* and *Enterococcus faecalis* isolates.

Antimicrobial	Expected MIC range[1]	Number (%) of tests within expected range	Expected MIC range[1]	Number (%) of tests within expected range
Amikacin (AMK)	0.5 - 4	169/170 (99.4)	64 - 256	45/45 (100)
Amoxicillin-Clavulanic Acid (AMC)	1-8	170/170 (100)	0.12 - 1	43/45 (95.6)
Ampicillin (AMP)	2-8	169/170 (99.4)	0.5 - 2	45/45 (100)
Cefoxitin (FOX)	2-8	170/170 (100)	--	N/A
Ceftiofur (TIO)	0.25 - 1	170/170 (100)	--	N/A
Ceftriaxone (CRO)	0.03 - 0.12	170/170 (100)	--	N/A
Cephalothin (CEP)	4-16	170/170 (100)	--	N/A
Chloramphenicol (CHL)	2-8	170/170 (100)	4-16	43/45 (95.6)
Ciprofloxacin (CIP)	0.004 - 0.015	170/170 (100)	0.25 - 2	45/45 (100)
Gentamicin (GEN)	0.25 - 1	170/170 (100)	4-16	45/45 (100)
Kanamycin (KAN)	1-4	170/170 (100)	16 - 64	45/45 (100)
Nalidixic Acid (NAL)	1-4	170/170 (100)	--	N/A
Streptomycin (STR)	4-16	160/170 (99.4)	--	N/A
Sulphamethoxazole (SMX)	--	N/A	--	N/A
Tetracycline (TCY)	0.5 - 2	170/170 (100)	8-32	41/45 (91.1)
Trimethoprim-Sulphamethoxazole (SXT)	≤ 0.5	170/170 (100)	≤ 0.5	45/45 (100)

[1] *expected MIC range from NCCLS/CLSI (M7-A6).*

Data Analysis, Validation, and Review

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 55, Table 56, and Table 57. In 2004, 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 CLSI (NCCLS/CLSI, 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. Annual differences in prevalence of resistance were assessed using chi-square tests with an alpha level of 0.05.

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.

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 AMR data, the number of *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, 2001), multiplied by 100 000. The national estimates for *S*. Typhimurium were calculated as followed: only one isolate per outbreak was kept; in provinces submitting isolates 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 *S.* Typhimurium.

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

Table 55. *Salmonella* and *E. coli* breakpoints.

Antimicrobial	Range tested in 2004 by NML µg/mL CMV1AGNF	Range tested in 2004 by LFZ µg/mL CMV7CNCD	Susceptible range µg/mL	Intermediate range µg/mL	Resistant range µg/mL
amikacin	0.5-64	0.5-4	≤ 16	32	≥ 64
amoxicillin-clavulanic acid	1.0/0.5 - 32/16	1.0/0.5 - 32/16	≤ 8/4	16/8	≥ 32/16
ampicillin	1-32	1-32	≤ 8	16	≥ 32
cefoxitin	0.5-32	0.5-16	≤ 8	16	≥ 32
ceftiofur	0.12-8	0.12-8	≤ 2	4	≥ 8
ceftriaxone	0.25-64	0.25-64	≤ 8	16-32	≥ 64
cephalothin	2-32	2-32	≤ 8	16	≥ 32
chloramphenicol	2-32	2-32	≤ 8	16	≥ 32
ciprofloxacin	0.015-4	0.015-4	≤ 1	2	≥ 4
gentamicin	0.25-16	0.25-16	≤ 4	8	≥ 16
kanamycin	8-64	8-64	≤ 16	32	≥ 64
nalidixic acid	0.5-32	0.5-32	≤ 16	-	≥ 32
streptomycin	32-64	32-64	≤ 32	-	≥ 64
sulfizoxazole (CMV1AGNF)/ sulfamethoxazole (CMV7CNCD)	16-256	16-512	≤ 256	-	≥ 512
tetracycline	4-32	4-32	≤ 4	8	≥ 16
trimethoprim-sulfamethoxazole	0.12/2.38-4/76	0.12/2.38-4/76	≤ 2/38	-	≥ 4/76

***Note**: All breakpoints are from NCCLS/CLSI M100-S15 Table 2A, M7-A6-MIC Testing section except breakpoints for ceftiofur (NCCLS/CLSI M31-A2, Table 2.) and streptomycin (NARMS 2001 Annual report). The plate CMV7CNCD was used by LFZ in 2004 and by NML from January to April 2004. The CMV1AGNF plate was used by NML only after April 2004.*

Table 56. *Campylobacter* spp. breakpoints.

Antimicrobial	Range tested in 2004 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.*

Table 57. *Enterococcus* spp. breakpoints.

Antimicrobial	Range tested in 2004 µg/mL CMV5ACDC	Susceptible range µg/mL	Intermediate range µg/mL	Resistant range µg/mL
Bacitracin	8-128			≥128[1]
Chloramphenicol	2-32	≤ 8	16	≥32[2]
Ciprofloxacin	0.12-4	≤1	2	≥4[2]
Erythromycin	0.5-8	≤0.5	1	≥8[2]
Flavomycin	1-32			≥16[1]
Gentamicin (high-level)	128-1024			≥500[2]
Kanamycin (high-level)	128-1024			≥2048[1]
Lincomycin	1-32			≥8[3]
Linezolid	0.5-8	≤2	4	≥8[2]
Nitrofurantoin	2-128	≤32	64	≥128[2]
Penicillin	0.5-16	≤8		≥16[2]
Quinupristin-dalfopristin	1-32	≤1	2	≥4[2]
Salinomycin	1-32			≥16[1]
Streptomycin (high-level)	512-2048			≥1000[2]
Tetracycline	4-32	≤4	8	≥16[2]
Tylosin	0.25-32			≥8[3]
Vancomycin	0.5-32	≤4	8-16	≥32[2]

Note: Breakpoints are from 1) DANMAP 2002, 2) NCCLS/CLSI M100/S15, 3) CDC personal communications.

B.3. Human Antimicrobial Use Data Collection and Analysis

CompuScript

Canadian CompuScript (CCS) tracks the number and size of prescriptions dispensed by retail pharmacies in Canada. Data fields include product name (including manufacturer), form, strength, province, the number of prescriptions, units of product, and dollars spent monthly 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).

CIPARS classified drugs and calculated Defined Daily Doses (DDDs) 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. The following DDD exceptions were made: for pediazole we used the DDD for erythromycin ethyl succinate, for trisulfaminic we used the DDD for sulfamerazine. 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 each product strength within the ATC groups, 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. 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. Only oral antimicrobials were kept in the 2004 report analysis.

Canadian Disease and Therapeutic Index

The *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).

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